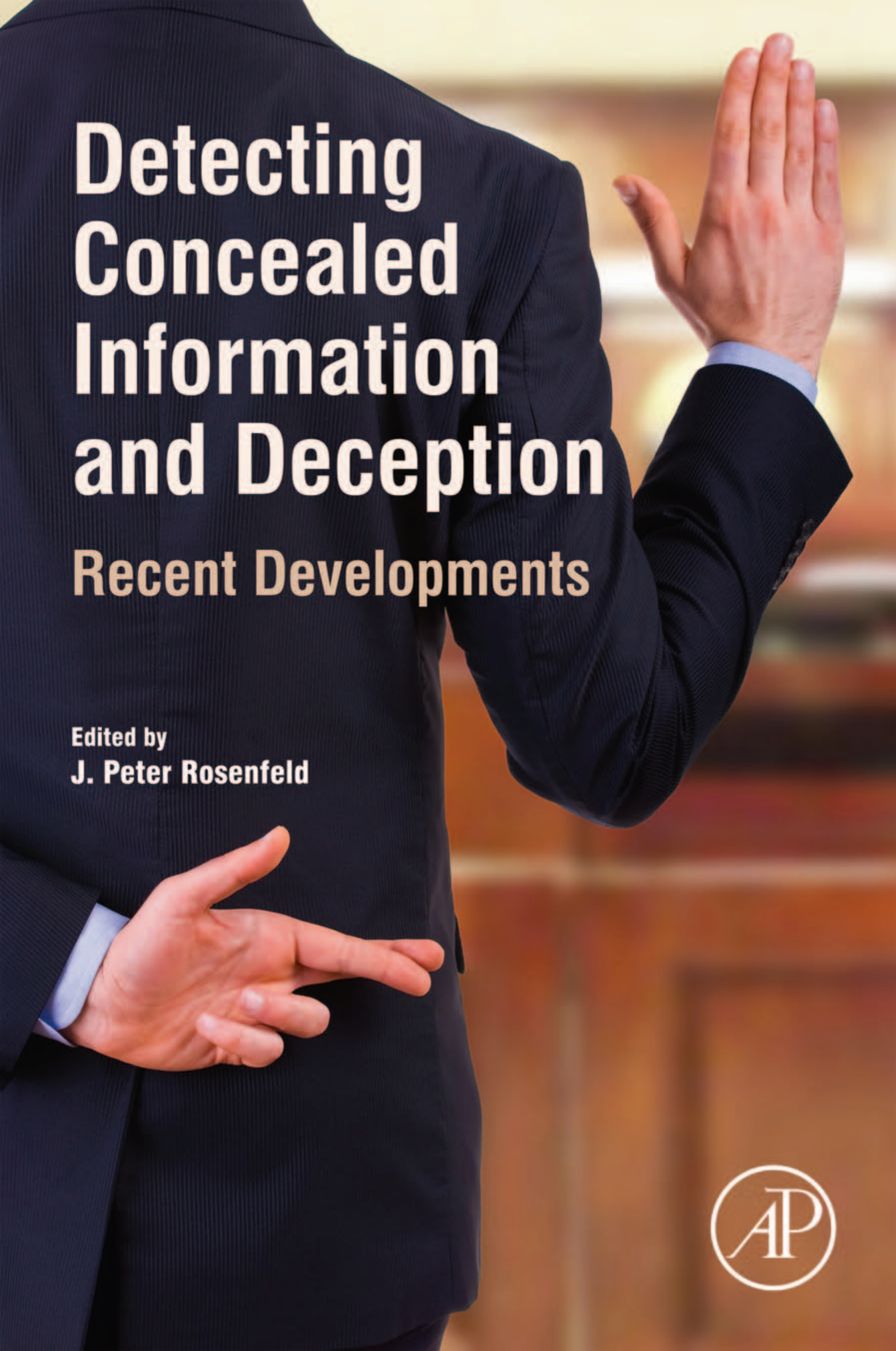

Detecting Concealed Information and Deception

Recent Developments

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J. Peter Rosenfeld

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Recent Developments

Edited by

J. PETER ROSENFELD
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PREFACE

Until about the year 2000, most field tests of deception involved the Comparison Question Test (CQT; formerly, the Control Question Test), a questioning protocol virtually always utilized with the subject connected to a polygraph machine. This machine typically recorded autonomic nervous system (ANS) responses, including skin resistance, cardiovascular activity, and breathing pattern, in conjunction with the relevant and control questions of the CQT. On the other hand, from about the 1960s forward, many deception research studies utilized a different questioning protocol called the Concealed Information Test (CIT; formerly, Guilty Knowledge Test), but also in conjunction with use of a polygraph tracking ANS responses. There were various reasons why CIT proponents rejected the CQT questioning approach, including the criticism that ANS responses to relevant questions about a suspect's personal crime involvement (e.g., Did you shoot your spouse?) could never be compared in a meaningful scientific way with ANS responses to so-called control questions (e.g., Did you ever think violent thoughts?). Such a comparison was the heart of the deception detection matter in the CQT, whose critics rightly pointed out the lack of standardization involved in interrogations designed to identify and formulate control questions for various subjects. In contrast, the CIT approach asked informational questions about crime details that would likely be known by perpetrators but not innocents. The comparison made in CIT research was between the ANS response to critical versus irrelevant items, all drawn from the same category. This comparison or difference is called the CIT effect. Thus, the guilty party, but not the innocent suspect, would recognize the presentation of the murder weapon (e.g., 356 Magnum) in a set of other possible murder weapon presentations (e.g., 45 Automatic, 38 Revolver, 22 Beretta, etc.), and this recognition would be signaled by relatively altered ANS responses only in the guilty suspect.

Deception research with other response systems in addition to the ANS—especially involving the central nervous system—began in the 1980s, and a burgeoning growth of all deception research work plus the introduction of yet more novel measurement methods and protocols was seen following the terrorist attack on the twin towers in New York on September 11, 2001. It is on this research that the present volume focuses. Much of the new work is by academic researchers, and is focused mainly on the CIT. Examples include chapters by myself on the now sizeable literature on event-related electroencephalography EEG potentials (especially P300) as signs of information recognition; by Ganis on the use of functional magnetic resonance imaging also to index recognition; by Gamer and Pertzov, and by Kircher on the use of oculomotor signs of familiarity and recognition; and by Sartori and by Suchotzki on behavioral indices (including the novel autobiographical Implicit Association Test and other manual dynamics measures) of recognized true versus false information. These four approaches discuss possible applications of these various novel dependent measure channels for use in field investigations. Another set of approaches to deception detection in field situations is based on novel analyses of verbal behavior. Some of this work is closely tied to considerations of the cognitive loading effects of deception. The chapters by Granhag and Luke, Vrij, and G. Nahari exemplify this approach.

Yet despite these many examples of clearly field-oriented research areas deemed critical for an up-to-date review of the field of deception detection—a goal of this book—it seemed essential for a volume like this one to include at the outset a background section devoted to a historical perspective and theoretical consideration of the psychological principles underlying the detection of concealed information and deceptive behavior. Ambach and Gamer review the physiological measurements traditionally used in conjunction with detection of concealed information. Matsuda and Nittono provide a parallel review, more oriented to central nervous system indices, and then give an original theoretical reconsideration of the roles of recognition and concealment phenomena in memory detection. Continuing this theoretical approach, Klein Selle, Verschuere & Ben Shakhar give a full traditional account of the CIT effect in terms of orienting and response inhibition theories, informed by novel findings suggesting response fractionation. Ben Shakhar and Tal Nahari consider the very important question of the external validity of CIT research by providing a thorough review of this complex literature. As a conclusion to this section, Osugi finally bridges the transition to the novel applications section by discussing how the ANS-based CIT is used in field tests in Japan, the only nation presently using this protocol as a standard technique in field investigations.

The final section of this volume considers special issues relating to modern detection of concealed information and deception. Elaad reviews psychosocial and psychophysiological correlates of self-assessed deceptive skills in individuals. Then Kleinberg reviews the topic of assessing deception on a large scale; that is, in many persons at the same time. This matter is crucial for the currently topical problem of antiterror screening at transportation portals. Finally, and importantly, attorney and biological psychologist Meixner provides a uniquely enlightened consideration about the possible admissibility of concealed information protocols in US courts.

Thus, this volume attempts to provide a comprehensive, up-to-date review of the state of the art in detection of concealed information and deception, against a background of the theoretical foundation of this area. The chapters should be of interest to forensic, clinical, and cognitive psychologists, neuroscientists, attorneys, and those interested in the new crossover field of law and neuroscience.

J. Peter Rosenfeld

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All authors wish to dedicate this volume to their departed colleague and pioneer in this field, John J. Furedy.

The editor thanks his wife, Elba Carmen Olivares Lopez, MD, for her help during this project; it could not have been completed without her support.

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SECTION 1

Background, History, and Theory

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CHAPTER 1

Physiological Measures in the Detection of Deception and Concealed Information

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Attempts to detect deception by means of physiological measurement have evolved over more than 100 years. Combining elaborated interrogation procedures with capturing bodily responses brought forth specific procedures and measurement techniques that are routinely used in forensic investigations all over the world. This chapter provides a brief overview of detection-of-deception paradigms and then focuses on the Concealed Information Test (CIT), which allows for detecting concealed (crime-related) knowledge. In contrast to electroencephalography (EEG) and neuroimaging techniques, this chapter emphases on "classic" polygraphic measurement, consisting of the typical multichannel recording of electrodermal, respiratory, and cardiovascular measures, which are mostly related to the autonomic nervous system. The diagnostic value and incremental information of each measure in case of their combination are discussed as well as the contribution of specific mental processes to the response pattern. From an applied perspective, we will discuss potential threats to the validity of the CIT, including its susceptibility to countermeasures, the leakage of crime-related information to innocents, and potential memory distortions due to high levels of stress and anxiety.

HISTORY

Deceptive behavior is one core feature of human interaction. The attempts to uncover it have been performed in personal, institutional, and forensic contexts with different approaches. Among the manifold methods that were used to detect deception, psychophysiological measurement has become most prominent over the last century. This technique, in general, makes use

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of the fact that bodily functions are linked to and correlated with mental processes. Therefore, observable or measurable bodily functions can allow for drawing inferences about particular mental processes.

Human feeling and thinking is always bound to a physical substrate, and human nature includes a close relationship between what we call mind and what we call body. In fact, human feelings and thoughts are always accompanied by bodily changes, which we call the physiological *correlates* of the psychological events and processes that they are related to. Naturally, such correlates always occur within the brain, which is directly involved as the physical substrate of emotion and cognition. Moreover, due to the multifold cross-linkage of anatomically and/or physiologically discernible systems within the human body, somatic systems other than the brain also easily get involved in psychophysiological processes, and to a variable degree.

Deception is no exception: Whatever mental processes are involved, they will always be bound to functional brain changes, and they will, most likely, be accompanied by temporal changes in other physiological systems. Physiological correlates of deceptive action can be open to observation; if hidden to the eye, they can eventually be detectable through an appropriate physiological measurement. Hence, it seems highly plausible to search for valid indicators of deception in physiological measures. Not surprisingly, this search began centuries ago, and detection attempts were made by means of observation and, with the development of measurement technology, by increasingly sophisticated methods of physiological measurement. These attempts primarily aimed at identifying bodily correlates of the mental processes associated with *deception*. The search was driven by the intention to detect deception in various, particularly forensic, contexts. Consequently, the choice and development of methods was guided by practical usefulness rather than theoretical considerations.

The colorful history of deception detection has been summarized by Lykken (1998) in his popular book "A Tremor in The Blood. Uses and Abuses of The Lie Detector." Despite all ups and downs that deception detection underwent throughout history, the issue has always maintained highest interest in the public as well as in forensic professionals. New methods said to detect deceit regularly commanded the greatest attention, and the application of a new method was often widened to forensic and commercial use long before its reliability, validity, and theoretical substantiation was fairly understood.

Early attempts to detect lies by means of physiological measurement trace back to the end of the 19th century (for a review, see Lykken, 1998). In 1895, Cesare Lombroso measured volume changes of the hand using a modified hydrosphygmograph during a forensic interrogation. Changes in heart rate and blood pressure, derived from this volume measurement, were used to distinguish truthful from deceptive answers of a culprit. Although cardiovascular measurement was further improved in the following years, respiratory measures also received attention in the context of truth detection. In 1914, Vittorio Benussi first used respiration measurement to tell truth from lies; from the breathing recordings, he calculated inspiration and expiration time and used them as deception indicators. The measurement techniques of heart rate, blood pressure, and respiration, which were the first physiological measures used to detect deception, were then further refined and combined into a single apparatus, which then also allowed for simultaneously plotting the temporal course of these measures on paper. John Larson was the first to apply such a multichannel writer, or polygraph, in 1921. The next important step in the history of lie detection was the inclusion of skin-resistance measurement by Leonarde Keeler who used the augmented combination of measures in several criminal cases in the 1930s. The combination of cardiac, vascular, respiratory, and electrodermal measurements that was established in these years has remained the core of polygraphic measurement up to the present.

For detecting deception, physiological measurement has always been combined with the interrogation of a suspect. However, no standardized interrogation protocol is known from the early decades of psychophysiological lie detection. Hence, beside the development of physiological measurement over decades, standardizing and optimizing the interrogation was then pursued as an aim of equivalent importance. John Reid introduced a combination of critical and control questions, performed with physiological measurement, in 1947, which later became well known as the Control or Comparison Question Test (CQT). In the first variant, the interrogation protocol combined a series of "crime-related" ("relevant," e.g., "Did you steal the money from the wallet?") and "control" ("irrelevant," e.g., "Does 2 plus 2 equal 4?") questions with multichannel physiological measurement. Although crime-related questions were supposed to induce an emotional reaction in a guilty rather than an innocent person, control questions were supposed to induce no emotional reaction, regardless of the examinee's guilt status. To infer this guilt status, the examinee's physiological response amplitudes were then compared between crime-related and control questions. In the later CQT, crime-related questions were not compared to irrelevant questions in the former sense, but to "comparison" questions that were supposed to elicit physiological reactions from innocent examinees (e.g., "During the first 16 years of your life, did you ever take something that did not belong to you?"). It was supposed that a guilty examinee will show stronger physiological responses to the crime-related questions, whereas innocents will show stronger physiological responses to the comparison questions.

Cleve Backster added a standardized scoring system in 1966. Theoretically, the observed or expected physiological differences between truth-telling and deceiving were mostly ascribed to changes in emotion and arousal that were induced to a different degree by different questions during the interrogation. It was assumed that emotional and arousal changes were reflected in each of the combined measures. Despite the frequent and widespread use of the CQT, it remained debatable up to the present whether the choice of individual questions in an individual interrogation in fact allows for a valid conclusion. The notion that there is no distinctive physiological pattern indicative of deception and reliably distinguishing it from truth-telling has remained a critical argument against the use of the CQT up to the present (Ben-Shakhar, 2012).

In 1959, David Lykken started to use a radically different approach. Instead of searching for physiological correlates specific to deception, he compared electrodermal responses to crime-related information (e.g., the stolen item) with those to equally plausible neutral items (e.g., other valuables). Lykken could show that participants who committed a mock crime before undergoing the test showed stronger electrodermal responses to crime-related items as compared to neutral alternatives. Innocent subjects, who remained ignorant of the relevant details of the mock crime, showed a nonsystematic response pattern across the different test items. Thus, this Guilty Knowledge Test (GKT), later called the Concealed Information Test (CIT), allows for identifying crime-related knowledge. In comparison to other techniques such as the CQT, it makes particular prerequisites for its application, namely the necessity of identifying several crime-related details in advance. When this condition is met, it then allows for a valid comparison of physiological responses to two distinct types of items (i.e., crime-related details and equally plausible alternatives), which further leads to classifying an examinee as possessing crime-related knowledge or not. Beside the electrodermal measure used in the first demonstration of the test, heart rate, blood-volume changes, and respiration later proved as additional valid and commonly used indicators of concealed-information recognition (Gamer, 2011). Later studies (e.g., Furedy & Ben-Shakhar, 1991) confirmed that it is primarily the difference between present and absent knowledge, not between guilt and innocence or between truthful and deceptive answering, that determines the physiological responding and the outcome of the CIT.

AUTONOMIC MEASURES

After the seminal studies outlined earlier, autonomic responses were increasingly used for detecting deception or the concealment of information for more than 100 years. Their use was fostered by the idea that such responses occur automatically and are difficult to control voluntarily. An early application was further facilitated by the fact that corresponding biosignals are relatively large and can thus be measured with rather simple devices. In general, autonomic responses mainly reflect activity of the sympathetic and the parasympathetic nervous systems. These two branches of the autonomic nervous system affect a number of organs in an antagonistic fashion. According to oversimplified accounts, the sympathetic nervous system was termed the "fight or flight" system and the parasympathetic one the "rest and digest" or "feed and breed" system. The fact that activity in both branches can be regulated instantaneously and rather independently of each other (Berntson, Cacioppo, & Quigley, 1991) in situations that do not directly relate to such activities, indicates that these systems should be better understood as permanently modulating vital functions to achieve homeostasis. Interestingly, as we will discuss in detail in the following, autonomic activity is strongly related to numerous psychological functions and therefore can be used as a proxy for specific aspects of internal information processing.

From an applied perspective, the most frequently used autonomic measures for detecting deception or concealed information are electrodermal responses, respiration, heart rate, and blood-volume changes (e.g., peripheral vasoconstriction or relative blood pressure). These measures, which are typically recorded by commercially available polygraph devices in field examinations, will be discussed in the following regarding underlying physiological mechanisms, measurement and scoring procedures, as well as their validity in detecting deception and concealed information.

Electrodermal Measures

Phasic changes in skin conductance or resistance are commonly referred to as electrodermal responses. These changes are monophasic, they usually occur 1–4 s after an event, and they last for several seconds until skin conductance returns to baseline levels. Although several variables can be extracted from these responses, the response amplitude is most frequently used to index the strength of activation (Dawson, Schell, & Filion, 2007). Because eccrine sweat glands, which constitute the physiological basis of electrodermal responses, are mainly regulated by the sympathetic nervous system, these responses can be regarded as a sensitive measure of sympathetic arousal (Wallin, 1981).

Across different interrogation techniques and experimental investigations, electrodermal responses were consistently shown to be higher (1) for deceptive as compared to truthful responses (e.g., Furedy, Davis, & Gurevich, 1988; Furedy, Posner, & Vincent, 1991; Gödert, Rill, & Vossel, 2001), (2) for concealed knowledge as compared to neutral alternatives in the CIT (Lykken, 1959, 1960; see Fig. 1.1) as well as (3) for deceptively denied relevant as compared to control questions in the CQT (Kircher & Raskin, 1988; Podlesny & Raskin, 1978). Similar results were also obtained for field studies on the CIT (Elaad, 1990; Elaad, Ginton, & Jungman, 1992). Given that this response pattern seemed relatively stable even when participants remained silent in the CIT (Bradley, MacLaren, & Carle, 1996) or even affirmed knowledge by answering "Yes" to questions about critical details (Elaad & Ben-Shakhar, 1989), it can be speculated that electrodermal responses do not reflect deception per se but rather indicate the enhanced significance of certain questions or items to the examinee. Although some proponents of the CQT describe this procedure as a "deception test" (e.g., Honts, 2004), such reasoning seems simplistic because relevant and comparison questions differ in a number of aspects that are not directly related to deceptive responding. For example, relevant questions are related to a crime and are specific and rather narrow, whereas comparison questions ask for a more general misdeed and cover large periods of time. Thus, it also seems plausible to assume that electrodermal responding in the test does not directly reflect deception but is rather related to broader concepts such as personal relevance or threat value.

In addition to showing differences in electrodermal responsiveness between groups of participants (e.g., participants who conducted a mock crime in a laboratory study as compared to innocents), several metaanalyses allow

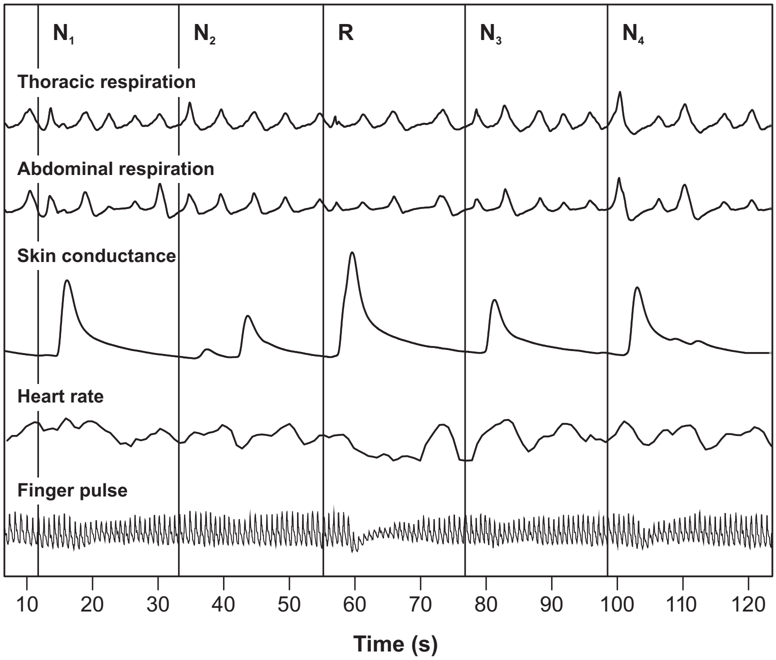

Figure 1.1 Illustration of an autonomic response profile of a guilty examinee in a concealed information test (CIT) examination. R denotes the relevant item and N_1 to N_4 the equally plausible neutral alternatives. Concealed-item recognition is reflected by a respiratory suppression, a greater increase in skin conductance, a transient heart-rate deceleration, and a peripheral vasoconstriction resulting in reduced pulse-volume amplitudes.

for estimating the validity of electrodermal responses in detecting concealed information as well as for revealing factors that modulate responsiveness across studies (Carmel, Dayan, Naveh, Raveh, & Ben-Shakhar, 2003; MacLaren, 2001). The most recent metaanalysis used measures from signal detection theory (SDT, Green & Swets, 1966) to estimate effect sizes for physiological responses in the CIT (Meijer, Klein Selle, Elber, & Ben-Shakhar, 2014). Specifically, Cohen's *d* (an effect size estimate) as well as the area under the Receiver Operating Characteristics (ROC) curve (area under the curve [AUC], from SDT, an estimate of classification accuracy) was calculated for 115 experimental conditions involving 3863 participants. As a rule of thumb, Cohen (1988) defined an effect size of $d = 0.80$ as a large effect. The area statistic AUC varies between 0 and 1 with 0.5 reflecting chance classification of individuals into experimental conditions. A value of 1 would indicate perfect separation between groups (e.g., between guilty and innocent examinees) based on the respective diagnostic technique. Meijer et al. reported an effect size of $d = 1.55$ for electodermal responses ($AUC = 0.848$) which constitutes a large effect. This effect was moderated by the level of motivation with higher motivation of participants resulting in stronger differences in electrodermal responses between concealed and neutral CIT items. Furthermore, a larger number of CIT questions resulted in higher validity estimates. Moreover, the authors compared the effect sizes between studies that examined a sample of unknowledgeable (i.e., innocent) examinees with studies that estimated the response distribution of such group by assuming nonsystematic responding across all CIT items (for a detailed explanation of such procedure, see Meijer, Smulders, Johnston, & Merckelbach, 2007). Validity estimates were larger for the former as compared to the latter procedure. This result suggests that authors tended to report results based on optimal cutoff values to differentiate guilty from innocent examinees. Such procedure was especially present in early publications in this domain and was less prominent in more recent studies. Collectively, these findings indicate that electrodermal responses have high validity for detecting concealed information. Given that electrodermal responses were also shown susceptible to mere deception when controlling for potential confounds related to the interrogation techniques (Furedy et al., 1988; Gödert et al., 2001), it remains to be elucidated whether this aspect can be further exploited by novel questioning techniques in the future. However, the controversial discussion on the validity of interrogation procedures that could be applied in field contexts (e.g., Honts, 2004; Iacono, 2008) demonstrates that it might be very difficult to emphasize this aspect of deceptive responding in future refinements of questioning procedures.

Respiratory Measures

As outlined previously, respiratory measures were already used very early on for distinguishing lies from truthful statements. These measures are usually recorded with pneumatic or piezoelectric transducers attached around the chest and/or the abdomen with belts or Velcro straps. Because the acquired signal is not calibrated in general, it has an arbitrary unit and cannot be directly compared between different individuals. The signal reflects volume changes of the torso that accompany breathing movements. Respiration is controlled by a complex interplay of central and autonomic (mainly vagal) circuits as well as by peripheral feedback loops (Lorig, 2007).

In contrast to many other autonomic measures, respiration can be controlled voluntarily.

Interestingly, first experimental investigations on thorax or abdomen movements reflecting expiratory and inspiratory respiration periods did not reveal a consistent pattern of changes accompanying deception or the concealment of information (Bradley & Ainsworth, 1984; Podlesny & Raskin, 1978). These results seemed to be due to high variability between individuals regarding which respiration parameters are affected by deception. Consequently, the use of an integrative measure of respiratory body movements resulted in substantially higher consistency across studies. This measure, termed respiration line length (RLL, Timm, 1982), is calculated by measuring the total length of the respiration tracing for specific time periods (e.g., 10 or 15 s) following question or item onset in CQT or CIT examinations. It combines respiration frequency and depth and thereby reflects an integrative estimate of respiratory suppression. Thus, RLL is reduced when an examinee breathes more slowly but also when he or she breathes less deeply. Because the RLL is disproportionately affected by the start of measurement (e.g., whether scoring starts within the inspiratory or the expiratory phase of the breathing cycle), it has been proposed to calculate RLL with gradually increasing and decreasing weights at the start and the end of the scoring period, respectively (e.g., first and last second, Elaad et al., 1992). Moreover, more sophisticated methods that allow for calculating weighted averages of RLL segments on a real-time scale based on the scoring of individual respiration cycles have recently been proposed (Matsuda & Ogawa, 2011).

The majority of studies in the last decades showed that RLL is consistently reduced for deceptively answered relevant questions as compared to control questions in the CQT (e.g., Kircher & Raskin, 1988), for concealed information as compared to equally plausible neutral items in laboratory (Bradley & Rettinger, 1992; Gamer, Rill, Vossel, & Gödert, 2006; see Fig. 1.1), as well as in field studies on the CIT (Elaad et al., 1992). To the best of our knowledge, RLL measures have not yet been examined in experimental paradigms that allow for isolating deception (e.g., the differentiation-of-deception paradigm). Similar to the observed pattern of electrodermal responses, this respiratory suppression might reflect the enhanced significance of certain questions or items to the examinee. Regarding the CIT, several studies showed that electrodermal and respiratory responses are only weakly correlated (Gamer, Verschuere, Crombez, & Vossel, 2008) and seem differentially affected by experimental manipulations.

For example, respiratory responses were found less sensitive to deliberate attempts of examinees to alter their response pattern with the aim of being classified as "innocent" (i.e., countermeasures, Ben-Shakhar & Dolev, 1996; Peth, Suchotzki, & Gamer, 2016). They were more affected by emotional aspects of CIT questions than electrodermal responses (Suzuki, Nakayama, & Furedy, 2004) and they were found reduced when participants were motivated to reveal their knowledge in the CIT examination (Klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2016).

A recent metaanalysis on the CIT allows for estimating the validity of respiratory measures when considered in isolation. Data were available from 42 experimental conditions with 1446 participants in total. Validity estimates indicated strong effects ($d = 1.11$, $AUC = 0.770$) that were, however, slightly smaller compared to electrodermal responses. It is currently unknown to what degree respiratory responses reflect deceptive responding specifically, but recent studies indicate that respiration might be more affected by motivational aspects such as strategic inhibition or emotional relevance as compared to mere significance of specific questions or items (Klein Selle et al., 2016; Klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2017; Suzuki et al., 2004). A main advantage of respiration recordings in detection of deception settings might be the opportunity to acquire these measures unobtrusively, for example by measuring slight body movements with sensors hidden in the polygraph examination chair. Although these recordings seem similarly valid as overt respiration measures (Elaad & Ben-Shakhar, 2008), such application raises important ethical concerns because informed consent is typically required in legal settings. Moreover, covert respiration recordings still need to be demonstrated more useful than overt measures under certain circumstances (e.g., countermeasures; Elaad & Ben-Shakhar, 2009).

Cardiovascular Measures

Activity in the cardiovascular system can be described by numerous measures related to cardiac (e.g., heart rate) or vascular properties (e.g., peripheral vasoconstriction) or measures reflecting an integration of these systems (e.g., blood pressure). The sympathetic as well as the parasympathetic system exert control over the heart and are capable of modulating heart rate (chronotropic control) and conduction (dromotropic control). Myocardial contractility (inotropic control) is mainly modulated by the sympathetic nervous system. Although both branches of the autonomic nervous system are capable of changing cardiac activity, the parasympathetic system has a much wider dynamic range of control over heart rate than does the sympathetic system (Berntson, Quigley, & Lozano, 2007). Moreover, the influence of both systems on cardiac chronotropy can be dissociated based on temporal properties. Although changes in sympathetic activity only modulate heart rate after a period of a few seconds, the parasympathetic system is capable of changing heart rate in less than one second (Somsen, Jennings, & der Molen, 2004). The vasculature smooth muscles that are also significantly contributing to blood pressure regulation are controlled by the sympathetic nervous system (Wallin, 1981).

With respect to deception or the concealment of information, different cardiovascular measures have been examined. Most consistent results have been obtained for heart rate changes that are usually measured with an electrocardiogram and quantified using real-time scaling approaches (Graham, 1978; Velden & Wölk, 1987). Heart rate accelerations were shown less prominent, or heart rate decelerations more pronounced, for deceptive as compared to truthful responses (Gödert et al., 2001), for deceptively answered relevant questions as compared to control questions in the CQT (Podlesny & Raskin, 1978; Raskin & Hare, 1978), and for concealed as compared to neutral items in the CIT (e.g., Gamer et al., 2006; Verschuere, Crombez, De Clercq, & Koster, 2004; see Fig. 1.1). The typical heart-rate profile when participants are answering verbally consists of an initial acceleration followed by a subsequent deceleration that seems most diagnostic for inferring deception or the concealment of information (e.g., Gamer et al., 2006). Removing verbal or behavioral responses from CIT examinations usually results in a reduction or extinction of the initial acceleration and reveals an early heart-rate deceleration following the presentation of critical CIT details (Gamer, 2011; Gamer, Gödert, Keth, Rill, & Vossel, 2008; Verschuere, Crombez, Smolders, & De Clercq, 2009). The temporal properties of this pattern (i.e., the emergence of a decelerative response within 1–2 s) indicates that concealment of information is related to an increase of parasympathetic activity in addition to the sympathetic effects triggering electrodermal responses. This coactivation of both branches of the autonomic nervous system is in line with the assumed synergistic instead of antagonistic effects of the sympathetic and the parasympathetic nervous systems (Berntson et al., 1991).

In addition to modulations of heart rate, several studies examined changes in peripheral blood flow accompanying deception or the concealment of information. These studies usually relied on photoplethysmographic techniques that quantify the relative amount of blood in the periphery of the body (usually at the distal phalanges of the fingers) by illuminating the skin with a light-emitting diode and measuring the amount of light either transmitted or reflected to a photodiode. The amount of light that reaches the photodiode is inversely related to the amount of blood in the tissue. In studies on deception and information concealment, the signal that was obtained with such measurement techniques was frequently quantified as finger pulse amplitudes or an integrative measure was obtained that combines amplitudes and pulse rate (so-called finger-pulse waveform length, Elaad & Ben-Shakhar, 2006). Peripheral blood flow was shown reduced for deceptively answered relevant questions as compared to control questions in the CQT (Kircher & Raskin, 1988; Podlesny & Raskin, 1978) and for critical items as compared to neutral alternatives in the CIT (e.g., Ambach, Bursch, & Stark, 2010; Elaad & Ben-Shakhar, 2006; see Fig. 1.1). Although photoplethysmographic recordings are easy to accomplish, it is important to note that because of variations in skin and vessel anatomy, differences in the placement of transducers, and changes in experimental conditions (e.g., room temperature, Macneill & Bradley, 2016), the resulting measures have an arbitrary unit and cannot be directly compared between groups of subjects or studies (Berntson et al., 2007). Because comparisons are usually accomplished within participants when examining effects of deception or information concealment, this does not necessarily cause problems. However, this restriction should be kept in mind when it comes to comparisons between groups of participants (e.g., different experimental groups or specific populations). It is also important to note that peripheral vasoconstriction seems to have much higher influence on the finger-pulse waveform length as compared to pulse rate (Vandenbosch, Verschuere, Crombez, & De Clercq, 2009). Finally, several studies in this domain used photoplethysmographic recordings to derive estimates of heart rate changes (e.g., Bradley & Ainsworth, 1984). Although such measurement is possible in general, it can be recommended to record an electrocardiogram instead for such purpose. The reasons for this recommendation are twofold: First, the reliability of heart beat detections from photoplethysmographic recordings is lower as compared to an electrocardiogram because of the smoothness of the pulse tracing. Second, the so-called pulse-transit time, that describes how long it takes until the pulse wave reaches the body periphery after a heartbeat, is not constant but inversely related to the current blood pressure (Barry & Mitchell, 1987). Thus, the measurement of heart rate changes from photoplethysmographic recordings is less precise than comparable analyses based on an electrocardiogram.

The last cardiovascular measure that has attracted considerable attention in the domain of deception detection is the so-called cardio channel that is routinely acquired in CQT examinations. This measure is obtained by applying a cuff to the upper arm that is inflated to a pressure somewhere between systolic and diastolic blood pressure. Variations in cuff pressure are then amplified and recorded using a connected pressure sensor. Most likely, this cardio measure reflects changes in relative blood pressure (Posey, Geddes, Williams, & Moore, 1969). Although this cardio channel seems to be valid in CQT examinations, with deceptively answered relevant questions triggering larger increases as compared to control questions (Kircher & Raskin, 1988), comparable diagnostic quality has not been obtained for CIT examinations. In the CIT, the cardio channel was either shown not to be valid at all (e.g., Elaad & Ben-Shakhar, 1989; Gamer et al., 2006) or cardio recordings even decreased electrodermal differences between concealed and neutral items, presumably because of the distraction resulting from the discomfort of the inflated blood-pressure cuff (Horvath et al., 1978). Nowadays, noninvasive techniques for a precise measurement of blood pressure are available (e.g., Volume-clamp or Peñaz method, Parati et al., 2003), that rely on quantifying the external pressure necessary to reach a constant level of blood in a certain area of the body (e.g., the fingers). This external pressure that needs to be adjusted on a beat-to-beat basis, is precisely reflecting the blood pressure in the underlying tissue. Although such methods have already been applied in a CQT examination (Podlesny & Kircher, 1999), they have not yet been used to examine blood pressure changes in CIT examinations in detail.

Taken together, deception and the concealment of information are associated with transient heart-rate decelerations, a peripheral vasoconstriction, and, at least under some circumstances, an increase in blood pressure. Due to the respiratory sinus arrhythmia, heart rate is coupled with respiration. Thus, the length of heart periods increases during expiration and decreases with inspiration. This physiological mechanism might explain why measures of heart rate and respiration usually show stronger correlations within CIT examinations as compared to respiration and skin conductance or heart rate and skin conductance that were only shown to correlate weakly within (Gamer, Gödert, et al., 2008) and across examinees (Gamer, Verschuere, et al., 2008). Consequently, respiration and heart rate were frequently shown to exhibit a similar pattern of modulation by experimental conditions that could be dissociated from electrodermal responses (e.g., regarding the susceptibility to countermeasures, Peth, et al., 2016, or the influence of deceptive denial, Ambach, Stark, Peper, & Vaitl, 2008b).

The validity of cardiovascular measures in the CIT has only been comprehensively analyzed for heart rate changes (Meijer et al., 2014). Across 37 experimental conditions with 1373 participants in total, validity estimates ($d = 0.89$, $AUC = 0.735$) were slightly lower than for respiratory measures but could still be considered as a large effect size based on the suggestions of Cohen (1988). Validity estimates for peripheral vasoconstriction (as calculated by the finger-pulse waveform length) varied between $AUC = 0.612$ (Ambach, Stark, & Vaitl, 2011) and $AUC = 0.902$ (Elaad & Ben-Shakhar, 2006) across studies but largely cluster around $AUC = 0.800$ (cf. Elaad, 2009; Elaad & Ben-Shakhar, 2008). Because peripheral vasoconstriction is similarly mediated by the sympathetic nervous system as are electrodermal responses, both measures are usually correlated (Vandenbosch et al., 2009), and it is thus currently unclear whether both variables assess different processes or can be used interchangeably to some degree.

In addition to the cardiovascular measures discussed earlier, some researchers suggested that other indices of cardiovascular activity could be suitable for differentiating deceptive from truthful responses or concealed information from neutral items in the CIT. Potential candidates are T-wave amplitudes as derived from an electrocardiogram that are modulated by sympathetic activity (Furedy, 1985; Rashba et al., 2002) or changes in heart rate variability that mainly capture vagal innervation of the heart (Berntson et al., 2007). Apart from potential problems in reliably quantifying such variables, it remains unclear whether they cover aspects of autonomic responding that are not sufficiently captured by the established measures of cardiovascular activity described previously.

Other Measures

In addition to techniques that are routinely used to measure aspects of information processing in the central nervous system (such as EEG or functional Magnetic Resonance Imaging [fMRI]), also other measures that are related to the activity of the autonomic nervous system might be used for detecting deception or concealed knowledge. However, it must be considered that the frequently used combination of electrodermal responses, respiratory suppression, and heart rate deceleration (Gamer, Verschuere, et al., 2008) already covers a broad range of changes in sympathetic and vagal activity. It thus remains unclear whether newly introduced measures can simply substitute other recordings or really provide new, incremental information that is not accounted for by traditional measures (Gamer, 2011). With respect to practicability and ease of measurement in field situations, two additional measures might be interesting: Changes in pupil diameter and facial temperature.

The pupil diameter is regulated by sympathetic as well as parasympathetic activity. The former system induces a dilation of the pupil, the latter system triggers pupil constriction. Few studies on the CIT demonstrated larger pupil dilation following the presentation of concealed items as compared to neutral details (Bradley & Janisse, 1981; Janisse & Bradley, 1980; Lubow & Fein, 1996; Seymour, Baker, & Gaunt, 2013). These effects occurred after an initial pupil constriction in response to the item onset and are thought to reflect mainly sympathetic activity. Interestingly, it has been shown that such delayed pupil dilation correlates tightly with electrodermal activity (Bradley, Miccoli, Escrig, & Lang, 2008). Thus, at least to some degree, pupil responses might be a useful alternative to skin conductance recordings in the CIT. It should be kept in mind, however, that pupil width is not only related to stimulus meaning but also highly dependent on visual stimulus characteristics (Barbur, Harlow, & Sahraie, 1992). Therefore, it seems indispensable to control physical stimulus properties such as brightness and contrast or to use auditory stimulus presentation while keeping lighting conditions in the examination room constant.

The second measure that might be interesting is facial temperature as obtained from thermographic techniques that allow for quantifying infrared emission from the human face. When head movements are small and when it can be made sure that the head is facing the thermographic camera during the recordings, covert measurements are possible. Previous studies showed that temperature of the periorbital region increased stronger following the presentation of relevant as compared to neutral CIT items (Park, Suk, Hwang, & Lee, 2013; Pavlidis, Eberhardt, & Levine, 2002; Pollina et al., 2006). This effect occurred early after stimulus presentation and allowed for a valid detection of concealed information. In an interview condition, it was additionally shown that facial temperature increased for deceptive as compared to truthful accounts (Warmelink et al., 2011) and a recent study demonstrated similar effects of deception within a card game (Panasiti et al., 2016). It should be noted, however, that different facial regions were used to quantify temperature changes across studies, and the latter study even demonstrated differential effects between cheek and nose regions. It is therefore unclear to what degree these findings are replicable and generalize to new studies. Regarding the physiological substantiation of the observed effects, it seems likely that such changes in facial temperature are primarily mediated by the sympathetic nervous system (Drummond & Lance, 1987), although modulations by muscle activity also seem possible. To what degree facial temperature changes following deception or information concealment are correlated to other autonomic measures is currently unknown.

In addition to the measures of autonomic nervous system activity discussed earlier, other measures might also be suitable and interesting in the field of forensic psychophysiology. However, given that sympathetic and parasympathetic activity can well be estimated based on a few indices, it seems unlikely that additional measures are substantially more valid than traditional ones or dramatically change the current perspective of how deception or information concealment recruits both branches of the autonomic nervous system. It is, however, possible that novel measures might have other advantages such as the possibility to record them from a distance without using sensors that need to be attached to the examinee. In principle, such applications might allow for unobtrusive recordings of autonomic responses that should be examined in more detail by future studies. Finally, autonomic measures have some general advantages for field application: They can be acquired with relative ease (regarding measurement requirements and feasibility), recorded signals have a high signal-to-noise ratio, and responses can be quantified reliably using established techniques.

COMBINING AUTONOMIC MEASURES

Recording several physiological measures, all indicative of the same question of interest, seems superior to recording one (even the best) single measure. The reasons for this are multifold:

First, examinees, as humans in general, differ in their physiological responsiveness (Hinz, Seibt, Hueber, & Schreinicke, 2000), which may strongly vary between cardiovascular, respiratory, and electrodermal measures. Beside differences in overall responsiveness in a measure, particularly the differential responses in this measure to crime-related versus crime-unrelated items, which are crucial in the CIT, may vary between individuals. Practically, if one examinee cannot be reliably classified as knowledgeable or innocent by means of phasic heart-rate changes, such classification might be possible on the basis of electrodermal responses. This pattern might be reversed in a different individual and, therefore, it would be promising to use the better measure for each examinee.

Second, although each of the measures is known as indicative of present versus absent knowledge, their validity may depend on different psychophysiological processes that are simultaneously active during the CIT. Hence, it is conceivable that collecting different measures helps to reduce estimation errors by covering more of these subprocesses than a single measure would cover. Consequently, an additional measure which is related to sub-processes not covered by the other measures can yield incremental information for detecting specific knowledge in the examinee, and consequently, for classifying the examinee as knowledgeable or not.

Third, during a CIT examination, each of the measures is susceptible to various influences that cannot be foreseen or even identified in the aftermath. For example, heart rate varies over the breathing cycle to an individually different degree, or deep breathes induce large electrodermal responses. Hence, capturing those confounding influences as completely as possible will help to improve the validity of the measure that is influenced. This holds for regular physiological correlations as well as for artifacts: If a skin conductance increase is, for example, induced by bodily movement or muscular exertion, this could be revealed by additionally, recording movements or muscular activity.

Fourth, capturing a particular physiological measure at a particular point in time is a unique event. The measured value will depend on many factors, of which some are coherent with the known test condition at that moment, and some others are not. The latter, commonly summarized as *random* influences, imply that, even under the same known test condition, response measures cannot be replicated perfectly. The resulting variation in a particular measure, captured repeatedly under the same test condition, is commonly called *error variance*. Measuring a greater number of events of the same type, for example by asking more questions in the CIT, will help to narrow confidence intervals: With increased number of observations, the standard estimation error of the mean is reduced, but this possibility is limited by the number of known crime-related items suitable for testing. Also, repeating the same question several times helps to reduce error variance; yet, the decay of physiological responses over time and over similar repetitions limits this benefit. Given a multichannel measurement, parts of the error variance will be common to all the measures, and some will not be. Capturing several measures will generally contribute to reducing the latter part of error variance and thus improve test accuracy.

Fifth, as a special feature of interrogation procedures or questioning techniques that are also used in field conditions, most guilty examinees will be motivated to cheat the test as well as they can. A series of possible countermeasures, effective to different degrees, are known (for a review, see Ben-Shakhar, 2011). The application of some of these countermeasures will be reflected in the recordings, or captured via additional recordings, and thus become detectable. As a specific type of countermeasure, humans are able to control each of the measures captured in a CIT, at least after suitable training. Examinees can concentrate on their breathing and adapt it to a self-chosen pattern, or they might have learned to increase their heart rate or to induce electrodermal responses by imposing cognitive load (e.g., by engaging in mental arithmetic) or eliciting emotional reactions (e.g., by remembering aversive episodes of their life). However, in case of a multichannel measurement, they will most probably fail to manipulate all recorded channels simultaneously in the desired direction.

To sum up, polygraphic recording is favorable over single-measure recording due to the incremental value of an additional measure over the preexisting ones. On the other hand, the responses from different physiological channels related to the same event (e.g., the presentation of a crime-related object) will always be intercorrelated to a certain degree, because some part of the quantified response is attributed to the specific type of event. Incremental value and intercorrelation can be regarded as complementary, because intercorrelation of measures reflects the fraction of information that can equally be obtained from each of the included measures, whereas the incremental information of a measure refers to the fraction of information that was added by this particular measure.

Based on the insight that values from the different measures in the CIT should be combined for improving test accuracy, specific procedures and algorithms were developed for such purpose. Powerful methods of combining channels were developed particularly under the applied perspective: How should the values from the individual physiological channels best be standardized and then combined to maximize classification accuracy? Bringing results from all channels onto a common scale and then averaging them would be one obvious possibility. Such "equal-weights" solution was in fact applied in a number of studies (e.g., Bradley, Malik, & Cullen, 2011; Elaad & Ben-Shakhar, 2008), but, according to the different validity with each single measure, it seems unlikely that this combination is optimal.

This implies the question of relative weights of the individual channels, which cannot be answered from a single case; yet, it was the matter of analytic laboratory studies that aimed to define outlasting relative weights (Gamer, Verschuere, et al., 2008). Although different analytic methods are conceivable, this approach used a binary logistic regression analysis, performed after standardizing physiological responses of each channel within each subject and then calculating the individual mean response difference to crime-related versus crime-unrelated objects. Individual weights were proposed in an initial study that was based on a limited number of participants ($N = 60$, Gamer et al., 2006) but then successfully applied in a number of subsequent studies (e.g., Gamer, Kosiol, & Vossel, 2010; Peth, Vossel, & Gamer, 2012). The classification function proved relatively stable across different data sets and experimental settings and yielded validity estimates exceeding the detection accuracy of individual data channels (Gamer, Verschuere, et al., 2008). Within the optimized classification function, slightly larger weights are assigned to electrodermal (i.e., skin conductance amplitudes) and respiratory measures (respiration line length) than to cardiac responses (mean heart-rate changes).

Besides verifying the values found as optimal weights in future studies, it might further be questioned whether the combination should be linear at all, or, for example, follow nonlinear dynamics or multivariate integration properties. Furthermore, the stability of weights found optimal in laboratory conditions needs to be studied with respect to their applicability in field situations.

The accuracy of the CIT is the main guideline for optimizing the test, and for assessing the value of specific test variants and modifications. According to the forensic scope of CIT development and research, the accuracy of individual subject classification is commonly preferred as a quality measure, rather than the statistical group effects of specific experimental treatments. Instead of subject classification, the ratio of correct versus incorrect identifications of crime-related objects can serve as an alternative measure of test quality. Such validity estimates might be especially relevant for recently proposed applications of a CIT variant aiming to identify currently unknown critical information (so-called Searching-CIT, Breska, Ben-Shakhar, & Gronau, 2012).

The classification of examinees as possessing or not possessing crime-related knowledge can be performed on the basis of a single measure or a combined measure. In both cases, an examinee's probability of belonging to the "guilty" group is estimated from the physiological values included. A classification rule, commonly a cutoff value, is then needed for classification. This point is critical and subjective because it implies assigning values to false "guilty" classifications relative to false "innocent" classifications. To avoid such issues, CIT studies commonly make use of ROC curves (see Bamber, 1975), which depict the proportion of hits (i.e., correct "guilty" classifications) as a function of the false positive rate (i.e., false "guilty" classifications) with the cutoff criterion continuously varied over the entire possible range. From the values underlying the ROC curve, classification statistics can be derived for specific cutoffs but more frequently, the area under the ROC curve is used as a validity estimate across all possible cutoff values. Consequently, a CIT study (with the aim to report test accuracy) has to include guilty participants as well as innocents, and the examiner has to be aware of the respective group assignment of each participant. This is a serious limitation for field applications of the CIT because each participant's guilt status has to be known in advance, and it makes laboratory CIT studies costlier by doubling the number of participants.

THEORETICAL ISSUES

It was mentioned in the first publication on the detection of concealed information (Lykken, 1959) that the new method was not meant to detect deception by a physiological pattern indicative of and specific to deception. Rather, it was the differential personal significance of objects the test should rely on. Correspondingly, theoretical explanations of this new method of detecting hidden information focused on the psychophysiological reaction that a newly presented object (be it a written answer alternative to a question, or a depicted, potentially crime-related object) usually elicits. This reaction, typically triggered by a change in the environment, was first mentioned by Pavlov (1927) and later elaborated on by Sokolov (1963); it is commonly referred to as the orienting reflex. It comprises a physiological response (e.g., a temporary increase in skin conductance), a behavioral response (typically facilitating perception from the source that triggered the orienting reflex), and a subjective event with its feelings and thoughts.

The strength of the physiological response, which was originally conceptualized as one-dimensionally varying in magnitude, is known to be determined by significance, novelty, and intensity of the triggering change in the environment. Referring to the CIT, the subjective significance of a newly presented stimulus is the most important determinant; stimulus novelty does play a role, but it is minor and tends to be in opposite direction because the known, crime-related items are less novel to the participant than the unknown, neutral items; finally, the intensity of the triggering stimulus is considered unimportant because it should not differ too much between CIT items.

Theoretical explanations of why and how the CIT works have long been restricted to the orienting reflex (Verschuere, Crombez, & Koster, 2004; Verschuere, Crombez, Koster, & Van Baelen, 2005). Most CIT findings could be sufficiently explained by this simple but fundamental psychophysiological phenomenon. Modifications of the CIT that led to changes in physiological responses were mostly interpreted as modifying the subjective significance of the crime-related item among unrelated stimuli of the same category (Furedy & Ben-Shakhar, 1991). There have always been alternative or additional explanations for the validity of the CIT (for an overview, see Verschuere & Ben-Shakhar, 2011). However, such explanations beyond the orienting response mostly played a minor role, or they explained either specific details or the effects of specific modifications of the CIT.

Electrodermal responses match the typical properties postulated for an orienting response, so that the response magnitude of the orienting reflex can be regarded as reflected in the electrodermal response magnitude (or amplitude). In contrast, the discussion of what decelerative heart-rate responses to recognized crime-related CIT details reflect has not been resolved so far (Barry & Maltzman, 1985; Gamer, Gödert, et al., 2008; Verschuere & Ben-Shakhar, 2011; Vossel & Zimmer, 1989).

Modifications of the classic, orienting-based explanatory model of CIT functioning were later introduced in two ways: First, the connection of the orienting response to physiological responding underwent a refinement, which included splitting the orienting response into subprocesses which were supposed to be differently reflected in physiological measures (Preliminary Process Theory; Barry, 1977, 1996). This modification became necessary due to the repeated observation of response fractionation (i.e., differential effects of an experimental treatment on different physiological measures), and due to other contradictions (e.g., small intercorrelations between measures, differential habituation profiles in different measures). In addition to the Preliminary Process Theory, embedding of the orienting response in defensive and appetitive motivational systems was introduced as another integrative perspective (Bradley, 2009).

Second, the assumption of processes in the CIT *additional* to the orienting response became more popular. Several approaches were made to disentangle mental subprocesses ongoing in a CIT and, thus, enrich CIT theory. Furedy et al. (1988) employed the so-called differentiation-of-deception paradigm to isolate physiological responses correlated to deception per se. Later studies aimed at separating an orienting component from processes associated with deception (Ambach et al., 2008b) or, more specifically, inhibition (Klein Selle et al., 2016, 2017). Another line of research investigated motivational and social influences on physiological responding in a CIT (Ambach, Assmann, Krieg, & Vaitl, 2012; Varga, Visu-Petra, Miclea, & Visu-Petra, 2015; Visu-Petra, Miclea, Bus, & Visu-Petra, 2012), which implies that motivation and social context were in question to influence physiological CIT responses in addition to orientation-based explanations. Summarizing the contribution of these studies to CIT theory, one major explanation remains orienting theory; particularly, electrodermal responses are maintained as indicators of orienting responses modified in amplitude by the two different item classes in the CIT. In addition, however, physiological responses in the CIT comprise correlates of specific mental processes associated with the particular task in a CIT, that is deception, or concealment of knowledge. These additional processes seem to have larger effect on cardiovascular and respiratory measures as compared to electrodermal responses. Among the discussed additional processes, the need to inhibit the predominant truthful answers as well as inhibiting one's revealing physiological responses seem to constitute important components.

APPLIED ISSUES

Almost all forensic applications in the broad field of psychophysiological detection of deception rely on autonomic measures. To some degree, this is related to early suggestions that it should be difficult to alter autonomic responses voluntarily, thus significantly complicating the use of countermeasures. It is estimated that lie detection techniques based on autonomic measures are used in more than 50 countries worldwide by law enforcement agencies (Lykken, 1998; Matte, 1996). The vast majority of applications use variants of the CQT. The only country worldwide that specifically focuses on CIT applications is Japan. Despite the widespread use of autonomic measures for the detection of deception or concealed information, field studies are rare and available reports often difficult to interpret because of flawed study designs. Specifically, confessions, which are most frequently used as the ground-truth criterion (i.e., whether an examinee is guilty or innocent), are contaminated by the test result (i.e., whether the examinee fails or passes the test) in basically all field studies on the CQT (e.g., Mangan, Armitage, & Adams, 2008) and the CIT (e.g., Elaad, 1990; Elaad et al., 1992). Under these circumstances, it has been demonstrated that perfect validity estimates can result from a test with chance-level accuracy (see Iacono, 2008, for an overview on these issues).

Based on these shortcomings, it seems essential to estimate whether laboratory studies can be generalized to field conditions. With respect to the CQT, the most problematic difference concerns emotional factors or specifically the threat of failing the examination. It has been demonstrated that this aspect significantly affects the specificity of the CQT (i.e., the hit rate among innocents), reducing it to chance-level accuracy in high-stakes situations (Patrick & Iacono, 1989). Because the CIT is based on detecting memory instead of deception or guilt, other differences between laboratory and field conditions might be more relevant. This mainly concerns all factors that impact the encoding and consolidation of memory. Specifically, it has been argued that high emotional arousal during the crime or a delay of the CIT by longer periods of time (e.g., months or even years) might result in severe memory impairments of guilty examinees (Honts, 2004). As a consequence, they might be incapable of remembering crime-related details and therefore pass the CIT examination because of lacking an autonomic differentiation of relevant and neutral CIT items. Although using experimental procedures (e.g., mock crimes) that resemble certain characteristics of field conditions, traditional CIT laboratory studies frequently optimized recognition of crime-related details by overlearning such information and using short periods between encoding and the CIT examination. Only recently, researchers began to use experimental designs that relied on incidental instead of explicit encoding (Carmel et al., 2003), which manipulated the stress level during the mock crime (Peth et al., 2012) or that delayed the CIT examination by several weeks (Gamer et al., 2010; Nahari & Ben-Shakhar, 2011). Collectively, these studies demonstrated that CIT validity is rather stable under these circumstances when relying on central aspects of the mock crime. Enhanced arousal was shown to facilitate instead of impede detection of concealed information. Based on these findings, one can speculate that laboratory studies on the CIT might better generalize to field conditions than CQT studies.

The main threats to CIT validity that have not yet been sufficiently resolved concern the leakage of relevant information to innocents and the susceptibility of the test to countermeasures. Because the test is relying on memory, also innocents who can recognize crime-related information should show enhanced autonomic responding to these items and correspondingly fail the test (Lykken, 1959). To reduce this problem, Bradley and colleagues proposed to use an active wording of CIT questions (e.g., "Which weapon *did you use* to kill the cashier?" instead of "Which weapon *was used* to kill the cashier?"). It was suggested that under these circumstances, innocents with crime-related knowledge could still answer truthfully even when identifying the critical information whereas guilty examinees have to answer deceptively. The group around Bradley published a number of studies substantiating this reasoning by showing significantly enhanced responding of guilty examinees as compared to informed innocents when active wording was used (Bradley et al., 1996; Bradley & Rettinger, 1992; Bradley & Warfield, 1984). Unfortunately, there are also several more recent studies that failed to replicate this pattern (Gamer, 2010; Gamer, Gödert, et al., 2008; Gamer et al., 2010; Nahari & Ben-Shakhar, 2011). The reasons for this discrepancy are still unclear. On the one hand, it has been shown that deception contributes to differential autonomic responding in the CIT (Ambach, Dummel, Lüer, & Vaitl, 2011; Ambach et al., 2008b). But on the other hand, it seems difficult to identify the source of memory when information was deeply memorized and when guilty as well as informed innocent examinees are highly motivated to pass the test (Gamer, 2010; Peth et al., 2015). Future research should aim at further identifying and disentangling factors that determine autonomic responsiveness in the CIT (e.g., memory strength, motivation, deception, attention) and refine analytic strategies to decode these aspects from the pattern of autonomic recordings.

With respect to the use of countermeasures, several studies have demonstrated that participants can use certain techniques to deliberately alter their pattern of autonomic responsiveness to appear innocent. This applies to CQT as well as to CIT examinations and does not require substantial training (for a review, see Ben-Shakhar, 2011). Although spontaneous and general state countermeasures (e.g., distracting attention from the test) do not seem effective, specific point countermeasures that are executed following specific test questions or items are more promising (Honts & Amato, 2002). With respect to the latter category, one can differentiate between physical (e.g., biting on the tongue, wiggling the toes) and mental countermeasures (e.g., recalling emotional memories, mental arithmetic). In general, physical countermeasures can be detected more easily (Honts, Raskin, & Kircher, 1987), but it is still unclear whether this applies to all possible categories of covert movements. Interestingly, countermeasures seem differentially effective for different autonomic measures. Although they severely reduce differential electrodermal responses, they seem less effective for respiratory and heart rate measures in the CIT (Ben-Shakhar & Dolev, 1996; Elaad & Ben-Shakhar, 2009; Honts, Devitt, Winbush, & Kircher, 1996). Therefore, a combination of different autonomic data channels reduced the impact of countermeasures on CIT validity (Peth et al., 2016). Although it seems impossible to prevent participants from using any countermeasure at all, several studies attempted to include a secondary task (Ambach, Stark, Peper, & Vaitl, 2008a; Ambach, Stark, et al., 2011) or modified the interrogation procedure (e.g., complex trial protocol, Rosenfeld, Hu, Labkovsky, Meixner, & Winograd, 2013) to make countermeasure use more difficult or less effective. Another interesting possibility might be a data-driven approach for detecting countermeasure usage from the pattern of physiological responding. Based on the assumption that natural-item salience based on recognition processes differs from artificial salience generated by countermeasure use, there might be subtle signs in autonomic responsiveness that reveal such differentiation. This would, however, require a large set of autonomic CIT data to detect such patterns and future studies on independent samples to ensure validity of these techniques using cross-classification approaches. Generally, one needs to be very careful in interpreting the detection of countermeasure use because also innocents might tend to use such techniques because of fearing a misclassification as guilty.

OUTLOOK

Although autonomic measures have been used for detecting deception or concealed information for more than a century, such applications are still timely and yield high validity estimates especially in CIT examinations. Still, a number of open questions remain that need to be addressed by further research (Ben-Shakhar, 2012). On the one hand, this applies to theoretical advancements regarding the physiological substantiation of different psychological processes that are involved in these interrogation methods. On the other hand, several applied issues regarding improvements in classification accuracy, resistance to or detection of countermeasures, as well as prerequisites for a successful test construction warrant further investigations in this domain.

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CHAPTER 2

Concealed Information Test: Theoretical Background

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INTRODUCTION

He who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may be cast.

Leonardo da Vinci (1452–1519)

The idea that physiological measures can be used to detect hidden (crime-related) memories has intrigued researchers around the globe since the last century. Memory detection, using the Concealed Information Test (CIT), relies on a simple multiple-choice questioning format. Specifically, each of the selected questions is followed by the serial presentation of one critical (concealed) and several control items. When the critical items consistently induce a pattern of differential responses, relative to the control items (i.e., the CIT effect), knowledge about the event (e.g., crime) is inferred. The initial studies inspiring this field of research examined the validity of the CIT using just a single physiological measure, namely, the skin conductance response (SCR; e.g., Ellson, Burke, Davis, & Saltzman, 1952; Geldreich, 1941, 1942; Lykken, 1959, 1960). Subsequent studies examined the validity of additional physiological measures, such as respiration and heart rate (HR) (e.g., Cutrow, Parks, Lucas, & Thomas, 1972; Thackray & Orne, 1968), and factors that affect their validity (e.g., the type of verbal responses: Ambach, Stark, Peper, & Vaitl, 2008; Horneman & O'Gorman, 1985; Kugelmass, Lieblich, & Bergman, 1967; drugs: Iacono, Boisvenu, & Fleming, 1984; Waid, Orne, Cook, & Orne, 1981). Moreover, attempts were made to shed light on the theoretical underpinnings of the CIT effect. This line of research carries a special importance as a theoretical foundation is an essential requirement of any scientifically based technique (Messick, 1995). A well-grounded theory allows us to determine the

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optimal conditions under which the technique will be most effective, as well as its limitations. Moreover, it provides knowledge about different factors that affect the outcomes of the test, which is especially important for the CIT as we generalize from experimental to real-life forensic settings. Finally, in the case of the CIT, a theory could also be informative regarding the most efficient physiological and behavioral measures.

In this chapter we shall review the various theoretical accounts of the CIT effect, focusing on the oldest and most often applied autonomic nervous system (ANS)-based CIT. Importantly, we will make a distinction between (1) several unitary approaches (that rely on a single underlying mechanism; e.g., the orienting response [OR]) and (2) a recently proposed response fractionation approach (that relies on multiple underlying mechanisms). We will also evaluate the quality and utility of current CIT theory using a number of explicit criteria: parsimony, precision, testability, and empirical validity. Finally, toward the end of this chapter we will touch upon the theoretical underpinnings of the more recently used central nervous system (CNS)- and behavioral-based CIT.

UNITARY APPROACHES

Over the last few decades, CIT theory has been characterized by a predominantly unitary focus. Specifically, each theory was built around a single underlying mechanism assumed to elicit enhanced responses to the critical CIT items in all the ANS measures applied in the CIT. The earliest theories focused primarily on emotional–motivational factors, such as punishment and emotional conflict, while the later theories focused on cognitive factors such as orientation and inhibition (see Ben-Shakhar & Furedy, 1990; Verschuere & Ben-Shakhar, 2011).

Emotional Theories

Three of the earliest unitary theories emphasized emotional factors and were formulated by Davis (1961): the conditioned response theory, the punishment theory, and the emotional conflict theory. The conditioned response theory holds that the critical items serve as conditioned stimuli, which induce fear and arousal, similar to the emotions typically experienced during crimes. The punishment theory, on the other hand, holds that the fear of punishment (i.e., consequences of failing the test) underlies the CIT effect; the emotional conflict theory states that the CIT effect reflects an emotional conflict between the prepotent truth response and the need to lie.[1] These theories are, however, not specific to the CIT and have never been fully elaborated. Moreover, the limited available research suggests that such emotional factors as stress, arousal, and fear of punishment have little to no effect on detection efficiency with the CIT (e.g., Bradley & Janisse, 1981; Elaad & Ben-Shakhar, 1989; Horneman & O'Gorman, 1985; klein Selle et al., 2017; Kugelmass & Lieblich, 1966; Kugelmass et al., 1967; Verschuere, Crombez, Smolders, & De Clercq, 2009). Hence, other processes are likely to lie at the core of this test.

Motivation-Impairment Theory

The motivation-impairment theory relates the CIT effect to the motivation to avoid detection. Specifically, the more motivated the examinees, the more likely they are to be detected. The role of motivation has been examined in numerous studies, using either a financial incentive or motivational instructions. In the first two of these studies (Gustafson & Orne, 1963, 1965) half of the participants were told that only people of superior intelligence could beat the polygraph test, thereby motivating them to avoid detection. The other half of the participants were told that only people with psychopathic tendencies could beat the test, thereby motivating them to be detected. While these and later studies have revealed mixed effects, Meijer, klein Selle, Elber, and Ben-Shakhar (2014) showed in their meta-analysis that the motivation to conceal increases SCR detection efficiency. Still, detection was also high under low motivational conditions ($d = 1.33$ as compared to $d = 1.66$ for the high motivation condition), implying that motivation is not a necessary condition for obtaining a CIT effect. Furthermore, the effect of motivation to avoid detection can be accounted for by other theories (see later).

Orienting Response Theory

You're at a crowded party where the music is loud, glasses are clinking, and different conversations fill up the room. Yet, amid this abundance of distracting stimuli, you can zero in on the one conversation you want to hear. Then, when someone mentions your name from across the room, you quickly turn your head and redirect your attention to that (more interesting) conversation. This phenomenon has been labeled the "cocktail

[1] Emotional conflict theory is related to arousal inhibition theory, which will be discussed later.

party effect" and illustrates the concept of the OR. Sokolov (1963, 1966) described the OR as a complex of behavioral and physiological reactions in response to any novel stimulus or a change in stimulation. Importantly, when a stimulus carries a special significance (e.g., one's own name) an enhanced OR occurs. It was quickly realized this quality of the OR could be used to identify "guilty examinees" (e.g., Lieblich, Kugelmass, & Ben-Shakhar, 1970; Lykken, 1974). In particular, Lykken (1974) argued that "…for the guilty subject only, the 'correct' alternative will have a special significance, an added 'signal value,' which will tend to produce a stronger orienting reflex than that subject will show to other alternatives (p. 728)." For the innocent examinees, the correct items do not possess such significance or signal value and thus all items are equivalent and evoke similar ORs.

OR theory has, up till now, been the most influential account of the CIT effect. The strongest (indirect) evidence for this theory relates to the observation that the critical CIT items elicit a pattern of enhanced responding that characterizes OR to significant stimuli: a larger SCR, a shorter respiration line length (RLL),[2] slower HR, and increased pupil dilation (Gamer, 2011). More direct evidence for this theory, however, was found only with the SCR. In this line of research, different features of the OR were examined. The most examined feature, habituation, refers to a gradual decline in responding with repeated stimulus presentation. In various CIT studies, response habituation has been shown for the SCR, but not for the RLL and HR (e.g., Ben-Shakhar & Elaad, 2002; Elaad & Ben-Shakhar, 1997; Gamer, Godert, Keth, Rill, & Vossel, 2008). Two less examined features are generalization (e.g., responding to stimuli presented in one modality generalizes to other modalities) and dishabituation (i.e., the recovery of a response that habituated). Generalization has been shown in one previous study, but again only for the SCR (Ben-Shakhar, Frost, Gati, & Kresh, 1996). Dishabituation, on the other hand, has not been observed in the CIT (Ben-Shakhar, Gati, Ben-Bassat, & Sniper, 2000). Ben-Shakhar et al. argued, however, that dishabituation has not always been demonstrated in OR research either (see Siddle & Lipp, 1997).

Another well-known feature of the OR is its sensitivity to stimulus significance. A stimulus is considered to be significant when it carries a special importance, relevance, or interest, whether positive or negative (see Bernstein, 1979; Dindo & Fowles, 2008). Although classical OR theory

[2] The RLL is a composite measure of both the depth and speed of respiration. Hence, a shorter RLL reflects a relatively slow and shallow respiration pattern.

does not explicitly state whether it views significance as a dichotomy (see the next section) or as a continuum (see "Feature-Matching Theory," later), a continuous view, in which stimuli differ in the degree of significance, is generally accepted. This implies that the higher the significance level of the critical CIT stimuli, the larger the OR, and consequently the larger the CIT effect. Indeed, a number of studies revealed larger responses for high significant stimuli compared to low significant stimuli; however, the majority of these studies observed such enhanced responses only with SCR, but not with RLL and HR measures (Baker, 2008; Barry, 1981; Ben-Shakhar & Gati, 1987; Coles & Duncan-Johnson, 1975; Feld, Specht, & Gamer, 2010; Greene, Dengerink, & Staples, 1974; Jokinen, Santtila, Ravaja, & Puttonen, 2006; klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2017; Stormark, 2004; Vico, Guerra, Robles, Vila, & Anllo-Vento, 2010). Similarly, klein Selle, Verschuere, Kindt, Meijer, Nahari et al. (2017; Experiment 2) found preliminary evidence that the use of emotional stimuli in the CIT (both critical and control) can increase detection efficiency, at least for the SCR (no effect was found for RLL or HR). The higher significance of the emotional stimuli might explain the larger CIT effect observed with the SCR. Indeed, the degree of significance or importance of a stimulus is not only determined by cognitive factors, but also by motivational and emotional factors. For example, the effects of motivation to avoid detection discussed earlier can be accounted for by OR theory because the critical CIT items are more significant for highly motivated examinees than for indifferent examinees. Still, the concept of significance is rather broad and vague. It is therefore not always clear whether (1) a stimulus is highly or only slightly significant, and (2) whether the significance level of a stimulus is sufficient to induce an enhanced OR. For example, although it may be predicted that the murder weapon is sufficiently significant to induce an enhanced OR, what about the victim's clothes? Even with perfect memory, it cannot be ascertained that such information will have sufficient significance.

Taken together, while the SCR seems to posses several important OR characteristics such as habituation, generalization, and sensitivity to stimulus significance, other response measures (RLL, HR) do not seem to follow the predicted OR characteristics.

Dichotomization Theory

The dichotomization theory, which is closely linked to OR theory, originated from the work of Lieblich et al. (1970) and was later extended by

Ben-Shakhar (1977, 1980). According to this approach, knowledgeable examinees dichotomize the stimulus set into two distinct categories—critical versus control—and ignore the differences between stimuli within each category. In terms of Sokolov's (1963) theoretical formulation, it is postulated that a single neuronal model is formed for each stimulus category. Ben-Shakhar et al. tested several predictions derived from the dichotomization approach using the SCR measure. First, as it was assumed that the differences within categories are ignored, similar SCR detection scores were predicted when a single control item is repeated and when several different control items are used. This prediction was tested and confirmed by Ben-Shakhar (1977). Second, as it was assumed that habituation generalizes within each category, with little to no carryover across categories, it was predicted that the more frequently presented category (typically the control category) will habituate faster. It was accordingly demonstrated that the responses to frequently presented critical stimuli habituate faster than the responses to rare control stimuli, demonstrating a negative detection (detection of the rare control stimuli) (Ben-Shakhar, 1977; Ben-Shakhar, Lieblich, & Kugelmass, 1975; Lieblich et al., 1970). Rare critical stimuli, however, induced larger responses than rare control stimuli. Hence, the theory was updated to include the effect of significance. Indeed, a subsequent study showed that relative significance may be a more potent factor in eliciting orienting than relative novelty (Ben-Shakhar, 1994). Third, the dichotomization theory predicts that differential responding depends on the serial position of the stimulus within its own, but not within the alternative category. Hence, when the CIT is based on a single critical item (and thus its serial position within its own category is always 1), similar responses should be observed throughout the test. Ben-Shakhar and Lieblich (1982), however, found larger SCRs with earlier presentations of the critical stimulus, which led to a revision of the dichotomization theory and the formulation of a feature-matching theory (see next).

Feature-Matching Theory

The feature-matching theory was intended to supplement OR theory by specifying the nature of the comparator (match/mismatch) mechanism proposed by Sokolov (1963). Specifically, it is posited that each incoming stimulus is compared with the representation of the critical stimulus and with the representations of recently presented stimuli by two feature-matching processes (Tversky, 1977). The degree of match/mismatch between the input and the critical stimulus determines the significance value of the input, and the degree of match/mismatch of the input with previously presented stimuli determines the novelty value of the input. The levels of novelty and significance are then integrated to determine the magnitude of the OR. One major advantage of this approach, compared to the dichotomization approach, is that stimulus significance and novelty are viewed as a continuum rather than a dichotomy. The feature-matching approach was also tested, and largely corroborated, in a series of studies conducted by Ben-Shakhar and Gati (e.g., Ben-Shakhar & Gati, 1987; Ben-Shakhar et al., 2000; Gati & Ben-Shakhar, 1990). All these studies, however, again relied only on the SCR measure. Furthermore, contrary to prediction, Ben-Shakhar and Gati (2003) found that the frequency of components common to the critical and control stimuli had no effect on OR magnitude to the critical stimulus. OR magnitude was affected only by the serial position of these components and consequently Ben-Shakhar and Gati (2003) suggested a revision of the feature-matching theory.

Arousal Inhibition Theory

The arousal inhibition theory holds that attempts at inhibition of physiological arousal underlie the CIT effect. Thinking of the situation of the knowledgeable examinee in a CIT, it is conceivable that the examinee not only recognizes (and orients to) the critical items, but in order to look innocent also attempts to inhibit the experienced physiological arousal. Attempts to inhibit arousal are, however, typically associated with increased rather than decreased physiological responses (Pennebaker & Chew, 1985). It is further noteworthy that attempts at arousal inhibition are likely to be accompanied by a conflicting emotional state (i.e., emotional conflict theory). This experienced conflict, however, may be reduced when participants remain silent and do not answer deceptively. Attempts at arousal inhibition, on the other hand, are expected to be high in both a deceptive and a silent condition.

The inhibition theory is immediately appealing as arousal inhibition characterizes individuals motivated to avoid detection. The theory is also indirectly supported by the emotional regulation literature, which has shown that attempts at arousal inhibition come with a physiological cost. Specifically, several studies revealed that inhibition of physiological arousal results in a response pattern that resembles the CIT effect (e.g., Dan-Glauser & Gross, 2011; for studies on experiential and expressive suppression see

Demaree et al., 2006; Gross & Levenson, 1993, 1997). A direct test of the inhibition theory was provided by Verschuere, Crombez, Koster, Van Bockstaele, and De Clercq (2007). These authors used a startle eye-blink paradigm in which startle probes were presented both during critical and control items. While OR theory predicted greater startle modulation (measured by eye-blink magnitude) to the critical pictures, inhibition theory predicted reduced startle modulation. The data supported an inhibition account and hence the authors ran two additional experiments in which participants either were or were not instructed to inhibit physiological responding. Only when instructed to inhibit, reduced startle modulation was observed.

Evaluation of the Unitary Approaches

Over the last few decades, a number of unitary theories have aimed to explain the differential responses to concealed information—each of these theories emphasized a single underlying mechanism. Some of the earlier unitary theories focused on emotional and motivational mechanisms, which were found to contribute to the CIT effect, but are not necessary for it to occur. Hence, other approaches emphasizing cognitive mechanisms, such as orienting and inhibition, were proposed and considered to be more likely candidates. The unitary nature of these theories, however, means that a single mechanism was proposed to explain the differential responding (to the critical stimuli) of all physiological measures (e.g., SCR, RLL, HR). This is rather surprising as most of the evidence for these theories (especially for OR and its related theories) was based entirely on the SCR measure.

RESPONSE FRACTIONATION APPROACH

The automatic generalization of findings with the SCR to other physiological measures seems to have been premature; a number of research findings revealed a divergence or even a fractionation between the different measures. First, while the SCR has been shown to habituate over the course of the CIT, both the RLL and HR are relatively resistant to habituation (e.g., Ben-Shakhar & Elaad, 2002; Elaad & Ben-Shakhar, 1997; Gamer, Godert, et al., 2008). Second, the different measures were found to correlate neither across participants (Gamer, Verschuere, Crombez, & Vossel, 2008) nor within participants across CIT questions (Gamer, Godert, et al., 2008). Third, a number of experimental manipulations were found to divergently affect the SCR and cardiorespiratory (RLL and HR) measures (e.g., overt deception: Ambach et al., 2008; interfering task: Ambach, Stark, & Vaitl, 2011; question repetition: Ben-Shakhar & Elaad, 2002). Ambach et al. (2011), for example, introduced a parallel n-back task during the CIT that was assumed to engage additional mental activity. While the parallel task enhanced the SCR CIT effect, it reduced the RLL and HR CIT effects. A similar fractionation was observed by Ben-Shakhar and Elaad (2002), who examined the effects of question repetition and variation. The authors found a monotonic relationship between the number of different questions used and the CIT effect with the SCR, but not with the RLL or HR. Importantly, the observed fractionation in these studies may be caused by either one or both of the following: (1) the RLL and HR measures may simply be more noisy and less sensitive measures than the SCR, or (2) the SCR and cardiorespiratory (RLL and HR) measures may be driven by different mechanisms.

The idea of physiological response fractionation is not new and a series of studies conducted by Barry et al., which refuted Sokolov's classical unitary OR, were largely ignored by the majority of the CIT community (for an exception see Ambach et al., 2011). To accommodate the results of various studies demonstrating response fractionation, Barry developed the preliminary process theory (PPT; i.e., Barry, 1996, 2006, 2009). This theory describes different processing stages that innervate the physiological measures separately, rather than in a unitary fashion. The initial processing stage, stimulus registration, is triggered by the presentation of a stimulus and functions on an all-or-none basis. It is the beginning of the sequential stimulus processing and is reflected by a deceleration of the HR (the first evoked cardiac response to the event). The output of this stage then triggers the parallel processing of stimulus novelty and intensity and while novelty processing is reflected by a respiratory pause, intensity processing is reflected in peripheral vasoconstriction (the peripheral pulse amplitude response). The interaction of stimulus novelty and intensity then generates the occurrence of a phasic OR, which is reflected by the SCR. All in all, this theory aims to provide a comprehensive framework for explaining the phenomenon of physiological response fractionation. When applying the PPT to the CIT, it may explain the differential respiration (the critical items are rare and in that sense also novel) and skin conductance (the critical items are significant) responses to the critical, concealed items. It fails to explain the differential HR responses to concealed information items, however. Specifically, as the PPT relates HR to the mere process of stimulus registration, all stimuli would be expected to induce a similar deceleration (Ben-Shakhar, Gamer, Iacono, Meijer, & Verschuere, 2015). Consequently, there was a need for another response fractionation model that would better account for the CIT effect.

Response Fractionation Theory

As there is much evidence for the orienting account of the CIT effect based on SCR, but not on the other measures, the question of which previously discussed mechanisms may underlie the RLL and HR measures remains. One likely candidate is arousal inhibition. Indeed, both the respiratory suppression and deceleration of the HR typically observed in the CIT have also been observed in several emotional response inhibition studies (e.g., Dan-Glauser & Gross, 2011; Demaree et al., 2006; Gross & Levenson, 1993, 1997). Moreover, the prolonged deceleration of the HR (up to 15 s) induced by concealed information items seems to fit with intentional attempts to inhibit responding, attempts that persist until another item is presented.

Several studies examined the roles of orienting and inhibition in the CIT. Most of these studies, however, targeted the response inhibition factor (i.e., inhibition of the behavioral component), not the arousal inhibition factor (i.e., inhibition of the physiological component; e.g., Ambach et al., 2008; Elaad & Ben-Shakhar, 1989; Furedy & Ben-Shakhar, 1991; Horneman & O'Gorman, 1985; Kugelmass et al., 1967; Suchotzki, Verschuere, Peth, Crombez, & Gamer, 2015). Ambach et al. (2008), for example, examined the effects of response inhibition by requiring their participants to answer either deceptively or truthfully 4 s after item presentation (see also Verschuere et al., 2009). The deceptive and truthful responses were given both by pressing one of two response keys and by means of a vocal *yes* or *no* response. This overt response manipulation had a rather drastic effect on the outcomes of the CIT: while the SCR CIT effect was similar in the deceptive and truthful conditions, the RLL and HR CIT effects disappeared in the truthful condition. Similarly, Suchotzki et al. (2015) tried to disentangle orienting and response inhibition by instructing participants to deny knowledge of one crime and admit knowledge of a second crime. Although overt deception was not necessary for the SCR, it was crucial for finding a CIT effect with both reaction time (RT) and fMRI measures. Suchotzki et al. (2015) subsequently reasoned that overt deception was needed for these measures as it increases the need for inhibition. Importantly, however, the differential response (yes vs. no) in the two conditions may have acted as a confound and influenced the physiological responses (a critique that also holds for Ambach et al., 2008). Consequently, it cannot be stated with certainty which mechanism caused the differential findings (e.g., inhibition, overt deception, answer-related processes).

Several other studies aimed to manipulate arousal inhibition rather than response inhibition. An initial attempt was made by Gustafson and Orne (1965), who compared the commonly used deceive condition, in which participants were motivated to avoid detection, with an additional detected condition, in which participants were motivated to be detected. Participants were also given feedback about their performance in the first CIT trial (succeeded vs. not succeeded) before continuing on to the second trial. The results revealed no main effect of motivational state, but an interaction between motivational state and feedback. Specifically, when feedback was compatible with participants' motivational state (e.g., detected by the machine when motivated to be detected), participants were detected significantly less with the electrodermal measure on the second trial, as compared to when feedback was incompatible with their motivational state. It is, however, unclear whether this feedback effect was moderated by inhibition. Two later studies (Horvath, 1978, 1979), which relied on a card-test paradigm, used similar motivational instructions and also found little support for the role of inhibition. Specifically, Horvath (1979) motivated half of its participants to have their card detected and the other half to avoid detection of their card. Although SCR detection efficiency was higher for examinees trying to be detected, it was highly similar to that of a nonmotivated group in Horvath (1978), which suggests that SCR detection efficiency is not contingent on the need for inhibition. Several decades later, Matsuda, Nittono, and Ogawa (2013) manipulated the arousal inhibition factor by using a disclosure manipulation. Specifically, participants witnessed how one of their stolen (i.e., critical) items was disclosed to the experimenter. Importantly, this disclosure was reasoned to remove the need to inhibit experienced arousal during the CIT. Still, as all participants were tested on stolen mock-crime items, it may be argued that not all attempts at arousal inhibition were successfully eliminated. While the results revealed no effect on the SCR and HR measures, the RLL CIT effect disappeared when tested on previously disclosed items. Two more recent studies (Elaad, 2013; Zvi, Nachson, & Elaad, 2012) manipulated guilty and informed innocent participants' state of mind (coping or cooperative). The coping instructions were reasoned to increase a defensive motivation and attempts at arousal inhibition. Importantly, however, as all participants were motivated to prove their innocence, also participants in the cooperative condition might have attempted to inhibit their responses. While the state of mind had no influence on the RLL, larger SCRs were observed when participants tried to cope with the CIT. Taken together, the results of the previously discussed studies were inconsistent. Importantly, it is unclear whether all attempts at arousal inhibition were eliminated and whether the size of the OR was unaffected. Consequently, it cannot be concluded with certainty which of the mechanisms caused the differential findings.

In an attempt to overcome these potential weaknesses, klein Selle, Verschuere, Kindt, Meijer, and Ben-Shakhar (2016) manipulated the arousal inhibition factor by contrasting the motivation to conceal with the motivation to reveal. These contrasting motivational states were induced using a suspect versus a witness role-playing scenario. Specifically, participants were either assigned the role of a suspect and motivated to *avoid detection* by *concealing* the crime-related information (as in typical CIT studies), or assigned the role of a witness and motivated to *be detected* by *revealing* the crime-related information. Importantly, as the enhanced arousal elicited by the concealed critical items was expected to be threatening to suspects, but not to witnesses, only suspects should inhibit responses. On the other hand, as the significance of the critical items was expected to be equal in the two conditions, suspects and witnesses should show a similar OR to these items. The results confirmed the authors' prediction by showing a similar increase in the SCR (elicited by the critical stimuli) in the two conditions. The RLL and HR, on the other hand, suppressed only in the suspect condition suggesting that these measures are driven by arousal inhibition.

In a follow-up study, klein Selle, Verschuere, Kindt, Meijer et al. (2017) extended their earlier work to the autobiographical version of the CIT. Thus, instead of relying on mock-crime—related items, they relied on personally related items. The motivational manipulation, however, remained the same: while half of the participants were motivated to *conceal* their personal items, the other half were motivated to *reveal* their personal items. Further, in order to allow for a more definite conclusion regarding the roles of orienting and inhibition, item significance was manipulated by including both high and low salient personal items. Corroborating the earlier findings, the SCR increased similarly, in both motivational conditions, while the RLL and HR suppressed only when motivated to conceal. Moreover, while the SCR was sensitive to item-salience (as predicted from OR theory), the RLL and HR were not. The results of these two studies led the authors to formulate a response fractionation model that holds that, in the CIT, the SCR is driven by orienting, while the RLL and HR are driven by arousal inhibition.

Evaluation of the Response Fractionation Theory

The previously presented response fractionation model can explain why several previous studies found divergent effects of their manipulations on the SCR and cardiorespiratory (RLL and HR) measures (e.g., Ambach et al., 2011; Ben-Shakhar & Elaad, 2002). It can further explain why the correlations between the different response measures are low (Gamer, Godert, et al., 2008; Gamer, Verschuere, et al., 2008). The response fractionation model can also account for a number of more specific findings. First, as the model suggests that only the SCR reflects an OR (which is known to habituate), it can explain why this measure is more sensitive to habituation than the RLL and HR (e.g., Ben-Shakhar & Elaad, 2002; Elaad & Ben-Shakhar, 1997; Gamer, Godert, et al., 2008). Second, as the model suggests that the HR reflects inhibition, it can explain why the typically observed deceleration may last for 15 s rather than only 5 s as predicted by orienting theory (Richards & Casey, 1992). Finally, it may explain why the RLL and HR measures are more resistant to countermeasures than the SCR (Ben-Shakhar & Dolev, 1996; Honts, Devitt, Winbush, & Kircher, 1996; Peth, Suchotzki & Gamer, 2016). Countermeasures are deliberate attempts to distort the physiological responses and are most effective when examinees aim to enhance responses to the neutral control items. This can be accomplished either by physical means (e.g., biting the tongue, wiggling the toes) or by mental means (e.g., recalling sad events, exercising mental arithmetic). Importantly, these methods may increase the saliency of the control items and also increase the size of the OR to these items (as reflected by the SCR). Consequently, SCR differentiation may decrease. Attempts at arousal inhibition (when viewing the critical items), on the other hand, are unlikely to be affected (as reflected by the RLL and HR). Taken together, the response fractionation model can explain a number of old findings, even those that previously seemed contradictory. This ability is a key feature of a good theory and is a testimony to its generalizability.

When digging into the CIT literature, we find that there are also a number of previous findings that cannot be readily explained by our model. For example, Zaitsu (2016) found the CIT effect with the RLL, but not with the SCR and HR, to be stronger in the field than in the laboratory. Similarly, the inhibition manipulation applied by Matsuda et al. (2013) affected the RLL, but not the SCR and HR. This particular fractionation of responses points to the possibility that the RLL and HR are driven by different processes, while our model assumes that they are driven by the same mechanism. Alternatively, the RLL-HR dissociation may also reflect measurement error. Moreover, it bears mentioning that the artificial nature of the laboratory studies may not have revealed the mechanisms underlying physiological responding in real-life CIT examinations. Suzuki, Nakayama, and Furedy (2004), for example, noted that respiratory apnea occurs rarely in the lab, but frequently in the field and may reflect an emotional factor. Hence, there may be other yet-to-be-identified factors that play a role in forensic applications of the CIT.

At the beginning of this chapter we mentioned several explicit criteria that can be used to evaluate the quality and utility of current CIT theory: parsimony, precision, testability, and empirical validity. First, parsimony: The criterion of parsimony is one of simplicity and stems from the work of the English philosopher and theologian William of Occam (1284–1347). In short, it states that a simpler or more parsimonious theory is preferred over a complex one. Theories gain power when they can explain much data with a few constructs. Second, a good theory should be precise, especially in psychology. Specifically, its constructs should be explicitly and clearly defined, making the theory understandable and free from ambiguities. If different researchers can't agree about its predictions, the theory is useless because it cannot be evaluated. Third, a good theory should be testable. If a theory cannot be tested, it can't be confirmed or refuted. Finally, a good theory should fit the empirical data it aims to explain. When applying these criteria to the response fractionation theory of the CIT, it seems that while it is less parsimonious than the unitary theories, the criterion of parsimony is nevertheless largely satisfied. Indeed, the theory describes only two underlying mechanisms and includes no unnecessary constructs that are not a vital part of the theory. The theory may become more complex, however, when future research will also try to uncover the mechanisms underlying other types of physiological or behavioral measures and/or some of the currently unexplained research findings (Matsuda et al., 2013; Zaitsu, 2016). Similarly, also the criterion of testability seems to be satisfied. Indeed, the two studies by klein Selle et al. (2016) and klein Selle, Verschuere, Kindt, Meijer et al. (2017) successfully tested two differing predictions. Moreover, several other predictions that can be generated from the theory could be easily tested in future studies (see the next section). The criterion of precision, on the other hand, seems only partly satisfied. Specifically, although the orienting and arousal inhibition factors are clearly defined, the concept of significance remains somewhat ambiguous (see earlier), context-dependent, and requires a more precise definition. Finally, the criterion of empirical validity seems to be only partly satisfied. As discussed earlier, although the response fractional model can explain a wide variety of previous findings, several findings are inconsistent with the theory. Taken together, the CIT fractionation theory is strong in the sense of being parsimonious, and testable. At the same time, more empirical validation is needed and some of its concepts can be formulated with more precision.

FUTURE DIRECTIONS

More studies are needed to verify the response fractionation theory. This future line of research could take several directions. First, the results found in the klein Selle et al. (2016) and klein Selle, Verschuere, Kindt, Meijer et al. (2017) studies should be replicated in other laboratories. Second, different manipulations of arousal inhibition, or orienting, should be tested. Third, other predictions derived from the theory should be experimentally investigated. For example, if the RLL and HR measures reflect attempts at arousal inhibition, they could possibly also be sensitive to manipulations of response inhibition (e.g., a deceptive verbal response; see Verschuere et al., 2009). Similarly, detection efficiency using these measures would be expected to be enhanced for individuals with poor inhibitory skills—poor skills will lead to greater efforts to inhibit and enhanced responses. Future studies could test this by identifying such individuals using a preliminary screening test (see also Matsuda, Ogawa, Tsuneoka, & Verschuere, 2015; Noordraven & Verschuere, 2013).

Furthermore, as research progresses, the response fractionation model is expected to expand and include other measures and their mechanisms. This development is crucial as recent CIT studies have not relied only on ANS measures, but also on CNS and behavioral measures (see the Introduction). An increasingly popular measure is the P300 component of the event-related potential (ERP). Although the P300, like the OR, is affected by stimulus novelty and significance (Donchin, 1981; Kubo & Nittono, 2009), its amplitude has also been shown to be sensitive to inhibition (Polich, 2007). These findings are supported by Rosenfeld, Ozsan, and Ward (2017) who replicated klein Selle et al. (2016) with ERP measures. Their results indicated that both orienting and inhibition contribute to the P300 CIT effect. Specifically, while orienting only (in the witness condition) was sufficient to induce enlarged P300s to the critical compared to the control items, the critical-control difference was larger when both orienting and inhibition played a role (in the suspect condition). In contrast to klein Selle et al. (2016), however, Rosenfeld et al. (2017) had participants watch a video of the crime in addition to reading a fake newspaper article. Hence, the authors argue that their results may also be explained by differences in item processing caused by the video. Another recently used measure that is both cheap and easy to implement is RT. No sensors or electrodes need to be attached—all that is needed is a computer with software that can record RT. The underlying mechanisms of the RT-CIT, however, remain to be explored; while research suggests a pivotal role of response inhibition (Seymour & Schumacher, 2009; Verschuere & De Houwer, 2011), the orienting factor hasn't been properly investigated (but see Suchotzki et al., 2015).

Although RTs are easily obtained, examinees are aware that their responses are being recorded and this awareness may induce attempts at countermeasures. Hence, there seems to be a need for measures that can be obtained covertly. Covert respiration measures were already successfully applied by Elaad and Ben-Shakhar (2009). These authors used hidden respiratory transducers in the seat and the back support of the examination chair. Likewise, eye-tracking technology may be used to covertly detect concealed knowledge. Peth, Kim, and Gamer (2013) already suggested that while eye fixations may be more related to an initial OR, eye blinks might reflect processes related to inhibition. Support for the latter claim was provided by a second study of Peth et al. (2016). These authors found that mental countermeasures, which require cognitive effort and inhibition, lead to a similar degree of blinking suppression as the presentation of critical, crime-related details. It should be noted, however, that the available CIT studies examining eye movements are scarce and the validity estimates are only weak to moderate (see also Schwedes & Wentura, 2012, 2016).

More promising validity estimates were obtained using a novel CIT paradigm that combines both simultaneous and serial presentation of the stimuli (see Lancry, Nahari, Ben-Shakhar, & Pertzov, 2017). Interestingly, these authors found an initial attraction of eye gaze (which may reflect orienting) to the critical items followed by a strong repulsion of eye gaze (which may reflect inhibition). Taken together, the research on the underlying mechanisms of several CNS and behavioral measures is scarce. Hence, future studies are needed to clarify which mechanisms increase the P300, delay the RT, and direct our eyes to the concealed items.

SUMMARY AND CONCLUSIONS

A scientific test is much stronger with a solid theory at its base. In the present chapter, therefore, we reviewed the different accounts of the CIT and covered the theoretical development over time. Although many studies supported the orienting-based theories, most of them were based solely on the SCR measure. Moreover, several research findings revealed a divergence between the various response measures. This led to the idea of physiological response fractionation. Based on the results of two studies, klein Selle et al. (2016) and klein Selle, Verschuere, Kindt, Meijer et al. (2017) accordingly presented a response fractionation model in which the SCR is assumed to reflect an OR and the RLL and HR measures are assumed to reflect attempts at arousal inhibition.

Still, future research is needed to verify and expand current CIT theory—to test differing predictions, to determine the mechanisms underlying other physiological and behavioral measures, and to examine whether the theory holds under real-life circumstances. A strong theory will not only benefit CIT researchers and practitioners, but (hopefully) may also encourage a wider use of the test.

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CHAPTER 3

The External Validity of Studies Examining the Detection of Concealed Knowledge Using the Concealed Information Test

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INTRODUCTION

Several psychophysiological methods for the detection of deception and concealed knowledge (popularly labeled polygraph techniques) have been developed since the beginning of the 20th century. In recent years and especially since the September 11th terror attack in the United States, the study of psychophysiological detection of deception has attracted a great deal of interest among researchers as well as practitioners, and has become an important area of applied psychology (e.g., Ben-Shakhar & Furedy, 1990; Lykken, 1998; National Research Council, 2003; Raskin, 1989; Reid & Inbau, 1977; Verschuere, Ben-Shakhar, & Meijer, 2011).

The most promising method of psychophysiological detection, traditionally labeled the Guilty Knowledge Test (see Lykken, 1959, 1960), but more recently referred to as the Concealed Information Test (CIT), is designed to detect concealed knowledge (for a review of recent CIT research, see Ben-Shakhar, 2012; Rosenfeld, Ben-Shakhar, & Ganis, 2012; Verschuere et al., 2011). The CIT utilizes a series of multiple-choice questions, each having one relevant alternative, also labeled as the probe (e.g., a feature of the crime under investigation), and several neutral (control) alternatives chosen so that an innocent suspect would not be able to discriminate them from the probe (Lykken, 1998). The relevant alternatives are significant only for knowledgeable (guilty) individuals and there is ample evidence, mostly from psychophysiological research on orienting responses (ORs), indicating that significant stimuli elicit enhanced ORs

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(e.g., Gati & Ben-Shakhar, 1990; Siddle, 1991; Sokolov, 1963, but see also Klein-Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2016, 2017). Thus, if the suspect's physiological responses to the relevant alternative are consistently larger than to the neutral (or irrelevant) alternatives, knowledge about the event (e.g., crime) is inferred. As long as information about the event has not leaked out to innocent suspects, the probability that an innocent suspect would produce consistently stronger responses to the relevant than to the neutral alternatives depends only on the number of questions and the number of alternative answers per question, and hence it can be controlled such that maximal protection for the innocent is provided. Clearly the detection of concealed information does not necessarily imply that the suspect is guilty, as other explanations may be offered for the possession of guilty knowledge (e.g., witnessing the crime). Thus, deception or guilt can be inferred only indirectly and such conclusions require additional investigation and evidence.

The criterion validity of the CIT has been confirmed by a large number of studies conducted since the early 1960s. The results of these studies have been analyzed and described in three meta-analyses (Ben-Shakhar & Elaad, 2003; MacLaren, 2001; Meijer, Klein Selle, Elber, & Ben-Shakhar, 2014). The more recent meta-analysis (Meijer et al., 2014) covered 100 laboratory studies, which used two versions of the CIT (either for detecting personal information, or mock-crime details) and utilized three autonomic nervous system (ANS) measures (skin conductance response, SCR; respiration line length, RLL; and heart rate, HR) as well as the P300 component of the event-related potential (ERP). The reported overall averages of Cohen's *d* effect size (Cohen, 1992), reflecting the differentiation between knowledgeable and unknowledgeable examinees, were 1.55, 1.11, 0.89, and 1.89 for these four measures, respectively.

However, despite these impressive validity estimates, several studies have raised concerns regarding the external validity of this research (e.g., Ben-Shakhar, 2012; Meijer, Verschuere, Gamer, Merckelbach, & Ben-Shakhar, 2016). Specifically, the bulk of CIT studies were conducted in artificial laboratory settings where volunteering participants (in most cases, college students) were requested to commit a mock crime, with no consequences for their well-being. Clearly, the best approach would be to examine the validity of the CIT as practiced with real suspects. However, it is extremely difficult to design and execute methodologically sound field studies in this area. Specifically, a ground truth criterion is typically unavailable and the use of confessions is problematic for various reasons, but primarily because confessions may depend on the test's outcomes. For example, Iacono (1991) demonstrated that when using confessions elicited after a failed polygraph test as a measure of ground truth, even a chance level accurate procedure may yield near perfect accuracy rates (see also, Iacono & Lykken, 2002; Patrick & Iacono, 1991). In addition, criminal investigators are typically exposed to a great deal of prior information about the suspects and the cases under investigation, which may introduce a confirmation bias and may affect the manner by which they conduct the test and interpret its outcomes (e.g., Ben-Shakhar, Bar-Hillel, & Lieblich, 1986).

Recently, Zaitsu (2016) used a different approach and examined the external validity of CIT studies by comparing detection efficiency, based on respiration, electrodermal rate, and HR, of card tests administered in a laboratory experiment and during realistic police investigations. The results indicated that while respiration suppression was larger in the field, no differences were found for the other two measures. The author concluded that his results indicate that CIT laboratory experiments have adequate external validity and can be generalized to the field. However, while this result is encouraging, it leaves room for doubt because card test questions differ drastically from CIT questions about crime details; consequently this comparison does not capture many of the important factors differentiating experiments and realistic investigations. We shall elaborate on these factors next.

An alternative solution to the problem of external validity is to examine the various factors differentiating between the typical laboratory experiment settings and the realistic forensic settings and to manipulate these factors in controlled experiments. This approach has been recently adopted by several researchers, allowing evaluation of whether and to what extent each factor affects the test's outcomes. It should be noted, however, that replicating real-life conditions in the laboratory is very difficult for various reasons, including ethical considerations.

Factors differentiating between laboratory experimental settings and realistic forensic investigations are discussed next.

Leakage of Critical Concealed Information Test Items

Implementation of the CIT depends on a successful concealment of the critical items. Whereas in mock-crime studies concealment is perfectly guaranteed, in real life this is not necessarily the case, and critical items may leak to innocent suspects, either through the media or during the course of police interrogations. Clearly, leakage of critical items to innocent suspects may introduce unacceptable rates of false-positive outcomes.

Several studies examined the effect of information leakage on the detection efficiency of the CIT and on false-positive outcomes. Most of these studies were conducted by Bradley et al. (Bradley, MacLaren, & Carle, 1996; Bradley & Rettinger, 1992; Bradley & Warfield, 1984; see Bradley, Barefoot, & Arsenault, 2011 for a review of the leakage literature). Generally, these studies demonstrated that although informed innocent participants show larger relative responses to the critical items, as compared with uninformed innocents, they could be differentiated from guilty participants. However, more recent studies (Gamer, Kosiol, & Vossel, 2010; Nahari & Ben-Shakhar, 2011) demonstrated that while informed innocents were not differentiated from guilty participants when the CIT was administered immediately after the mock crime, when the test was delayed (as is usually the case in realistic criminal investigations), they showed smaller differential responses to the critical items, as compared with guilty participants. This was mediated in both studies by the fact that informed innocents forgot critical items more than guilty participants.

Several attempts to reduce the damaging effects of information leakage (in addition to improving police practices) were examined by some researchers. Bradley and Warfield (1984) proposed a modified version of the CIT, labeled the Guilty Action Test (GAT), in which the formulation of the questions emphasizes actions rather than knowledge (e.g., "Did you kill Mr. X with a gun? Knife?..." rather than "Was Mr. X killed with a gun? Knife?..."). Under the GAT, guilty suspects are deceptive when giving negative answers to these questions, whereas informed innocents are telling the truth. Bradley et al. (1996) directly compared the CIT and the GAT and showed that the GAT significantly reduced the false-positive rates, although these rates were still very high (50%). On the other hand, a more recent study by Gamer (2010) failed to find any differences between the two test formats: In both formats informed innocents were undifferentiated from guilty participants when the test was administered immediately after the crime.

Previewing the CIT questions has also been offered as a means to prevent the usage of items that might have leaked. Presenting the CIT questions prior to the test may provide examinees with an opportunity to explain that they are familiar with certain items (e.g., they were mentioned in prior interrogations). Verschuere and Crombez (2008) demonstrated that previewing CIT items does not reduce the test's validity. Ben-Shakhar, Gronau, and Elaad (1999) used target items to which participants had to respond in addition to the critical and control items. Under this procedure, the rate of false-positive outcomes among informed innocents was somewhat reduced. If additional research shows that this result is robust, future applications of the CIT with ANS measures should adopt the protocol that has been used in all CIT studies using ERP measures (e.g., Rosenfeld et al., 2012) and should include target items.

Perceiving and Memorizing Crime-Related Items

Any attempt to implement the CIT as an aid in forensic investigations requires an identification of a sufficient number of salient crime-related features. It is essential that these crime-related items will be perceived by the culprits, stored in memory, and retrieved when the CIT is administered. In typical CIT experiments we try to guarantee that all participants encode all critical items, and in most cases, their memory of these items is tested before the CIT. However, in reality it is impossible to know whether the culprits paid attention to the crime-related items and whether they remember them when the CIT is administered, usually after a long time delay.

Recently, a few studies used more realistic mock crimes and examined the effects of memory for the critical items on the CIT's outcomes. Carmel, Dayan, Raveh, Naveh, and Ben-Shakhar (2003) were the first to compare the standard mock crime typically employed in many CIT experiments with a more realistic mock crime. In the standard mock-crime condition, all the relevant details were specified in advance and after completion of the mock crime participants were asked to name all the relevant details. If they had trouble remembering any of the details, the experimenter reminded them. Participants in the realistic mock-crime condition were told that they should steal a CD-ROM from a certain office, but none of the other details were mentioned. Furthermore, they were told that they could stay in that office for no longer than 5 min, after which the teaching assistant would return to his office. In addition, half of the participants in each condition were tested immediately, while the others took the CIT a week later. The results indicated that the realistic mock-crime condition was associated with weaker detection efficiency than the standard condition. This difference can be accounted for by the lower recall rate observed in the realistic condition. However, these effects were influenced by the type of CIT questions used. The authors made a distinction between central items directly related to the crime (e.g., the stolen item) and peripheral items (e.g., a picture on the crime scene's wall). When the detection score was based only on the central items the differences between the two types of mock crime were no longer statistically significant. Specifically, neither detection efficiency nor memory was affected by the time delay.

Subsequent studies examining these issues used more realistic versions of the mock crime paradigm and examined the effects of delaying the CIT. Gamer et al. (2010) used the GAT and administered the test either immediately after the mock crime or 2 weeks later. In addition to the guilty and innocent conditions, they included an informed innocent condition where the crime details were revealed to the participants via a newspaper report. The results revealed that detection efficiency of the guilty participants, based on a combination of SCR, RLL, and HR, was unaffected by the time delay, but the differential responses of the informed innocents significantly declined when the test was delayed. Memory of the critical items was affected by the time delay; whereas guilty participants forgot mainly peripheral items, the informed innocents tended to forget both item types. Similar results were reported by Nahari and Ben-Shakhar (2011). Specifically, detection efficiency declined in the delayed condition but mainly for peripheral details, and although no distinction between guilty and informed innocents was possible in the immediate CIT, some distinction emerged in the delayed condition.

Several straightforward conclusions can be drawn from these findings. First, as the decline in detection efficiency was observed mostly with peripheral items, it is recommended that any application of the CIT should be based only on central items. This of course may limit the number of items that can be used in some situations, but in those cases questions should be repeated several times. Although the use of multiple items is preferable, two studies (Elaad & Ben-Shakhar, 1997; Ben-Shakhar & Elaad, 2002) demonstrated that many repetitions of a few questions can compensate for lack of multiple questions. Second, while leakage of critical information should be avoided, it seems that the damage of leakage is not severe when the test is delayed and clearly in practice criminal investigations are never conducted immediately after a crime was committed. Third, to increase external validity, future CIT studies should adopt the more realistic version of the mock crime paradigm and include a delayed test. It would be important to include much longer delays than a week or two, because longer delays are more characteristic of the real-life settings.

The Effect of Emotional Arousal on the Outcomes of the Concealed Information Test

Another important difference between the typical experimental setup and realistic criminal investigations is the level of stress experienced by the examinees. However, there are several indications that this factor does not threaten the external validity of CIT experiments. First, two studies (Bradley & Janisse, 1981; Kugelmass & Lieblich, 1966) manipulated the level of stress experienced by examinees while taking the CIT and included levels that seem to resemble realistic situations. Kugelmass and Lieblich (1966) tested Israeli policemen who participated in a police training course. In the high arousal condition, participants were told that chances for promotion were dependent on passing the test. Bradley and Janisse (1981) manipulated the threat of punishment by informing subjects that they would receive a painful but not permanently damaging electric shock if found guilty. Both studies demonstrated that the level of stress had no effect on the outcomes of the CIT. It was concluded that "within a considerable range of stress no necessary decrease in the detection efficiency of the GSR channel need be expected" (Kugelmass & Lieblich, 1966, p. 215). Thus, these two studies suggest that detection efficiency estimated in laboratory experiments can be generalized to situations characterized by much higher levels of motivation and stress.

Second, a more recent study (Peth, Vossel, & Gamer, 2012) manipulated the level of stress during mock-crime execution. Specifically, in the experimental condition a confederate entered the room while subjects committed the mock crime. This manipulation did not affect the relative responses to the critical CIT items with electrodermal, respiration, and cardiovascular measures. Furthermore, the data revealed that under the high arousal level, detection efficiency based on central items tended to be unaffected by delaying the test. The authors concluded that "emotional arousal might facilitate the detection of concealed information sometime after the crime occurred" (Peth et al., 2012, p. 381).

Third, Klein Selle et al. (2017) used a different manipulation of emotional arousal and also concluded that it has no effect on CIT detection efficiency with the RLL and HR measures, but it may even enhance detection efficiency with the SCR measure. Specifically, these authors conducted two experiments and manipulated emotional arousal by using CIT items that differed in their arousal level and valence. In Experiment 1, CIT detection efficiency was unaffected by both emotional arousal/valence and time delay. However, physiological and recognition data indicated that the arousal manipulation did not produce the expected effects. Consequently, the authors conducted a second experiment using more arousing stimuli. The results of Experiment 2 revealed that both memory and CIT detection efficiency using skin conductance, but not respiration and heart rate measures, were enhanced for emotional compared to neutral pictures.

The results of these experiments indicate that from the perspective of emotional arousal, the results of mock crime experiments can be generalized because detection efficiency is not expected to decline when arousal level is increased. It should be noted that detection efficiency depends on the relative responses to crime-related versus neutral control items and while arousal level may enhance responses to all items it does not affect the relative responses to the crime-related items.

The Effect of Motivation to Avoid Detection on the Outcome of the Concealed Information Test

In addition to the higher level of stress and arousal experienced by real suspects undergoing police interrogations as compared with experimental participants, real culprits are likely to be more motivated to avoid being detected. Indeed the effect of motivation to avoid detection on the CIT's outcomes has been extensively studied since the 1960s. However, the results of these studies were inconsistent and while some studies concluded that an enhanced level of motivation has no effect on the detection efficiency of the CIT (e.g., Furedy & Ben-Shakhar, 1991; Horvath, 1978, 1979; Lieblich, Naftali, Shmueli, & Kugelmass, 1974), other studies showed enhanced detection efficiency when participants were motivated to avoid detection (e.g., Elaad & Ben-Shakhar, 1989; Gustafson & Orne, 1963).

These conflicting results may have been resolved by two meta-analyses of CIT research (Ben-Shakhar & Elaad, 2003; Meijer et al., 2014) that revealed significantly larger CIT effect sizes under motivational instruction or an incentive to successfully avoid detection as compared with control conditions. It should also be noted that none of the studies that manipulated motivation showed a reduction of detection efficiency under high motivational conditions. Thus, from an external validity perspective, the conclusion derived from studies examining motivation is similar to the conclusion based on the emotional arousal studies, namely, the results of mock-crime experiments can be generalized because detection efficiency is not expected to decline under conditions of high levels of motivation to avoid detection. However, this conclusion should be qualified because most studies examining the role of motivation, including the two meta-analyses, were based on a single physiological measure (SCR). Recent studies revealed that the different physiological measures used in the CIT may reflect different processes and may be affected by different factors (Klein-Selle et al., 2016; Klein Selle, Verschuere, Kindt, Meijer, et al., 2017; for details see also Chapter 2). Thus, it is important to examine the role of motivation using additional physiological measures. A first step in this direction was recently made by Rosenfeld, Labkovsky, Davydova, Ward, and Rosenfeld (2017), who used the P300 component of the ERPs and found that this measure was not affected by an incentive. However, the manipulation in this study focused on the attempt to successfully malinger brain injury rather than avoiding being detected in committing a crime (for the latest and most complete summary of this work, see Chapter 6).

Another factor related to the motivation of suspects to avoid detection is the potential use of countermeasures, namely attempts to distort the physiological responses such that differential responses to the critical items will be reduced or eliminated. While countermeasures can be used in laboratory experiments, especially when subjects are motivated to avoid detection, their use by real culprits undergoing police investigations is more likely. Countermeasures can be effective when subjects attempt to create or enhance responses to the neutral items. This can be achieved either by physical means (subjects can bite their tongue to inflict pain when the control items are presented) or mental means (recalling exciting and emotional memories, or performing mental activities during presentation of control items).

The effects of both mental and physical countermeasures on the CIT's outcomes with the SCR and the P300 measures have been examined in several studies and in many cases they drastically reduced the CIT effect and increased the rates of false-negative outcomes (e.g., Ben-Shakhar & Dolev, 1996; Honts, Devitt, Winbush, & Kircher, 1996; Mertens & Allen, 2008; Rosenfeld, Soskins, Bosh, & Ryan, 2004; see a review in Ben-Shakhar, 2011). However, while both Ben-Shakhar and Dolev (1996) and Honts et al. (1996) found that countermeasures were effective with the SCR measure, they were not effective when the respiration measure was used. In addition, while initial studies demonstrated that countermeasures can be effective with the P300 measure in the original three-stimulus protocol version of the P300 CIT (Mertens & Allen, 2008; Rosenfeld, 2011; Rosenfeld et al., 2004), subsequent studies conducted by Rosenfeld et al. demonstrated that a new protocol that separates the response to the probe/irrelevant items from the response to the target item (the complex trial protocol) is countermeasure-resistant when the P300 measure is used (Meixner & Rosenfeld, 2010; Rosenfeld & Labkovsky, 2010; Rosenfeld et al., 2008). These studies have been replicated by Lukacs et al. (2016). Thus, if countermeasures are indeed more likely in realistic investigations, it would imply that the external validity of CIT studies using the SCR measure may be compromised, but not using P300 in the complex trial protocol.

The Effect of Free Choice to Deceive or Conceal Information on the Outcome of the Concealed Information Test

One of the factors missing from most experimental setups is the free choice of participants to commit a mock crime and conceal the relevant information. The vast majority of deception research relied on experiments where participants were either instructed to give deceptive answers to simple autobiographical questions (e.g., Furedy, Davis, & Gurevich, 1988) or to enact a mock crime and conceal knowledge of its details (e.g., Lykken, 1959; Nahari & Ben-Shakhar, 2011). However, deception in realistic situations is typically defined as a voluntary act (e.g., Vrij, 2008) and consequently the essential choice (i.e., the intentional component) is missing from most deception studies (see also Farah, Hutchinson, Phelps, & Wagner, 2014; Kanwisher, 2009; Meijer et al., 2016; Sip, Roepstorff, McGregor, & Frith, 2008). Thus, it is unclear whether results based on experiments where participants are instructed to cheat or conceal information would generalize to realistic situations where individuals freely choose to deceive or conceal information.

A few studies that relied on the differentiation of deception (DoD) paradigm allowed participants to choose between a truthful and a deceptive answer to each question, typically, a simple autobiographical question (e.g., Furedy, Gigliotti, & Ben-Shakhar, 1994; Spence, Kaylor-Hughes, Farrow, & Wilkinson, 2008; Sun, May, Liu, Liu, & Lau, 2011). However, even this procedure lacks ecological validity because participants had to respond deceptively to about half of the questions.

Several recent studies tried to manipulate authentic lying. They relied on interactive games or on a modified version of the DoD where participants could freely choose whether to lie or tell the truth, and examined brain functions associated with the decision to lie (e.g., Carrion, Keenan, & Sebanz, 2010; Kireev, Korotkov, Medvedeva, & Medvedev, 2013; Pfister, Foerster, & Kunde, 2014; Sip et al., 2010, 2012; Sun, Chan, Hu, Wang, & Lee, 2015; Yin, Reuter, & Weber, 2016). These studies are clearly very important as they can shed light on the mechanisms underlying the decision to deceive. Furthermore, they can clarify whether different brain areas are activated during spontaneous versus instructed lies. However, as these studies did not focus on the detection of deception and were not designed to reveal whether voluntary deception affects detection efficiency, they are uninformative as far the external validity of the CIT is concerned. Thus, the question of whether the CIT can be applied for detecting crimes committed by free choice rather than by instructions remains open.

Nahari, Breska, Elber, Klein Selle, and Ben-Shakhar (2017) examined the effect of choosing to commit a mock crime on the outcomes of the CIT. Participants in the experimental condition were given a choice to either commit a mock crime, or to do a computerized task. In the control condition participants were randomly assigned to either a condition where they were instructed to commit the mock crime or to a condition where they had to execute the computerized task. The results showed similar CIT effects (i.e., differential responses to the critical items) in participants who committed the mock crime by instructions and by free choice. Specifically, no significant differences between the instructed and the choice conditions were found with SCR, RLL, and voice reaction time detection scores. However, there were differences between the individuals who decided to commit the mock crime and those who preferred the computerized task. Specifically, the choice to commit the mock crime was correlated with openness to experience, as defined by the big five inventory (see McCrae & Costa, 1987), and with gender (men were more likely to choose the mock crime than women). This line of work should be further explored and replicated, as the factor of choice is one that is difficult to manipulate and control, and we have little understanding of the true differences between choosing and being instructed to enact a crime and conceal information. One possible direction for future research could adopt the game-like deception or other spontaneous cheating paradigm combined with the CIT.

Discussion

Our review of the studies dealing with the external validity of CIT research has relied primarily on controlled experiments that manipulated several factors representing the major differences between laboratory settings and the forensic application of the CIT. This may be less desirable than testing the validity of the CIT directly as practiced in the forensic setting, but unfortunately, such direct attempts are rare and those that were made suffered from various methodological limitations (e.g., Ginton, Daie, Elaad, & Ben-Shakhar, 1982; Iacono, 1991).

The results of the studies reviewed in this chapter indicate that as far as emotional arousal and motivation to avoid detection are concerned, CIT laboratory experiments can be generalized. Both of these factors have either no effect on the outcomes of the CIT, or may even imply that detection efficiency, based on the electrodermal measure, may be higher in realistic situations than in the lab. Free choice to commit a mock crime and conceal the critical information also does not seem to affect the outcomes of the test, but this conclusion is based on a single experiment (Nahari et al., 2017) that should be replicated and extended.

The role of memory of the critical crime details is more complex. Studies reviewed here showed that the standard mock-crime procedure adopted in many laboratory CIT studies is highly artificial and may produce inflated detection efficiency estimates (e.g., Carmel et al., 2003). Consequently, estimates of CIT detection accuracy should rely only on more realistic mock crime procedures, such as those adopted by Gamer et al. (Gamer et al., 2010; Peth et al., 2012). The more realistic mock crime procedure should include a delayed test, which is typical of realistic situations. Desirably, the delay should be longer than just 1 or 2 weeks. Indeed, several studies revealed a reduction in memory for the critical items and a reduced CIT effect when the test was delayed (e.g., Carmel et al., 2003; Nahari & Ben-Shakhar, 2011; Peth et al., 2012). But these studies also revealed that the reduced CIT effect in the delayed test is caused mostly by the use of peripheral items. So the practical conclusion from this research is to construct CITs based exclusively on central and salient items.

In contrast to these factors, leakage of critical crime-scene items presents a serious threat to the validity of the CIT. While the standard laboratory studies prevented leakage, unfortunately this is not the case in realistic criminal investigations. Consequently, from this respect, results of CIT experiments may produce inflated validity estimates and in particular smaller rates of false-positive outcomes relative to those expected in the realistic setting. We offered several means that may reduce the risk of information leakage, such as previewing the items, but the only real solution to this threat is a modification of police practices, such that critical features of the event are identified and concealed at the outset of the investigation, as a standard investigative practice. This may seem difficult to achieve and may be one of the reasons for the limited use of the CIT in many countries, but the Japanese experience indicates that it is possible (e.g., Osugi, 2011).

Another major threat to the validity of the CIT is the potentially harmful effects of countermeasures. We did not emphasize this factor here because in principle, countermeasures can occur in laboratory experiments, most of which encouraged participants to avoid detection. Thus, this factor does not differentiate laboratory experiments from realistic police investigations. However, as the stakes in the realistic situation are much higher than in the lab, it is possible that countermeasures are more likely to occur in real practice. Unfortunately, no good means to protect against countermeasures (especially mental countermeasures) are available (see a discussion in Ben-Shakhar, 2012). The only method that has been demonstrated to be protected from countermeasures is the complex trial protocol developed by Rosenfeld and his colleagues (e.g., Meixner & Rosenfeld, 2010; Rosenfeld et al., 2008). But this will require the use of ERPs rather than ANS measures and at present ERPs have not been applied in realistic forensic settings.

Future Recommendations for Research and Practice

In spite of the methodological difficulties associated with field research, efforts should be made to design and conduct methodologically sound field validity studies. The natural setting for such studies seems to be the Japanese criminal investigations arena because the CIT is the standard polygraph method used in Japan and because Japanese polygraph investigators have the proper scientific training (Osugi, 2011). More importantly, from the description of how the CIT is conducted by the Japanese Police (Osugi, 2011), it seems that CITs are conducted independently of other criminal investigations and it is not used as a means to elicit confessions. Thus, if confessions are made independent of the CIT's outcomes, they may serve as a criterion, although it is not always reliable due to false confessions (e.g., Kassin & Gudjonsson, 2004; Kassin & Kiechel, 1996). Validity studies based on confessions made independent of the test's outcomes may shed light on the validity of the CIT in practice. At the same time, future CIT experiments should try and use more ecologically valid settings and more realistic mock crime procedures, including delayed testing. Hopefully, future meta-analyses of CIT studies will focus only on experiments using realistic procedures that will yield more generalizable validity estimates.

Future applications of the CIT should consider several lessons from this review. First, only central and salient items should be used. Identification of these items should be made soon after the crime by police examiners who are knowledgeable about the nature of the CIT. In particular great efforts should be made to keep these items secret from the public. These items should be previewed before conducting the CIT, and of course items for which suspects have prior knowledge should not be included in the test. Finally, the use of ERPs with the complex trial protocol should be seriously considered. Hopefully these recommendations would lead to more frequent use of the CIT, which seems to be the most efficient method of detecting perpetrators based on their knowledge of intimate crime details.

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CHAPTER 4

Physiological Responses in the Concealed Information Test: A Selective Review in the Light of Recognition and Concealment*

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INTRODUCTION

The Concealed Information Test (CIT), also known as the Guilty Knowledge Test, was developed to examine a suspect's recognition of a crime (Lykken, 1959; Verschuere, Ben-Shakhar, & Meijer, 2011). Fig. 4.1 shows an example of the CIT for the theft of a ring. The fact that a ring was stolen is not declared. In the CIT, an examiner presents a crime-relevant

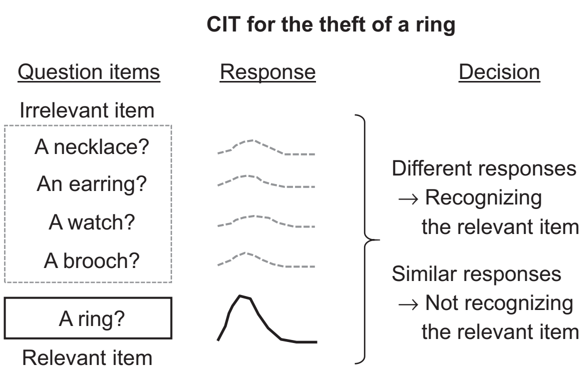

Figure 4.1 An example of the concealed information test (CIT). The CIT consists of one crime-relevant item and several crime-irrelevant items. The examiner infers the examinee's recognition by comparing the responses for the relevant and irrelevant items.

* This article is based partly on an article previously published in Japanese (Matsuda, 2016).

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item (in this case, a ring) and several crime-irrelevant items (e.g., a necklace, an earring, a watch, and a brooch) that are selected such that ignorant people cannot distinguish among the relevant and irrelevant items. Therefore, different physiological responses to relevant and irrelevant items indicate that the suspect recognizes the relevant item. In contrast, similar responses for both sets of items indicate that the suspect does not recognize the relevant item. The CIT is used in criminal investigations, especially in Japan. Around 100 examiners, who officially belong to the forensic science laboratories of police headquarters, conduct around 5000 CITs per year (Osugi, 2011).

The Control Question Test or Comparison Question Test (CQT) is the most commonly used polygraph test for criminal investigations worldwide (Raskin & Kircher, 2014). It measures an examinee's physiological responses upon answering deceptively to crime-relevant questions. In contrast, the CIT examines recognition, not deception. In fact, the CIT can be conducted without overtly deceptive answers (Verschuere & Ben-Shakhar, 2011). It examines only whether the examinee recognizes the crime-relevant item by comparing responses between the crime-relevant and irrelevant items. This feature makes the CIT a scientifically valid procedure.

Although the CIT is definitely not a deception-detection test but a recognition-detection test, it is performed only when an examinee may be concealing crime-relevant information. The CIT is not performed for individuals who already have confessed their true recognition. Thus, as shown in Fig. 4.2, the CIT examines recognition but the obtained physiological responses in the CIT include both recognition- and concealment-related

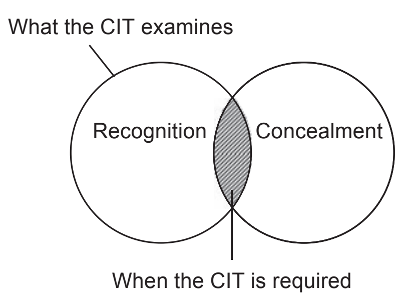

Figure 4.2 A convenient figure to show the difference between what the concealed information test (CIT) examines and what the CIT responses actually reflect. The CIT examines recognition; however, the CIT is performed only when concealment of recognition is suspected.

responses. The act of concealment is considered a kind of deception (Vrij, 2008) and, therefore, the responses in the CIT partly reflect deception.

Recent studies have shown that both recognition and concealment affect physiological responses during the CIT. This chapter summarizes the physiological responses to crime-relevant information that perpetrators try to conceal, and it reveals the cognitive processes underlying concealment. In particular, we focus on autonomic and central responses. First, we outline the typical physiological responses produced when an examinee recognizes crime-relevant information and conceals it during the CIT. Then, we deconstruct these responses into recognition- and concealment-related ones. In general, psychophysiologists estimate cognitive processes on the basis of physiological responses (Donchin, 1981). Thus, we estimate cognitive processes related to concealing the truth from recognition- and concealment-related physiological responses in the CIT.

PHYSIOLOGICAL RESPONSES DURING THE CONCEALED INFORMATION TEST

This section introduces typical physiological responses to the relevant item compared to those responses to the irrelevant items during the CIT. The first CITs measured the electrodermal activity, which is an index of autonomic response (Lykken, 1959). In the 1990s, researchers started measuring the event-related potential (ERP) as an index of central nervous activity (Farwell & Donchin, 1991; Rosenfeld et al., 1988). In the 2000s, researchers started performing functional magnetic resonance imaging (fMRI) during the CIT (Gamer, Bauermann, Stoeter, & Vossel, 2007; Langleben et al., 2002; Nose, Murai, & Taira, 2009).

Autonomic Responses

The field CIT in Japan measures several autonomic responses simultaneously. Fig. 4.3 shows the typical autonomic responses produced when an examinee knows the crime-relevant item. Typically, skin conductance, which is one index of electrodermal activity, increases more for a relevant item than for irrelevant items. The heart rate and pulse volume decrease more for a relevant item than for irrelevant items. Respiration is suppressed more for a relevant item than for irrelevant items. Here, we present an overview of what these autonomic responses reflect.

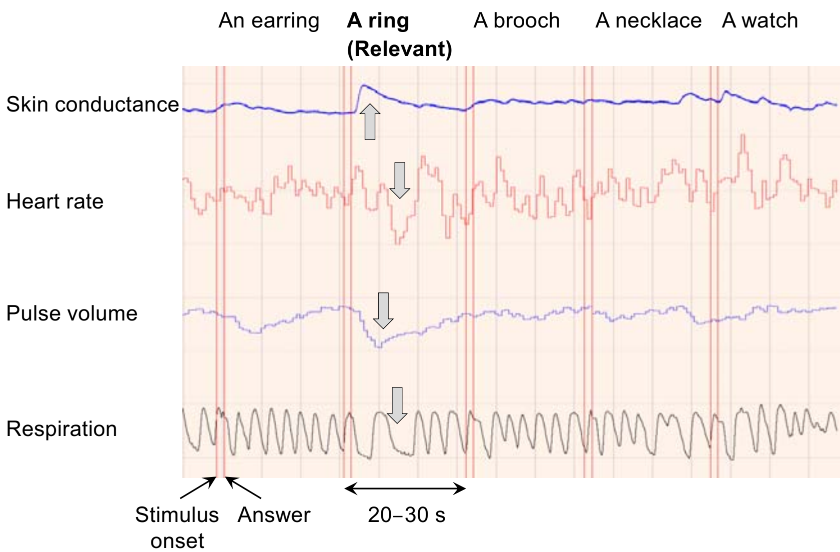

Figure 4.3 An example of autonomic responses in the concealed information test. The relevant item elicits greater skin conductance, slower heart rate, smaller pulse volume, and more suppressed respiration than the irrelevant items.

Skin Conductance

In the CIT, skin conductance begins to increase around 1–2 s after item onset, and it reaches its maximum at around 5–7 s (Hirota, Ogawa, Matsuda, & Takasawa, 2009). The amplitude is greater for a relevant item than for irrelevant items. Skin conductance is associated with sweat activity, and it increases with skin sympathetic nerve activity (Dawson, Schell, & Filion, 2007). From an evolutionary perspective, when organisms face salient stimulation, their hands and feet start to sweat, owing to the promotion of grasping efficiency, and thus, they prepare for action to approach or avoid the salient stimulus source (Bradley, 2009; Codispoti & De Cesarei, 2007). Humans still show this response and, therefore, novel or significant stimuli elicit greater skin conductance.

Heart Rate

In the CIT, heart rate decreases within around 3 s after item onset and then increases momentarily (Matsuda, Nittono, Hirota, Ogawa, & Takasawa, 2009; Verschuere, Crombez, De Clercq, & Koster, 2004; Verschuere, Crombez, Smolders, & De Clercq, 2009). It then begins to decrease again around 5 s after item onset, and this state lasts for over 10 s. In general, the initial heart rate decrease, which is caused by parasympathetic nerve activity

(Bradley & Lang, 2007), reflects the sensory/perceptual intake and information-gathering function of orienting to novel or significant stimuli by motor inhibition (Bradley, Keil, & Lang, 2012; Lacey, 1967). In contrast, the second and longer-lasting heart-rate decrease would compensate for the increase in blood pressure caused by peripheral vasoconstriction and, therefore, maintain the homeostasis of blood pressure (Hirota et al., 2009). The suppression of respiration also would affect this heart-rate decrease.

Pulse Volume

In the CIT, pulse volume begins to decrease around 3–4 s after item onset, and it reaches its minimum at around 7–10 s (Hirota et al., 2009; Matsuda, Hirota, Ogawa, Takasawa, & Shigemasu, 2009). The minimum is lower for the relevant item than for the irrelevant items. The decrease in pulse volume reflects peripheral vasoconstriction; this is caused by the skin sympathetic-nerve activity (Sawada, Tanaka, & Yamakoshi, 2001). The decrease in cutaneous blood flow also reflects this activity. When organisms face a significant stimulus, they have to prepare for action. Thus, they gather blood in the trunk of the body by constricting peripheral blood vessels so that they can provide blood to the skeletal musculature of the limbs when action is actually required (Turpin, 1986).

Respiration

In the CIT, respiration is suppressed (i.e., slower and/or smaller) from around 1 s after the relevant item's onset, and this state lasts 10–20 s (Kobayashi, 2011; Matsuda, Nittono, et al., 2009; Matsuda, Nittono, & Ogawa, 2011). Respiration is regulated by the complex interplay of central and autonomic (mainly parasympathetic) structures and peripheral feedback circuits (Gamer, 2011a; Lorig, 2007). Respiration is under both involuntary and voluntary control. The slow and shallow breathing observed in the CIT generally is associated with withdrawal from the environment (Wientjes, 1992). Moreover, instructions to inhibit physiological responses to affective pictures lower the respiratory amplitude and rate (Dan-Glauser & Gross, 2011). Withdrawing from the environment and paying attention to physiological responses would cause the respiration suppression in the CIT.

Orienting Response

The increase in skin conductance and the decrease in pulse volume indicate greater sympathetic nerve activity, and the decrease in heart rate indicates greater parasympathetic nerve activity. The relevant item apparently coactivates both sympathetic and parasympathetic nerve systems (Berntson & Cacioppo, 2007). This coactivation is associated with the orienting response (Bradley et al., 2012; Gamer, 2011a). The orienting response is an organism's initial response to a novel or significant stimulus (Barry & Rushby, 2006). The significance of a stimulus is defined by its arousal and task relevance (Bradley, 2009). In the CIT, the relevant item is a rare stimulus for a participant who knows it. In the example of Fig. 4.1, the relevant item is presented only once out of five times. Moreover, the participant sometimes memorizes the relevant item during an arousing experience, for example, perpetrating a crime (Peth, Vossel, & Gamer, 2012). The relevant item is also task relevant because the aim of the CIT is to detect the participant's recognition of the relevant item and the participant has to conceal its recognition during this test. Thus, the relevant item is rare and significant for participants who recognize it. The autonomic responses in the CIT mainly are considered orienting responses (Gamer, 2011a).

Event-Related Brain Potential

The ERP is generated during an ongoing electroencephalogram (EEG) and represents the brain activity in response to events. Fig. 4.4 shows the ERPs elicited by the relevant and irrelevant items in Matsuda et al. (2011) and Matsuda, Nittono, and Ogawa (2013a). The ERP consists of several components. Most CIT studies on ERPs reported a greater P3 (or P300) component for the relevant item than for the irrelevant items (Rosenfeld, 2011). Some studies reported a greater N2 component (Gamer & Berti, 2010; Hu, Pornpattananangkul, & Rosenfeld, 2013; Matsuda, Nittono, et al., 2009; Matsuda, Nittono, & Ogawa, 2013b), a greater slow wave or late positive potential (LPP) (Matsuda & Nittono, 2015b; Matsuda, Nittono, et al., 2009; Matsuda et al., 2011), and greater late posterior negativity (LPN) or late negative potential (Farwell, 2012; Hu, Bergström, Bodenhausen, & Rosenfeld, 2015; Soskins, Rosenfeld, & Niendam, 2001) for the relevant item than for the irrelevant items. The following subsections will explain these ERP components.

P3

P3 has a parietal-dominant scalp topography and a positive peak at around 300–800 ms, depending on stimulus complexity, after item onset. P3 typically is elicited by rare and task-relevant stimuli. Recent studies suggest that P3 may stem from neural inhibitory activity organized to delimit

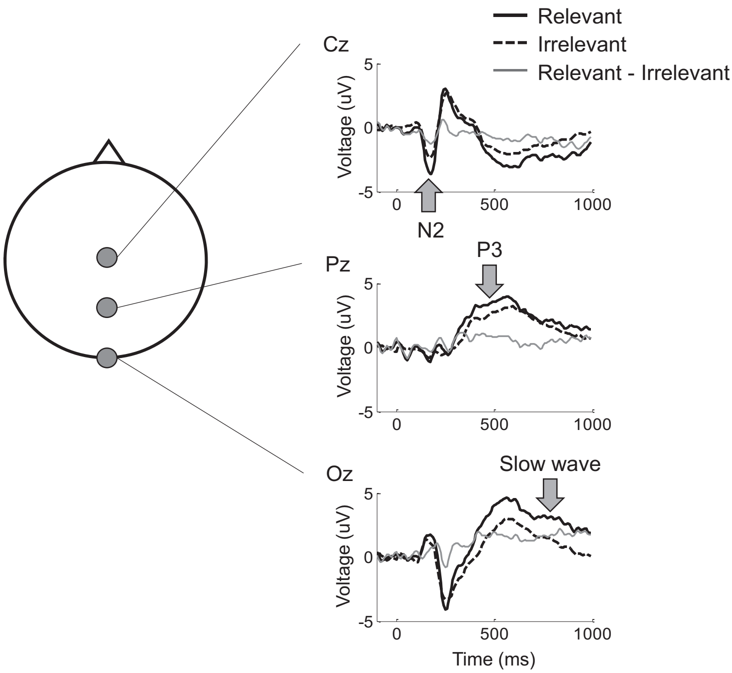

Figure 4.4 An example of ERPs in the concealed information test based on Matsuda, Nittono, and Ogawa (2013a). The relevant item elicits greater N2, P3, and positive slow wave than the irrelevant items at central (Cz), parietal (Pz), and occipital (Oz) midline scalp electrodes, respectively.

task-extraneous events that sculpt attentional focus and promote memory operations for task-relevant stimuli (Polich, 2007). P3 is associated with a stimulus-evaluation process and is often used as a measure of attention resources available for task performance (Donchin & Coles, 1988).

N2

N2 has a frontocentral dominant scalp topography and a negative peak at around 200–300 ms after item onset. N2 is associated not only with attention and novelty or mismatching but also strategic monitoring and control of motor responses. Folstein and Van Petten (2008) proposed that N2 can be divided into attention-, mismatch-, and control-related subcomponents. N2 seemingly is related to detecting a stimulus that is different from others. Several different CIT studies have reported that N2 associated with attention or control is elicited by the relevant item, although recent studies have indicated that N2 cannot be used reliably as an index of the CIT (Ganis, Bridges, Hsu, & Schendan, 2016).

Slow Wave

The slow wave, or LPP, in the CIT has a frontal-negative and posterior-positive scalp distribution, and occurs around 500–1000 ms after item onset. A slow wave with this type of scalp distribution is elicited when an additional cognitive control (e.g., information updating) is required after identifying a stimulus (García-Larrea & Cézanne-Bert, 1998). The slow wave in the CIT indicates that the relevant item recruits additional cognitive control after it is identified (Matsuda & Nittono, 2015b). In contrast, many previous studies have reported the slow wave or LPP elicited by affective stimuli (Weinberg, Ferri, & Hajcak, 2013). However, the slow wave elicited by affective stimuli has a central-parietal positive scalp distribution, which differs from the distribution in the CIT (Matsuda & Nittono, 2015b).

Late Posterior Negativity

LPN, or late negative potential, has a parietal dominant scalp topography and a peak at around 1200 ms after item onset. LPN reflects action monitoring owing to a high level of response conflict (Johansson & Mecklinger, 2003). In the CIT, enlarged LPN may reflect the enhanced need to monitor the response conflict between top-down suppression and automatic recognition processes (Hu et al., 2015).

Electroencephalogram

Recently, some studies have focused on background EEG as well as ERPs. For example, Matsuda, Nittono, and Allen (2013) used the frontal hemispheric asymmetry of alpha power as a measure of the CIT. They found that the alpha power for the relevant item was lower for the right-frontal site than for the left-frontal site. Because the alpha power is related inversely to regional brain activity (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998), this result indicates that the relevant item activates the right-frontal area more than the left-frontal area. In general, the frontal asymmetry is an index of the motivation direction. Greater right-frontal activity compared to left-frontal activity is known to reflect the motivation to withdraw, whereas the reverse reflects the motivation to approach (Harmon-Jones, Gable, & Peterson, 2010).

Functional Magnetic Resonance Imaging

Gamer (2011b) metaanalyzed six CIT studies that used fMRI. The results are shown in Fig. 4.5. Compared to the irrelevant items, the relevant item

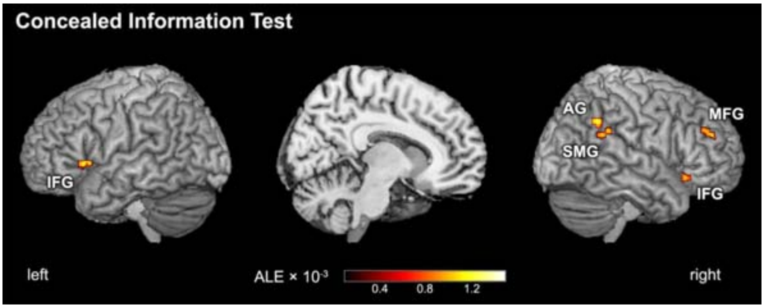

Figure 4.5 A result of the activation likelihood estimates (ALE) metaanalysis of activation peaks in the concealed information test based on Gamer (2011b). The maps' thresholds were set at the ALE value corresponding to $P < .05$. *AG*, angular gyrus; *IFG*, inferior frontal gyrus; *MFG*, middle frontal gyrus; *SMG*, supramarginal gyrus.

elicits greater activation of the right-middle frontal gyrus, left- and right-inferior frontal gyrus, and right temporoparietal junction (i.e., angular gyrus and supramarginal gyrus).

The inferior frontal gyrus and temporoparietal junction form a ventral frontoparietal network. The right ventral frontoparietal network is activated upon detecting unexpected or rare events (Corbetta & Shulman, 2002). Therefore, this activation may reflect orienting responses (Gamer, 2011b).

The middle frontal gyrus also is called the dorsolateral prefrontal cortex. The middle frontal gyrus is activated upon monitoring and manipulating cognitive representations in the working memory (Barbey, Koenigs, & Grafman, 2013). In particular, right-middle frontal activation can support cognitive processes to enable goal-directed behavior and adaptive decision-making (Barbey et al., 2013). The right-middle frontal gyrus also is associated with response inhibition (Shackman, McMenamin, Maxwell, Greischar, & Davidson, 2009). Similarly, the right inferior gyrus is characterized as a brake and is activated by inhibiting responses and memory retrieval (Aron, Robbins, & Poldrack, 2004, 2014). The result finding that the relevant item activates the right frontal area is consistent with that of the frontal alpha asymmetry (Matsuda et al., 2013).

MANIPULATION OF CONCEALMENT

The previous section noted the physiological changes that occur when a participant recognizes crime-relevant information and conceals it. The crime-relevant item elicits greater skin conductance, slower heart rate, smaller pulse volume, and more suppressed respiration than the crime-irrelevant items. It also elicits greater N2, P3, slow wave, and LPN of ERPs. Moreover, the right frontal cortex, in addition to the ventral frontoparietal network, is more activated.

As shown in Fig. 4.2, these physiological responses would reflect recognition and concealment of recognition. The present section introduces CIT studies that aimed to identify the cognitive processes of the CIT by separating recognition- and concealment-related physiological responses. These studies manipulated concealment by conducting an unusual CIT that asked participants to reveal their recognition and comparing the results with those obtained through the usual CIT in which participants conceal their recognition. Three different procedures were used for participants to reveal their recognition. For the first procedure, participants were instructed to answer honestly to the relevant item they recognized. In the second procedure, the CIT was performed after the participants revealed the relevant item. In the third procedure, participants were motivated to reveal the relevant item through the CIT without overt actions, for example, by assigning them the role of witness instead of perpetrator. We next review these studies and the identified physiological responses associated with recognition and concealment.

Concealed Information Test With Honest Answers

Ambach, Stark, Peper, and Vaitl (2008) asked participants to conduct a mock theft and then performed CITs based on autonomic responses. Half of the participants received the usual CIT in which they answered "no" to all the questions and consequently answered deceptively to the question on the stolen item. The other half received an unusual CIT in which they honestly answered "yes" to the question on the stolen item and "no" to the other questions. The relevant item with a deceptive answer elicited greater skin conductance, slower heart rate, and suppressed respiration compared with the irrelevant items. On the other hand, the relevant item with an honest answer did not elicit slower heart rate and suppressed respiration. Moreover, although the relevant item with an honest answer elicited greater skin conductance compared with the irrelevant items, its amplitude was smaller than that in the case of the relevant item with a deceptive answer.

Ellwanger, Rosenfeld, Sweet, and Bhatt (1996) measured P3 with a similar procedure using a malingering scenario rather than a forensic one. The relevant item elicited greater P3 than the irrelevant items, not only in the usual CIT but also in the unusual CIT. This P3 amplitude elicited by the relevant item was greater for an honest answer than for a deceptive answer.

The procedure of comparing physiological responses between the honest answer and the deceptive answer has both advantages and disadvantages. In this procedure, participants answer deceptively to the relevant item in the usual CIT and honestly to the relevant item in the unusual CIT. That is, manipulation of concealment can be confirmed as overt behaviors. However, although participants answer in the same way to both the relevant and irrelevant items in the usual CIT, they answer differently in the unusual CIT. This difference in answers changes the task structure and thus may affect physiological responses. For example, the greater P3 with an honest answer than with a deceptive answer (Ellwanger et al., 1996) may be caused by the increase in task relevance for the relevant item when participants answer differently in the unusual CIT.

Concealed Information Test After Revealing Recognition

Three studies compared physiological responses between the usual CIT in which participants concealed their recognition and an unusual CIT in which they revealed their recognition before the CIT and, thus, did not need to conceal it. Kubo and Nittono (2009) asked participants to remember a number on a playing card they picked from five different cards and conducted CITs in which the five numbers were presented. In the usual CIT, the participants were instructed to conceal the memorized number. In the unusual CIT, they were instructed to tell the memorized number to the experimenter before the test. In both CITs, the participants pressed the same button for both of the relevant and irrelevant items. The concealed items elicited greater P3 compared with the irrelevant items, whereas the already-revealed item did not elicit greater P3. Gamer and Berti (2010) asked participants to memorize one playing card and conceal its memory through the CIT (i.e., concealed item). Then, they showed a different playing card and asked the participants to memorize it but gave no further instruction regarding this card (i.e., mere recognition item). The participants pressed the same key to the concealed item, mere recognition item, and irrelevant items. The mere recognition item did not elicit greater P3 and skin conductance, but it elicited greater N2. In addition, the ERP waveforms in these two studies (i.e., Fig. 2 in Kubo & Nittono, 2009 and Figs. 1 and 2 in Gamer & Berti, 2010) appear to indicate that the concealed items elicited the greater slow wave.

Matsuda, Nittono, et al. (2013b) examined more various physiological responses. In this study, participants stole two items, but one of them was found by the experimenter. Then, the participants received two CITs. One was the usual CIT on the stolen item in which the participants had to conceal its recognition. The other was an unusual CIT on the stolen but already-revealed item in which the participants did not need to conceal its recognition. In both CITs, the participants pressed the same button to the theft-relevant and -irrelevant items. The concealed item elicited greater N2, P3, slow wave, and skin conductance; smaller heart rate and pulse volume; and suppressed respiration. However, the already-revealed item did not elicit greater slow wave and suppressed respiration. Matsuda and Nittono (2015a) investigated the source of the slow wave by using standardized low-resolution brain electromagnetic tomography (sLORETA) (Pascual-Marqui, Esslen, Kochi, & Lehmann, 2002). The result is shown in Fig. 4.6. The source of the slow wave is estimated to be in the right-middle and inferior frontal gyrus (Matsuda & Nittono, 2015a). This result is consistent with the fMRI result obtained in Gamer (2011b).

This second procedure to manipulate concealment overcame the disadvantage of the first procedure: In the second procedure, the participants behaviorally responded to the relevant and irrelevant items in the same way. Thus, we can consider that the physiological differences between the concealed and already-revealed items purely reflect the effect of concealment. Conversely, this second procedure does not exactly control how the participants interpret the meaning of the already-revealed item. Whether the participants actually have no intention to conceal the

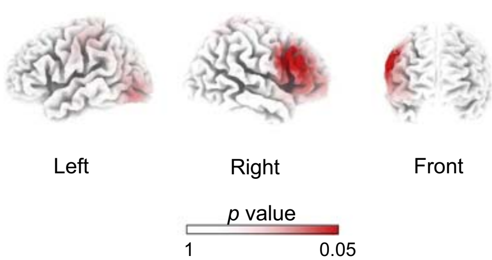

Figure 4.6 The source analysis results for the slow wave by sLORETA based on Matsuda and Nittono (2015a). Red areas [dark gray in print version] denote cortical areas with significantly higher levels of activity for the relevant item than for the irrelevant items when the participants conceal their recognition.

already-revealed item is unclear (klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2016), although subjective rating of the intention to conceal was very low for the already-revealed item (Kubo & Nittono, 2009; Matsuda, Nittono, et al., 2013b).

Concealed Information Test With Intention to Reveal Recognition

Recently, some studies instructed participants to try not to conceal, but rather to reveal, their recognition through the CIT (klein Selle et al., 2016; klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2017; Kubo & Nittono, 2009; Rosenfeld, Ozsan, & Ward, 2017). klein Selle et al. (2016) assigned participants either the role of a suspect, for which they were motivated to avoid detection by concealing the relevant item, or the role of a witness, for which they were motivated to be detected by revealing the relevant item without overt action. The relevant item with the intention to reveal elicited greater skin conductance compared with the irrelevant items; however, it did not elicit slower heart rate and elicited not suppressed but accelerated respiration. Kubo and Nittono (2009) asked participants to make an effort to inform the experimenter of the relevant item by enhancing brain response. The relevant item with the intention to reveal elicited greater P3 than the irrelevant item as well as the relevant item with the intention to conceal. Rosenfeld et al. (2017) used the same experimental protocol as klein Selle et al. (2016) and reported that the relevant item with the intention to reveal elicited greater P3 than the irrelevant item. The P3 difference between the relevant and irrelevant items was greater with the intention to conceal than with the intention to reveal. Furthermore, the relevant item with the intention to conceal delayed the N2/N3 latency, which was not observed for the relevant item with the intention to reveal.

This third procedure to manipulate concealment overcame the disadvantage of the second procedure in that the meaning of the revealed item was clear to the participants. However, the intention to reveal may recruit additional cognitive control. Trying to reveal the recognition is subjectively as difficult as trying to conceal it (Kubo & Nittono, 2009). The additional cognitive control induced by the intention to reveal may increase or elicit physiological responses. One example of these may be respiration acceleration, as shown in klein Selle et al. (2016).

COGNITIVE PROCESSES OF THE CONCEALED INFORMATION TEST

The studies that we introduced in the previous section show partly inconsistent results, but we also can find some robust results. First, recognition of the relevant item elicited greater skin conductance and N2 compared with the irrelevant items. Second, concealment amplified the skin conductance and P3. Third, concealment elicited slow wave and respiration suppression. We summarized these physiological changes and proposed a model for cognitive processes during the CIT.

Recognition-Related Cognitive Process

The top of Fig. 4.7 shows the recognition-related physiological responses and cognitive processes that the responses would reflect. Mere recognition

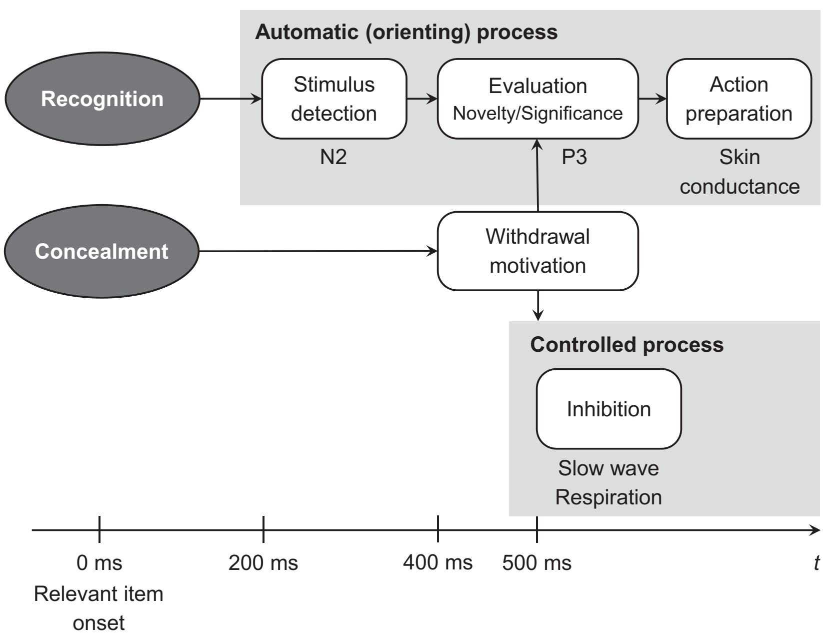

Figure 4.7 A model of cognitive processes after the relevant item is shown in the concealed information test. When an examinee has recognition of the relevant item, he/she detects the item at around 200 ms after its onset. Then he/she evaluates the novelty and significance of the item. Based on the evaluation, he/she prepares for action. In contrast, when the examinee intends to conceal the recognition, withdrawal motivation occurs, which affects the orienting process by amplifying the significance of the relevant item. Furthermore, withdrawal motivation recruits the controlled process, during which the examinee tries to inhibit his/her orienting responses. This controlled process begins at around 500 ms after the relevant item's onset.

of the relevant item can elicit skin conductance and N2. Skin conductance is a major index of orienting responses. Orienting responses are elicited due to the novelty and significance of the relevant item. As shown in Fig. 4.7, orienting responses generally consist of several steps. Organisms detect a salient stimulus that differs from other stimuli; then, they evaluate it and prepare for action if necessary (Bradley, 2009). In these steps, N2 is associated with the stimulus-detection step and skin conductance with the action-preparation step. Because the latency of N2 is 200−400 ms, this orienting process would begin at about 200 ms after stimulus onset. However, it should be noted that N2 depends on the physical characteristics of stimuli and is sometimes unobservable (Ganis et al., 2016).

In general, a stimulus that is evaluated as being rare and/or significant also increases the P3 amplitude (Johnson, 1986). However, in the CIT, mere recognition of the relevant item sometimes does not elicit greater P3 compared with the irrelevant items (Meijer, Smulders, Merckelbach, & Wolf, 2007). For example, when participants picked one of playing cards and memorized it as a relevant item, a greater P3 was not observed after they revealed it (Gamer & Berti, 2010; Kubo & Nittono, 2009). The relevant item memorized like this would have insufficient significance for eliciting P3.

Concealment-Related Cognitive Process

Fig. 4.7 also shows the concealment-related physiological responses and cognitive processes that the responses would reflect. Concealing information not only amplified the skin conductance and P3 amplitude but also recruited the slow wave and respiration suppression. Concealment can be considered a type of withdrawal behavior to protect oneself. Furthermore, in the CIT, participants are motivated to avoid detection. Thus, the intention to conceal recognition would be associated with withdrawal motivation. This idea is supported by the finding that frontal brain asymmetry is observed when participants try to conceal their recognition (Matsuda et al., 2013).

The withdrawal motivation induced by the intention to conceal would increase the significance of the relevant item. Significance is defined partly by arousal, which is considered a nonspecific energizing force that intensifies either approach or withdrawal behavior (Bradley, 2000). Thus, the withdrawal motivation associated with concealment should increase the arousal level to the relevant item. This would increase the significance of the relevant item and amplify the skin conductance and P3, as shown in

Fig. 4.7. The latency of P3 would indicate that this process occurs around 400 ms after the relevant item's onset.

Furthermore, Fig. 4.7 also shows that the withdrawal motivation associated with concealment recruits a controlled process, which is reflected by the slow wave. Judging from the latency of the slow wave, this process would occur around 500 ms after the relevant item's onset. The main function in the controlled process would be the inhibition of physiological arousal (klein Selle et al., 2016, 2017). As shown in Fig. 4.6, the source of the slow wave is estimated to be in the right-middle and inferior-frontal gyrus. These areas are associated with inhibition (Aron et al., 2004; Kawashima et al., 1996). One example of inhibition of physiological responses would be the suppression of respiration.

CONCLUSION

The CIT is a recognition detection test; however, it additionally measures physiological responses when a perpetrator tries to conceal the recognition of crime-related information. Recent CIT studies experimentally have separated the concealment-related component from the recognition-related component and have identified the accompanying physiological responses. The mere recognition of crime-relevant information produces orienting responses, which indicates that such information is significant for the perpetrator. The intention to conceal recognition amplifies the orienting responses, thus indicating that concealment makes the information more significant for the perpetrator. Furthermore, the concealment of recognition also recruits cognitive control to inhibit physiological responses. Concealment is difficult to detect by observing the utterance and behavior; however, it causes various physiological changes inside the body. In the CIT, the intention to conceal plays the contradictory role of increasing the accuracy of detecting recognition by amplifying and diversifying physiological responses.

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CHAPTER 5

Field Findings From the Concealed Information Test in Japan

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CURRENT STATUS OF THE CONCEALED INFORMATION TEST IN JAPAN

The Concealed Information Test (CIT) is the only method of polygraph examination in Japan. Japanese examiners no longer use the Control Question Test or Comparison Question Test (CQT), which is the most commonly applied polygraph method around the world. The reason for discontinuing the latter test is that, in Japan, polygraph examinations are not employed as lie-detection tests, but as information-detection tests in criminal investigations. The investigation in Japan focuses on whether examinees recognize the crime-related information and how they recognize such information. Determining whether or not the examinees are lying is no longer the main purpose of the CIT in Japan.

The CIT has been scientifically recognized as a valid, reliable method in laboratory research (Verschuere, Ben-Shakhar, & Meijer, 2011); however, it has not been extensively utilized in the field, except in Japan (Osugi, 2011). Some countries, such as Israel and Lithuania, employ the CIT method combined with the CQT, but Japan appears to be the only country that uses the CIT exclusively. In this chapter, I provide a detailed description of why and how the CIT is applied effectively in Japan, and I describe some findings using field data.

In Japan, the CIT has been officially and systematically applied for the last 50 years, and the results obtained using that method have been accepted as evidence in court since the 1960s (Matsuda, Nittono, & Allen, 2012). Approximately 5000 polygraph examinations are conducted annually by about 100 polygraph examiners at forensic science laboratories at prefectural

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police headquarters (Osugi, 2011). The examiners are not criminal investigators but specialized technical staff members, who trained at the National Research Institute of Police Science, and they also engage in research. Detailed information about such examiners and the training system in Japan appears in Osugi (2011).

Polygraph examinations using the CIT in Japan are performed for almost all kinds of crimes, including murder, burglary, shoplifting, property damage, illegal drug use, and hit-and-run accidents. The reason for the CIT being applied so extensively in Japan is related to the distinctive features of the Japanese CIT. There are two main differences between the typical CIT and the Japanese form.

First, there is the effective use of searching questions. Two types of question are employed in the Japanese CIT: the known-solution question and searching question. The known-solution question consists of one crime-related alternative (previously identified in the criminal investigation) and three or four unrelated, irrelevant alternatives (selected as if innocent people cannot discriminate those alternatives from the crime-related one). By contrast, the searching question comprises potential alternatives in which particular crime-related information has yet to be determined in the investigation. Fig. 5.1 shows example of these two types of question in a case of theft. Q1, Q2, and Q3 are known-solution questions: the crime-related information has already been revealed. Thus, the examiner knows which alternative is related to the crime and would be recognized by a person involved in that crime. In contrast, Q4 is the searching question: neither the examiner nor the investigator knows which alternative is related to the crime. The examiner tries to develop alternatives that cover all possibilities. If the searching question is properly formulated, it cannot differ from the known-solution question for the criminal.

The second difference in the Japanese CIT is the application of question-focused judgment. The typical CIT was originally proposed by Lykken (1959) and has been partly used in other countries; it focuses on whether the examinee possesses some kind of crime-related information, and it pays little attention to revealing the specific details of that knowledge. Because their final judgment is whether the examinee is knowledgeable (guilty) or unknowledgeable (innocent), the examiner assesses the outcome with respect to the examinee. Here, I describe this judgment as examinee-focused judgment, following Ogawa, Matsuda, Tsuneoka, and Verschuere (2015). Fig. 5.1 shows the difference between question-focused judgment and examinee-focused judgment. The question-focused judgment applied

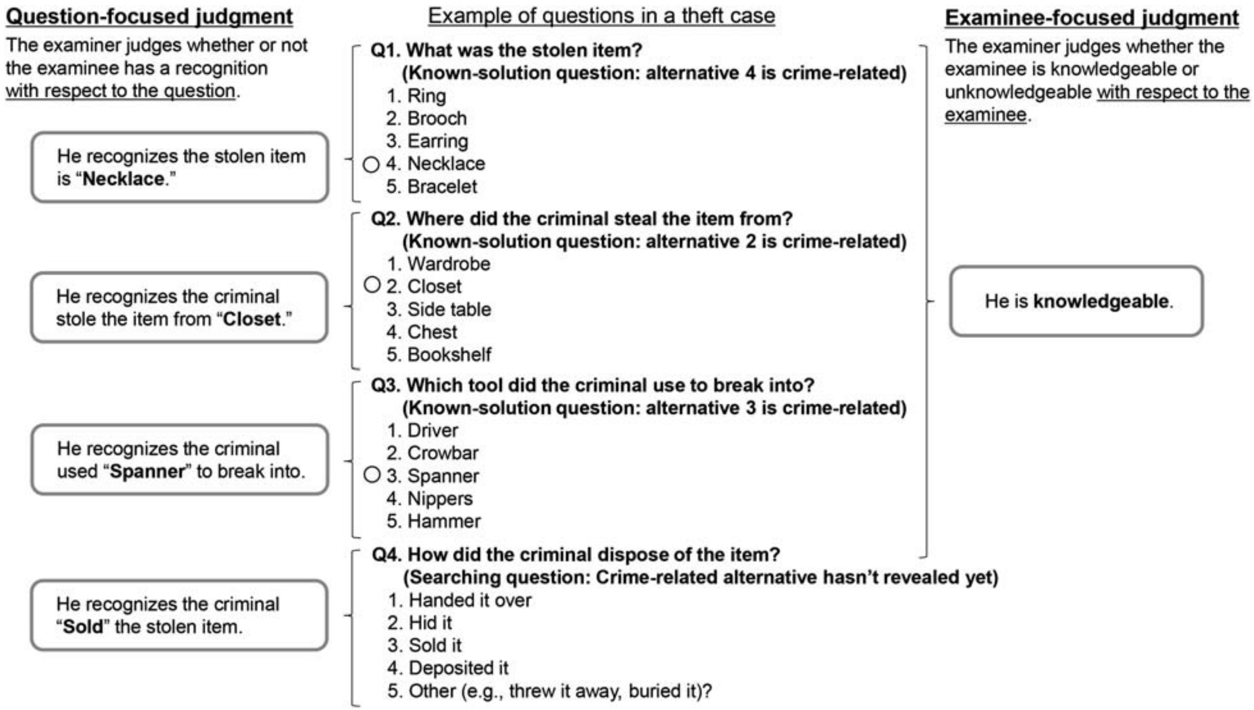

Figure 5.1 Example of known-solution and searching questions in a theft case and the difference between question-focused and examinee-focused judgment.

in the Japanese CIT focuses more on detailed aspects, such as what the examinee recognizes or fails to recognize. The final judgment depends on whether or not the examinee shows recognition within the question context; i.e., the examiner assesses the outcome with respect to the question. With the example in Fig. 5.1, in the Japanese CIT, the examiner assesses whether the examinee has recognition of the fact that the stolen item was a necklace by asking, "What was the stolen item?" The examinee also shows recognition that the criminal stole the item from a closet through the question, "Where did the criminal steal the item?" This methodological difference is complex and not easily understandable; however, it is key to understanding why the CIT is utilized extensively in Japan.

Before describing these features in detail, I will introduce various roles of the Japanese CIT and explain how it is used in criminal investigations. Details about the procedures related to the CIT in Japan appear in Osugi (2011).

VARIOUS ROLES

Although one might suppose that only criminals who have committed especially egregious offenses become examinees for polygraph examinations, that is not true in Japan. The CIT is just a memory test utilized to reveal whether or not the examinee possesses particular information; thus, the CIT is used in various ways and for different purposes. There are various types of criminals and different crimes are committed in various situations; as a result, it is unfortunately sometimes difficult to determine crime facts in detail. Police do not always obtain appropriate physical evidence. Some suspects who have already confessed their guilt may not always make a full confession; others do appear to make a full confession. Suspects may unintentionally omit certain details. Some suspects may make false confessions; others may not say anything at all. Thus, when using the CIT method for different crimes and accidents, police investigators need to examine a crime from many angles. As a result, the CIT can be utilized to target not only felonious offenses but also such individuals as potential suspects, nonsuspects, assumed victims, and innocent people.

In this section, I introduce five purposes and roles of the Japanese CIT using the examples of several hypothetical cases: (1) providing evidence for prosecution; (2) finding new evidence; (3) identifying a target crime;

(4) screening people when searching for a potential criminal; and (5) preventing false charges. Using related examples, I will explain how the Japanese CIT tries to serve as the key to solving a real criminal investigation.

Providing Evidence for Prosecution

The most typical way for using the CIT in Japan is providing evidence for prosecution, i.e., to reveal whether the examinee recognizes particular facts known only to the criminal. For example, in a hypothetical case of arson, the initial investigation has revealed the following facts: the fire started in the linen room of a hotel, and a small amount of heating oil was detected in that room. The investigators have identified a potential suspect, an ex-employee. The examiner can ask the following known-solution questions (I have indicated below the crime-related alternative by ○):

Q. Where did the fire start?
1. Kitchen
2. Clerk's office
3. Linen room (○)
4. Guest room
5. Lobby

Q. What did the criminal use to spread the fire?
1. Gasoline
2. Light oil
3. Heavy oil
4. Heating oil (○)
5. Firework fuel

If the examinee shows different responses to the crime-related (critical, probe) alternative compared with the unrelated (irrelevant) alternatives, the examiner judges that the examinee recognizes crime-related information that only the criminal should possess. If the details of the crime were not reported in the media, it is also possible to ask other questions, such as "What tool did the criminal use to start the fire?" and "What did the criminal set fire to?" Using the known-solution questions, it is possible to confirm in the CIT whether the examinee recognizes particular crime-related facts. Examiners usually add searching questions to gather more information about the arson, such as "Where did the criminal obtain the means for starting the fire?" and "When did the criminal make preparations to start the fire?" In that hypothetical case, the examiner may determine that the examinee recognized that the fire started in the linen room, the criminal used heating oil to spread the fire, and the criminal bought the oil at a gas station. If so, from the known-solution questions the CIT can provide evidence that the examinee recognized criminal facts that were consistent with previous results of the investigation. From the searching questions, the CIT can also provide evidence that the examinee recognized new information that were not revealed in detail in former investigation. These evidence support the investigation, including interrogations and further prosecutions.

Finding New Evidence

Physical evidence is very important in proper investigations leading to crime prosecution without errors. The CIT is sometimes conducted to obtain new physical evidence—even from suspects who have already confessed. Here, I will explain the unique role of the CIT, which is to induce as-yet unknown information. An essential prerequisite here is effective use of the searching questions.

Let us consider a robbery that involved an attack on a cash transport vehicle. The criminals have already been arrested and confessed their guilt; however, the stolen money and their weapon have not been found. One criminal makes the following assertion: "I robbed a cash transport vehicle using a knife and stole a lot of money. But after leaving the scene of the crime, I became afraid and burned the money." The criminal also states, "I gave the knife I used in the robbery to my accomplice. I don't know where the knife is now." Here, it is important for the criminal investigation to confirm whether or not the statement is true and to locate the stolen money—if it still exists—and the weapon used. In such a case, the investigators have to request a CIT, and the examiner poses questions, mainly searching questions. Like the investigator, the examiner does not know the correct answer to the questions. Thus, the questions have to include various possibilities as follows:

Q. Where is the stolen money now?

1. Your home
2. Your parents' home
3. Your workplace
4. Contract warehouse
5. Other places (e.g., bank, a friend's home)

Q. How did you dispose of the weapon?

1. Threw it away
2. Hid it
3. Buried it
4. Sunk it
5. Other ways (e.g., sold it, gave it to someone)

The examiner is also able to gain details about the location using a map or drawing. The examiner can ask other questions, such as "When did you dispose of the stolen money?" and "How much stolen money did you have?" These CIT questions are asked to confirm whether the criminal offers different information from that in their previous statement; in addition, new results may emerge that could lead to the stolen money and weapon. In this hypothetical case, the stolen money could be found in the space below the roof of the home of the suspect's parents and the weapon could also be found in a side ditch near the suspect's home. That being the case, the investigators could obtain strong evidence by further investigations following the CIT. That is one of the benefits of the Japanese CIT.

Identifying a Target Crime

There are some cases in which using ordinary criminal investigations, it is not possible to determine the nature of the crime that occurred. In such cases, it can be quite difficult for investigators to obtain a clear picture of the crime, and investigations consume considerable effort and time. Because the CIT can identify facts by asking various possibilities among various crimes, it can be used to help resolve the situation by identifying how the suspect recognizes the facts related to the crime. Here, two hypothetical cases illustrate how the CIT may be used in such cases.

The first example is a burglary, in which the thief stole a ruby ring from a house. The burglar left a footprint in the house: because of its small size, the footprint was thought to have been made by a woman. After a few weeks, the investigators found a potential suspect, who sold the stolen ring to a recycle store near the house. When the investigator asked the suspect how he got the ring, the suspect insisted that he found the ring on the road. It is necessary to determine what crimes the suspect is potentially guilty of. Even if the suspect told the truth, he has violated the law related to embezzlement of lost property. Some people may consider that he had told the truth because he had already made an admission against himself. Others might think that he burglarized the house and stole the ring. If that were true, he would have committed a burglary. However, the fact that the footprint left at the crime scene is too small for an adult man complicates the situation. It is possible that he worked with a woman accomplice or that he has an unusually small foot. Thus, the point is not just whether or not he committed the burglary. If he acquired the ring from someone knowing that it was stolen, he would have to be charged with receiving stolen property. In such a situation, police investigators have to conduct a thorough investigation to determine the truth.

The CIT is able to demonstrate its utility in this kind of case. The CIT can narrow down a fact from potential possibilities. For example, we could put the following question to the suspect:

Q. How did you get the ring?

1. You received the stolen ring from someone without paying anything
2. You paid money to get the stolen ring
3. Somebody asked you to dispose of a stolen ring
4. You stole the ring yourself and did it alone
5. You stole the ring together with an accomplice
6. You got the ring in some other ways (e.g., asked someone to steal it for you)

If the suspect continued to insist that he found the ring on the road, he would answer no to all question alternatives. The CIT examiner usually uses combinations of questions to identify what the suspect knows in detail. To confirm whether the suspect has certain recognitions related to the burglary, the examiner could ask such questions as "Where did the burglar steal the ring?" "How was the ring stored in the stolen place?" and "How did the burglar enter the crime scene?" To reveal whether or not the burglar had one or more accomplices, the examiner could ask such questions as "How many people took part in this crime?" and "What is the relationship between you and the accomplice?" In this hypothetical case, the examiner could judge that the examinee knew the situation as follows: the examinee entered "from a window," "stole the ring alone," found the ring "on a living room table," the crime took place "in a house near the station," and "at the beginning of May." Consequently, the examinee may confess his guilt, and his confession may reveal that he put on his wife's shoes because he set off in a rush. It should be noted that crimes always happen in an unpredictable way.

Another hypothetical example is the case of an old woman being found dead on her bed in her apartment. The investigators were unable to determine the cause of the woman's death because her body had already decomposed, and the hospital records could not identify a possible cause. Her son seemed to know something about the incident because he sometimes visited her and took care of her. But he stated that he had been unaware of her death until the apartment owner called him to inform him. The woman might have died alone because of disease or age; however, other possibilities could not be excluded. To confirm the situation, the CIT could be conducted with the son. The examiner could ask the following question to narrow down the possibilities:

Q. How were you involved in your mother's death?

1. Despite being responsible for her protection, you neglected her.
2. You left her for dead and did not report the incident.
3. You aided her suicide.
4. You killed her.
5. You helped bring about her accidental death.
6. You were involved in other ways (e.g., asked someone else to kill her).

The examiner can also ask additional questions, such as, "When did you first become aware of her death?" and "What did you do upon finding her body?" In this hypothetical case, the examiner may succeed in determining that there had been abandonment of the dead body: the examinee found her body a month earlier but decided not to report the death so as to obtain her pension; the son bought some air fresheners and set them in the room to conceal the death. After the CIT, the investigators might obtain his confession and records of security camera showing him withdraw her pension. Sometimes, it is possible to obtain the facts in this way.

Screening of Involved People When Searching for a Criminal

If a crime occurs in a school or workplace, investigators sometimes need to suspect people at that location. If an employee was working at a company that received a threatening letter, that employee would want the police to arrest the criminal as soon as possible: the employee would not want to be suspected and would also not wish other innocent employees to be suspected. If the letter contains information known only to employees, there is a high possibility that the criminal is an employee with a grudge against the company. However, sometimes it is hard for investigators to screen for potential suspects owing to lack of evidence. To promptly search for clues in such a case, examinations using the CIT may sometimes be conducted on many company employees (most of them are presumed innocent) to screen for potential suspects.

In this hypothetical case of intimidation, word has already gotten around about the threat within the company. Everyone at the company became aware of the threat in the form of a letter written to a representative director, which was typed and posted to the company in a brown envelope. The sender threatened to kill someone unless the director resigned. There were 15 employees at the small company, so 14 employees were probably innocent. The CIT can be performed to find one potential suspect among the 15 employees by asking the following questions:

Q. Where was the letter posted?

1. Kyoto
2. Osaka (○)
3. Kobe
4. Nagoya
5. Tokyo

Q. Where did the sender write the letter?

1. Home
2. Workplace
3. Library
4. Café
5. Other places (e.g., train station, friend's home)

The examiner can ask more questions, such as "When did the sender write the letter?" and "What font was used to write the letter?" If the examiner obtains different responses to particular alternatives for each question, the examiner may judge that one particular employee knows the facts about the threat: she wrote the letter at a café near her home a week ago and posted it in Osaka. After the CIT, investigators may identify her with a security camera at the café, which could decisively incriminate her. Such a solution may not arise smoothly without the cooperation of other employees.

Preventing False Charges

As described earlier, the Japanese CIT is mainly conducted to reveal the connection between the examinee and a crime. However, the CIT also plays an important role in showing that no relationship exists between a suspect and a crime, i.e., preventing false accusations. In this section, I introduce a hypothetical case of forced indecency that occurred at night. From behind her on a road, a man suddenly groped a woman's breasts with both hands, and he ran away when the victim screamed. A police officer on patrol found a suspicious-looking man, who was wandering around not far from the crime scene. The man got questioned by the police officer for suspicious behavior, and insisted that he was just walking around for a breath of air and had no knowledge of the assault. Although he denied any involvement, the investigators strongly suspected him because of his behavior. His appearance also matched that of the criminal as described by the victim as he ran away. To confirm the identification of the man, the CIT can be conducted using the following question:

Q. Which part of the victim's body did the criminal touch?

1. Buttocks
2. Thigh
3. Waist
4. Breasts (○)
5. Genitals

Additional questions, such as "Where did the crime occur?" "How did the criminal touch the body?" and "How did the victim react?" can also be asked here so that the examiner can assess knowledge on the part of the examinee. If there are no definite responses to any of the alternatives, the examiner concludes that the examinee does not know the correct answers to the questions.

In this hypothetical case, after the investigators got the result of the CIT, they believed that the criminal had to be a different person, and they decided to continue their investigations in the area. After a while, they arrested a person who matched the victim's description who was molesting another woman. That person confessed to several similar cases. Thus, the initial suspect proved innocent. Even a person who at first appears suspicious sometimes turns out to be innocent. The CIT plays an important role in preventing the false arrest of innocent people and supports investigations as they proceed in the proper fashion.

DISTINCTIVE FEATURES

We have seen that the Japanese CIT is conducted for various purposes using various types of questions. There are in fact many more cases that use searching questions than one might expect. It is no exaggeration to state that extensive use of the CIT for criminal investigations in Japan is enabled by effective use of searching questions; effective use of searching questions in Japan is supported by a unique judgment system—question-focused judgment. In this section, I give an overview of these two features.

Effective Use of Searching Questions

If police in Japan cannot obtain sufficient information through ordinary criminal investigation procedures, they can try to acquire further information using searching questions. As noted earlier, the known-solution question is one in which the answer is known by both the criminal and the police. Conversely, the searching question is one in which the answer is known only to the criminal. I have described previously how and why the Japanese police use searching questions in investigations. In this section, I describe the extent to which searching questions are used in Japan.

For the whole of Japan, there are no representative statistics about the usage rate of searching questions among all polygraph examinations; however, there is one report by Osugi (2014). In that study, I used the data relating to 30 people who were found guilty after the CIT; I obtained the data from CIT examinations I had conducted in the field. The data from those 30 people included questions in which I judged that the examinee had recognition for one of alternatives. Each recognition in those questions was ultimately verified by the examinee based on confessions and other evidence from investigations following the CIT. Each examination comprised about six questions; the total number of questions in all the examinations was 186. The cases involved various crimes, such as theft, indecent assault, hit-and-run accident, and molestation. In that study, I reported that searching questions amounted to 74% of all the 186 questions; thus, searching questions were used much more extensively than known-solution questions. I also observed that the CIT was not conducted using only known-solution questions; 60% of the CITs were carried out using a combination of known-solution and searching questions. I conducted 40% of the CITs using only searching questions. Those proportions may not be representative of use throughout Japan, but they still indicate the heavy, effective reliance on searching questions. For Japanese examiners, using searching questions is quite natural and necessary.

It should be noted that there is a difference between known-solution and searching questions when composing appropriate alternatives. Because the correct answer is unknown when using a searching question, it is sometimes difficult to compose questions with appropriate alternatives. To provide helpful information for a criminal investigation, examiners have to develop potential alternatives that cover all possibilities when creating effective searching questions. Composing inappropriate alternatives sometimes leads to ambiguous results: it is unclear whether the examinee lacked knowledge or if the examinee was unable to find the correct crime-related alternative even though they knew the correct answer. Examiners always try to adopt the broadest possible view when imagining what occurred with a crime, knowing that sometimes truth is indeed stranger than fiction.

Again, it is important here to understand the judgment method applied in Japan—question-focused judgment. The examiners never integrate the responses or results of all questions: they simply assess whether or not the examinee possesses knowledge related to each question. That means that the judgment related to one question does not influence the judgment related to other questions. Thus, even if the examiner determines that the examinee has no knowledge concerning a searching question, that judgment does not entail that the examinee possess no knowledge about the crime as a whole.

Application of Question-Focused Judgment

Effective use of searching questions is enabled by the question-focused judgment adopted in the Japanese CIT. As noted previously, in contrast to the examinee-focused judgment adopted in the typical CIT, examiners in Japan assess whether the examinee possesses knowledge related to each question. In this section, I describe two reasons for the Japanese CIT having adopted question-focused judgment.

The first reason is that memory or recognition is not always perfect. There are complicated cases. Guilty people sometimes incorrectly remember crime-related information (false-memory problem) or forget some detail. An innocent person may sometimes possess crime-related information (information-leakage problem) or imagine a particular possibility based on their experience. Some examinees do not properly understand a question in the CIT even though they have knowledge related to a crime;

others misunderstand the question if it is complicated. Accordingly, to prevent the contamination of accurate memory, Japanese examiners believe they should assess the questions separately. In addition, although it is not possible to control or completely remove such unexpected possibilities, examiners make efforts not to ask inappropriate questions. These efforts may include arranging thorough meetings with criminal investigators; grasping all possible leaked information by checking the media and investigations; confirming the examinees' statement and knowledge in a preinterview; and properly explaining each question and alternative before actually asking the question. However, there are still risks that derive from imperfect memories. It is inevitable for examinee-focused judgment to be influenced by these memory traits. A major error can easily result if questions are inappropriate; that is because all the responses from all the questions put to an examinee are integrated.

In contrast, because the Japanese CIT makes an assessment of the knowledge related to each question independently, examiners do not have to take into account such undesirable influences and interactions in their question-focused judgment. Again, examiners in Japan simply judge whether or not the examinee possesses knowledge related to each question. The results are sometimes difficult to understand because examiners often obtain mixed outcomes: the examinee may have knowledge related to some questions, but not for others; however, this is inevitable owing to memory traits. Japanese examiners consider that determining whether the examinee is guilty or why the examinee possesses knowledge is not the task of the examiner but that of the judge in court.

The second reason is that question-focused judgment provides criminal investigations with more concrete information than examinee-focused judgment. Only one piece of information (whether or not the examinee is knowledgeable) is obtained when examiners assess the result using examinee-focused judgment. However, different pieces of information (e.g., the examinee knows the stolen item, where the crime happened, and when the crime happened) equivalent to the number of questions used are basically obtained when examiners assess the result using question-focused judgment. As noted earlier, searching questions are extensively used in Japan, and the CIT is conducted for various purposes. Question-focused judgment is absolutely essential for those purposes; the information obtained in the CIT can contribute to the criminal investigation in a concrete way. If the investigator obtains a suspect's confession that is consistent with the CIT results without telling the suspect the concrete CIT results, the congruency can assure the credibility of the suspect's confession.

Question-focused judgment is subject to controversy: it sometimes creates a negative impression of being complicated, ambiguous, and not understandable for those who need and expect one clear conclusion. However, it is undeniable that the limited, concrete outcome works functionally in Japanese criminal investigations.

COUNTERING THE INFORMATION-LEAKAGE PROBLEM

Because the Japanese CIT uses searching questions and question-focused judgment, examiners have ways to address the problem of information leakage; that is considered one of the biggest challenges related to the CIT. In this section, I describe two main approaches to countering the information-leakage problem. It should be noted that methods to stop leaking are not examined here. Of course, investigators are educated about not divulging crime-related information to potential examinees and the necessity of preventing information being leaked by the police. However, almost nothing can be done to prevent information being leaked in other ways, such as by media and rumor. Thus, I examine here how Japanese examiners deal with the problem when crime-related information has already been leaked to a certain extent.

The first approach is using searching questions instead of known-solution questions related to the leaked information. Examiners can always ask searching questions because nobody except the criminal knows the correct answer with a searching question. This is an example of a typical burglary. The burglar entered a house by breaking a window and stole money from a chest in a bedroom. The next day, a local newspaper reported the burglary and theft of money from the house. An investigator identified a potential suspect, who lived nearby and asked him to go voluntarily to the police station. On the way to the station, the potential suspect said he had heard about the theft after having read about it in the newspaper and had also heard gossip in the neighborhood. When he stated he already knew that the burglar stole 1 million yen, the examiner should not, of course, ask the following question:

Q. What did the criminal steal?

1. Jewelry
2. Bullion
3. Credit cards
4. Money (○)
5. Business documents

The examiner also should not ask about the amount of money (1 million yen). If the potential suspect stated that he also knew that the money was stolen from a chest in a bedroom, the examiner should also not ask related known-solution questions. However, other questions remain, for which no one except the criminal knows the correct answer, such as how the criminal stole the money and how the criminal disposed of it. The examiner can ask the following searching questions:

Q. How did the burglar take the money out of the house?
1. In his hand
2. In his pocket
3. In his wallet
4. In his bag
5. Other ways (e.g., in a box, thrown from a window)

Q. How did the burglar largely dispose of the money?
1. Spent it
2. Gave it to someone
3. Hid it
4. Deposited it in a bank
5. Other ways (e.g., threw it away, burned it)

The second approach is to use more detailed alternatives without changing the target of the question by dividing the information into smaller categories in a stepwise fashion. Here, I continue the example of the previous burglary. It was revealed that the money was stolen from the bottom drawer of a chest in a bedroom. If the examinee states that he does not know where in the house the money was stolen, the examiner can ask the following question:

Q. From which room in the house did the burglar steal the money?
1. Kitchen
2. Study room
3. Living room
4. Bedroom (○)
5. Storeroom

However, the examiner cannot ask this question if the examinee knows or states that the money was stolen from a bedroom. If so, the examiner can ask about the place in a different way using more detailed alternatives as follows:

Q. From which part in the room did the burglar steal the money?
  1. Wardrobe
  2. Closet
  3. Side table
  4. Chest (○)
  5. Bookshelf

However, the examinee might state that someone told him that the money was stolen from a chest in a bedroom. If so, the examiner cannot use the previous question. The examiner must generate a question using more precise minor alternatives, as follows:

Q. From which drawer in the chest did the burglar steal the money?
  1. Top drawer
  2. Second drawer down
  3. Third drawer down
  4. Bottom drawer (○)

In this manner, the greater the amount of information leaked, the more detailed are the alternatives the examiner must use in the CIT. Even if there is a great deal of information leakage, the examiner can ask further detailed questions, such as "From which part of the drawer did the burglar steal the money?" However, at the same time, the more detailed the alternatives used in the question, the lower becomes the distinguishability in the question. Here, "distinguishability" is defined as how easily the examinee can distinguish each alternative in a question. If examiners use too detailed a question (especially as in the drawer example), they risk a decrease in the distinguishability of the alternative, which may affect the outcome. This means that even if the examinee is guilty, it might be difficult for him/her to recognize the crime-related information owing to low distinguishability. The examinee may have forgotten such detailed information. Alternatively, the examinee may not be able to distinguish each alternative because they are too similar. Thus, examiners should make the questions in a flexible manner, depending on the status of information leakage, statement made by the examinee, and demands of the investigators; they should also take into account such risks when using low-distinguishability questions in the Japanese CIT.

Regarding the use of low-distinguishability questions, Osugi (2014) examined their effectiveness and risks. In that study, two questions, which were different in terms of distinguishability, were selected without distinction of question type (known-solution or searching question) from the field data related to 30 cases, as noted earlier. That study used only data that included questions in which I judged that the examinee had a recognition for one of alternatives; each recognition in those questions was ultimately verified in that the examinee displayed knowledge based on confessions or other evidence from the investigation following the CIT. When the question was composed of alternatives that were distinguishable based on clearly broad categories, the question was defined as having high distinguishability. For example, "ring," "brooch," "earring," "necklace," and "bracelet" were the alternatives for the question "What was the stolen item?" Conversely, the question was defined as having low distinguishability when composed of specific subcategory alternatives that were similar to one another, for example, "ruby brooch," "turquoise brooch," "emerald brooch," "sapphire brooch," and "pearl brooch." I compared the two types of questions (high and low distinguishability) and two stimulus types (crime-related alternative and unrelated alternatives) as within factors. That study measured and analyzed four physiological measures: respiratory speed (RS), skin conductance response (SCR), heart rate (HR), and normalized pulse volume (NPV).

The results appear in Fig. 5.2, modified from Osugi (2014). There are significant differences in the responses between the crime-related alternative and other unrelated alternatives for both distinguishability questions with all indices. Greater responses to the crime-related alternative were evident for the high-distinguishability than for the low-distinguishability question for RS, SCR, and HR; there was no significant difference between the questions in NPV. In that study, the crime-related alternatives for a low-distinguishability question were detected as long as the examinee recognized the crime-related information; however, the responses to the low-distinguishability alternatives were relatively low even if recognized. Osugi (2014) suggested that low-distinguishability-question alternatives would make detection difficult in the CIT. High-distinguishability questions are more desirable for accurate detection. However, depending on the situation of each crime, examiners cannot always use such desirable questions. When making a question with low-distinguishability alternatives, it is important for examiners to understand that the result has limitations.

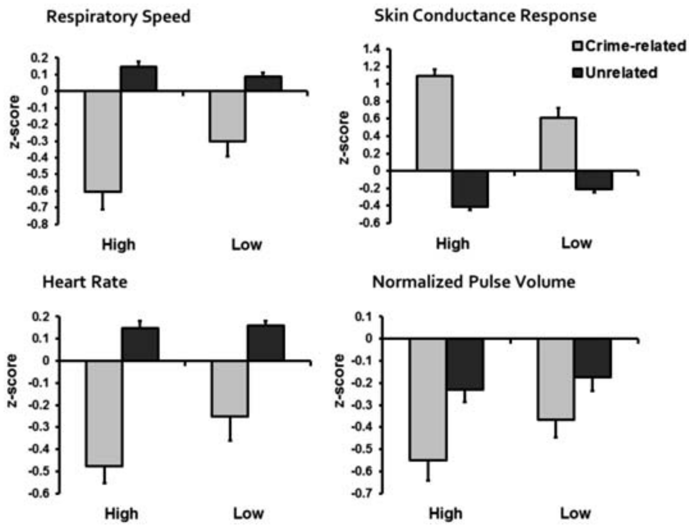

Figure 5.2 Respiratory speed, skin conductance response, heart rate, and normalized pulse volume z-score means for the crime-related alternative and unrelated alternatives in both high- and low-distinguishability conditions. Error bars indicate standard errors. *(Modified from Osugi, A. (2014). Review and analysis of the practical data conducted in Japanese criminal investigation.* International Journal of Psychophysiology, 2*(94), 131.)*

DIFFERENCES AND SIMILARITIES BETWEEN FIELD AND LABORATORY IN JAPAN

Whether or not differences exist between laboratory research and field application of the CIT has been an open question among researchers. Through numerous laboratory studies, it has been accepted that the CIT is theoretically valid (Verschuere et al., 2011); however, the external validity of those studies has yet to be proven because of the lack of proper field research (see Chapter 3). Fortunately, in Japan, the CIT is conducted for criminal investigations on a daily basis (e.g., Hira & Furumitsu, 2002; Nakayama, 2002; Osugi, 2011); some studies have compared the results of laboratory experiments with those of field examinations, and they have investigated the external validity of CIT studies (Osugi, 2010; Zaitsu, 2016).

Osugi (2010) reported the results of three comparisons using data from laboratory experiments and field examinations. In that experiment, 16 healthy police members participated; a card test (practice session) and mock-crime CIT were conducted. In the card test, the participants were asked about five numbers, including one they had chosen and memorized beforehand. In the mock-crime task, they were asked where they had stolen money from, e.g., bag, jacket, or notebook. In the field examination, 16 data sets from 16 polygraph examinations were selected. All of the data included assessments in which the examinee had particular knowledge; the judgments were shown to be correct after the examination because of the examinee's confession or physical evidence from the criminal investigation. The card test was also conducted using the same procedure as in the experiment; the real-crime CIT was performed for each examinee who committed various crimes, such as theft, hit-and-run accident, injury, snatch theft, and indecent assault. Each examination consisted of five or six questions related to the individual crime; among those questions, one question was chosen at random for the comparison. In the case of multiple questions that confirmed the examinee's recognition after the examination, the first encountered question was selected. In both the experiment and field examinations, RS, SCR, HR, and NPV were measured and analyzed as indices. Using those data, the following three comparisons were made: comparison 1 (card test vs. mock-crime CIT in the experiment); comparison 2 (card test vs. real-crime CIT in the field examinations); and comparison 3 (mock-crime CIT in the experiment vs. real-crime CIT in the field examinations).

Fig. 5.3 shows the RS, SCR, HR, and NPV z-score means for the two stimulus types (selected number or crime-related alternative, and unselected numbers or unrelated alternatives) in the four test conditions (card test in the experiment; mock-crime CIT in the experiment; card test in the examination; and real-crime CIT in the examination, which was modified from Osugi (2010)). The *t* test, which was conducted for each index in each test condition, revealed there were significant differences in responses between selected number or the crime-related alternative and other unselected numbers or unrelated alternatives. Moreover, analyses of variance, which were run in each comparison, showed a significant main effect of stimulus types; however, a significant main effect of the test conditions and interaction of the stimulus types × test conditions was not obtained in all comparisons. Thus, there were similarities between data from laboratory experiments and field examinations; evidently, knowledge of related information is sufficient for detection. Conversely, there were differences between the mock-crime CIT and real-crime CIT in the arousal levels during the test and effect sizes of the *t* test. Skin conductance level (SCL) and tonic HR were significantly higher during the real-crime CIT (SCL, $M = 18.22$ μS, $SD = 8.99$; HR,

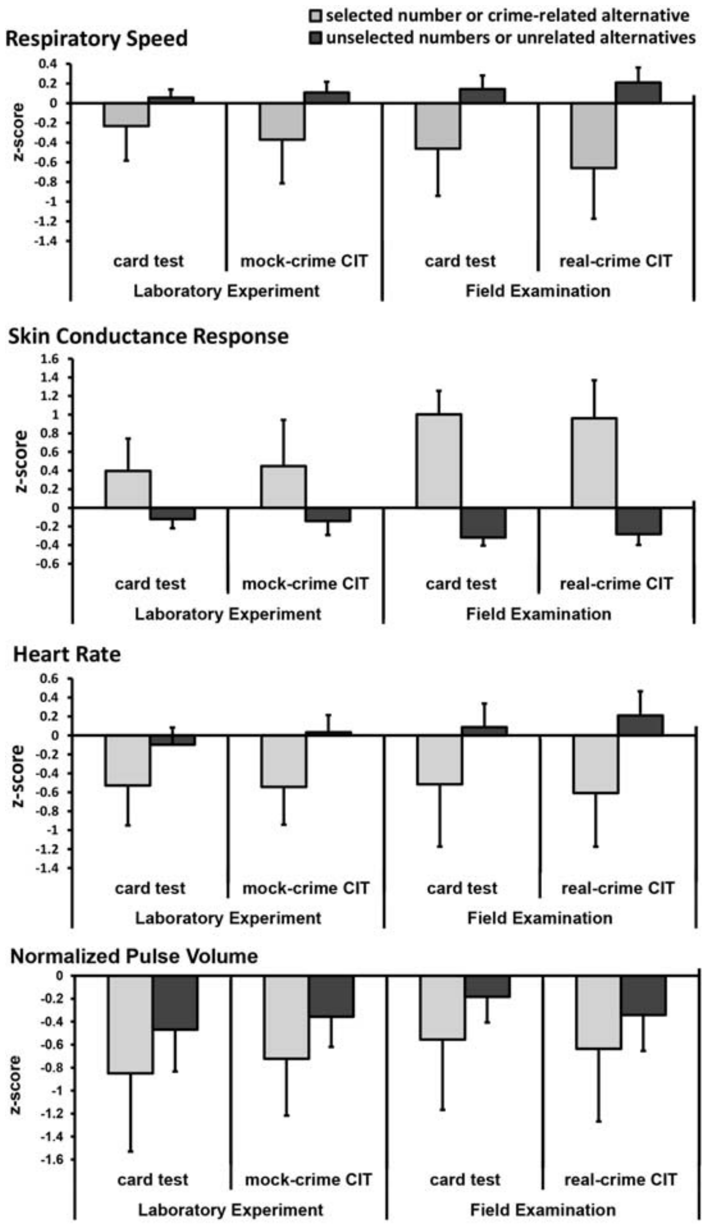

Figure 5.3 Respiratory speed, skin conductance response, heart rate, and normalized pulse volume z-score means for crime-related alternative and unrelated alternatives in laboratory experiment and field examination. Error bars indicate standard errors. *(Modified from Osugi, A. (2010). Gap and connection between laboratory research and field application of the CIT in Japan.* International Journal of Psychophysiology, *77(3), 238.)*

M = 92.81 bpm, *SD* = 16.32) than in the mock-crime CIT (SCL, *M* = 7.63 μS, *SD* = 4.20; HR, *M* = 69.49 bpm, *SD* = 10.34). The effect sizes by Cohen's *d* of RS and SCR were much larger in the real-crime CIT (RS, 2.22; SCR, 3.99) than in the mock-crime CIT (RS, 1.43; SCR, 1.52); those of HR and NPV were not so different between the real-crime CIT (HR, 1.81; NPV, 0.57) and mock-crime CIT (HR, 1.80; NPV, 0.89). It was revealed that these differences did not impede the detection ability of the CIT; however, there may be some differences between laboratory research and field application.

It should be noted that the field data could not be controlled for any settings because they were related to actual investigations, which causes some limitations. First, in that study, only real-crime CIT included various questions from different crimes. That means that such factors as stimulus saliency, distinguishability, and length of question presentation were not controlled; however, those factors could to a certain extent influence the responses in the real-crime CIT. It is difficult to select the same questions used in field examinations, but it might be needed to make a precise comparison. Another limitation is related to the selection of field examinations. It is difficult to confirm all recognitions on the part of examinees based on physical evidences; accordingly, in that study, I included questions that were consistent with the content of the examinee's confession following the CIT. Even though the examinee does not learn the actual outcomes of the CIT, that point could sometimes be controversial. Further studies could change the criteria selected for the examinations. In addition, to arousal level, there may have been differences in such factors as motivation and feeling of threat or punishment. I did not control and confirm those factors in that study; thus, further studies could control those factors in laboratory experiments. At the least, self-reporting to check such differences would be beneficial. Lastly, that study did not include questions in which I judged the examinee did not have recognition or data that were obtained by examinees who were proven innocent after the examination. It is difficult to obtain the no-recognition data that were actually demonstrated as lacking recognition; however, attempts should be made to include such data in the future.

Zaitsu (2016) reported similar results to those that appear above. He compared RS, SCR, and HR between the card test in a laboratory experiment and in a field examination. He concluded that there were no significant differences between the experiment and field examination in

SCR and HR; however, RS suppression to the critical item (selected number) was greater in the field examination than in the experiment. Zaitsu also found differences in tonic arousal levels during tests, but those differences did not impede the detection ability of the CIT.

FUTURE PROSPECTS AND LIMITATIONS

The CIT has been extensively and effectively used in Japan, but there are a number of challenges that should be addressed in the future. In this final section, I briefly describe these challenges toward encouraging the further development of the CIT.

The first issue is to use appropriate statistical assessments when interpreting results in field examinations. The CIT results are mainly based on the examiners' visual inspections (Osugi, 2011); however, it is necessary to apply statistical methods for the field CIT to gain greater validity in scientific circles. Some approaches have been adopted to improve the statistical methods used in the Japanese CIT (Matsuda et al., 2012; Matsuda, Ogawa, & Tsuneoka, 2015; Shibuya, 2011). Matsuda et al. (2012) reviewed various statistical methods; they proposed a flexible, adaptable method called the dynamic mixture distribution method (Matsuda, Hirota, Ogawa, Takasawa, & Shigemasu, 2009). However, some points still have to be addressed (details in Matsuda et al., 2012). More details about the statistical methods appear in Matsuda et al. (2012).

That technical issue is related to another challenge: enhancing the probative value of CIT evidence in court. In Japan, the results of the CIT have sometimes been accepted as court evidence. Such acceptance is, though, infrequent. Even among legal professionals, including prosecutors, lawyers, and judges, there are still many misinterpretations and incorrect comprehensions of the CIT. Unless such individuals properly understand what the examiners are doing when using the CIT and how they should interpret the results, CIT findings may not receive a fair evaluation in court. It is necessary to enhance accurate knowledge of the CIT among judicial professionals.

Of course, understanding on the part of police investigators is much more critical. Without that, CIT procedures cannot be correctly implemented, which may lead to inaccurate results. What the investigators found through their investigations before the CIT and how they controlled information obtained through their investigations are deeply related to the quality of the CIT questions (including both known-solution and searching questions). To better conduct the CIT, obtain more accurate results, and enhance the probative value of the CIT, it is important to educate police investigators who request the CIT and use its results in their investigation. Examiners have educated police investigators to help them understand how they should use the CIT effectively.

Making efforts to gain public understanding of the CIT is also worthwhile. Some people believe that polygraph examinations all take the form of the CQT because that is used most extensively around the world. Other people believe that the CIT is not a real-life method because they see it only on TV or movies; there, the polygraph examinations mostly appear in a way that projects a false image. Individuals who lack information about the CIT may feel extreme fear and unnecessary anxiety if they become an examinee. Ogawa, Matsuda, and Tsuneoka (2013) have reported an 86% correct detection rate (i.e., sensitivity) and 95% correct rejection rate (i.e., specificity, after excluding inconclusive decisions). Those results were based on 167 physiological data sets from mock-theft experiments conducted by 36 expert examiners in Japan. The findings indicate the CIT has quite a low false-positive rate when several questions are administered. Examiners try to dispel myths, present the facts for examinees, and inform the public through various opportunities, such as the present chapter of this book.

Finally, despite extensive application in Japan, it has to be acknowledged that the mechanisms of the CIT have not been fully elucidated. We do not yet comprehensively understand what factors enhance the response to the crime-related alternative and how those factors enhance responses. Further, we do not have clear answers for the following questions: how to make each question less biased; how to deal with countermeasures; and which indices should be combined for easier and faster implementation of the CIT. Further laboratory research should clarify the situation with regard to field application.

In sum, in this chapter, I have introduced field findings of the CIT in Japan. I described various roles of the Japanese CIT and two features supporting those roles using some hypothetical examples and real field data. I hope these explanations help researchers elucidate the mechanisms of the CIT and help other examiners and practitioners in other countries promote effective application of the CIT.

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SECTION 2

Neuroscience Applications

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CHAPTER 6

Effects of Motivational Manipulations on the P300-Based Complex Trial Protocol for Concealed Information Detection

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INTRODUCTION

An issue relevant for the concealed information test (CIT) is the motivational state of the tested subject. Thus it has been noted in many sources that there is a limit on the utility of lab research with the CIT, namely, that subjects in lab experiments are not motivated to the degree that a real suspected detainee in the field is motivated to defeat the test. Such a subject is motivated to preserve his/her freedom, or even life. Thus results obtained in the laboratory may not generalize to the field situation. On the other hand, if it is the case that subjects truly motivated (e.g., by the threat of loss of freedom) to defeat a CIT are easier to diagnose than mock-crime subjects—as is usually the case with skin conductance response (SCR)-based CITs (Meijer, Selle, Elber, & Ben-Shakhar, 2014)—then positive findings in the lab should be even more robust in a highly threatening, real-life situation.

Until very recently, little was known about the effects of motivation on P300-based CITs such as the *complex trial protocol* (CTP; Rosenfeld, Hu, Labkovsky, Meixner, & Winograd, 2013; Rosenfeld et al., 2008). It is important to have such information, because that P300-based CIT protocol is accurate and has unique resistance (although not immunity) to the usual countermeasures (CMs; Meijer et al., 2014; Rosenfeld, 2011). Indeed, the CTP has also been found resistant to more sophisticated CMs such as

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voluntary suppression of memory (Rosenfeld, Labkovsky, Davydova, Ward, & Rosenfeld, 2017; Rosenfeld, Ward, Drapekin, Labkovsky, & Tullman, 2017; Ward & Rosenfeld, 2017). Moreover, the CTP has now been independently replicated with its critical findings corroborated (Lukács et al., 2016).

The CTP represents the second generation of P300-based CITs. The original P300-based CIT, called the "3-stimulus protocol" (3SP; Rosenfeld, 2011; Rosenfeld et al., 1988), was developed to closely resemble autonomic CITs: Rare probe stimuli were presented in a Bernoulli series with frequent irrelevant stimuli. The former represented items relevant to the crime under investigation, such as the murder weapon (e.g., "356 Magnum"), whereas the latter stimulus type, as the name implies, was *irrelevant* to the specific crime, while bearing a categorical resemblance to the probe stimulus (e.g., "9 mm Beretta," "45 automatic," etc.). Because the probes are rare and meaningful for guilty/knowledgeable subjects, they elicit the P300 event-related potential (ERP) in guilty subjects, but not in innocent subjects who lack knowledge of the probe's meaningfulness, and for whom the probe is therefore just another irrelevant stimulus. A third typically utilized stimulus in the 3SP, called the target stimulus, is another irrelevant item, but one requiring a unique response, such as a left-button press (vs. a right-button press for probes and other irrelevants). The target stimulus forces attention to the other items (especially the probes) in the stimulus series, because missing it often would be evidence of noncooperation. Although customarily used, the target, however, is not necessary to assure attention, which may be enforced via preannounced pop quizzes on just-presented (probe or irrelevant) stimuli (Rosenfeld, 2011; Rosenfeld, Biroschak, & Furedy, 2006).

The 3SP was a relatively accurate, first-generation P300 CIT, but it was found quite vulnerable to simple CMs (Mertens & Allen, 2008; Rosenfeld, Soskins, Bosh, & Ryan, 2004), which led to the development of the CTP, which is illustrated in Fig. 6.1. There are two parts to the CTP trial: In the first part, either a probe or an irrelevant (as previously) is presented, and the subject executes Response 1 (always the same left-hand mouse button press) to acknowledge perception of Stimulus 1. About 1s later, either a target or a nontarget (Stimulus 2) is presented, and the subject executes Response 2, which is an actual target—nontarget discrimination response via one of the two buttons on the right-hand mouse. As noted earlier, the CTP is quite accurate in discriminating guilty and not guilty subjects; moreover, it is CM-resistant for reasons hypothesized in Rosenfeld et al. (2008) and Rosenfeld (2011).

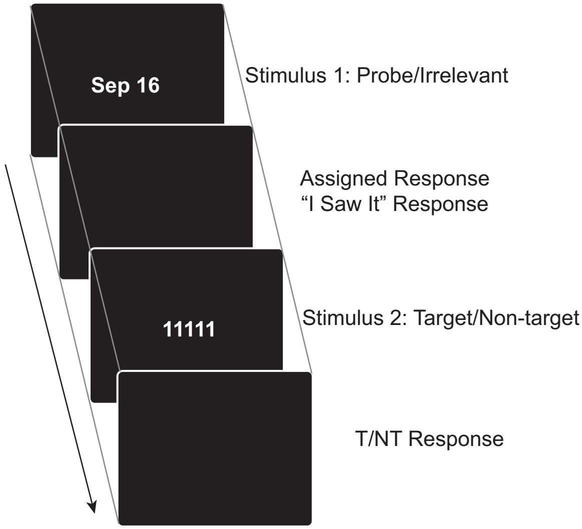

Figure 6.1 The Complex Trial Protocol (CTP) event sequence, with a subject's birth date as Stimulus 1 (S1; probe or irrelevant), then the perception acknowledgement response ("I saw it"), then the target or nontarget as Stimulus 2 (S2), followed by the target—nontarget (T/NT) response. Each stimulus endures 300 ms. The S1—S2 interval randomly varies 1300—1800 ms.

Regarding the effects of motivation on P300 CITs, we first utilized the 3SP (the CTP was not yet conceived) in Ellwanger, Rosenfeld, Sweet, and Bhatt (1996). In this paper, a truth-telling group, instructed only to do their best on P300 (measured from P300 peak to subsequent negative peak, or p-p) tests (involving semantic, as well as incidentally acquired, episodic memory), was compared to a motivated/incentivized "dishonest" group offered $10 to "beat the test." There were no significant P300 differences found, and indeed the sensitivity of the truth tellers was 0.74, versus a similar 0.73 for the incentivized dishonest group. The specificities were both 1.0.

It is important to point out now that the scenario used in this experiment was *malingering of cognitive deficit* (described in the next paragraph). The P300 CIT (3SP) used in this experiment was not originally developed to deal with the malingering scenario, but to deal with concealed information from a crime scene as described earlier. In that scenario, one tests to see if suspects recognize information relevant to the crime, and suspects trying to defeat that test will try to suppress their recognition of *all* probe stimuli. However, neuropsychologist colleagues (especially Jerry Sweet) pointed out to us that it was a natural transition to apply these P300 tests in detecting malingering of cognitive deficit. Thus, malingerers may claim to forget a learned word in explicit behavioral tests, or may claim to forget key semantic self-referring information such as the phone number or birth date, but if the information in question elicits a P300, this provides evidence that the verbally denied item is in fact recognized after all, and thus that the denier is a probable malingerer.

One must bear in mind, however, that the instructions given to malingering subjects regarding how to beat the test are somewhat different than those given to guilty subjects in a forensic criminal situation: As noted previously, the latter subject is encouraged to suppress reactions to *all* probe information. In contrast, sophisticated malingering subjects are typically taught to emulate the behavior of actual closed head-injury patients, by *not* missing correct responses to *all* critical/probe items, but to only about *half* (50%) of them. Thus, although it is the case that in both malingering and forensic scenarios, actual recognition is tested via its P300 signature, the differing tasks in the two scenarios obviate the simple assumption that motivational effects in one scenario apply to the other. Moreover, the results of Ellwanger et al. (1996) were based on the 3SP. The effects of motivational manipulations on the more powerful CTP may not be the same. It is, therefore, necessary to explore such effects independently in the two scenarios. That is, in part, what will be described in the remainder of this chapter. However, there is another level of analysis to consider:

In the pioneering studies of the effects of motivation on autonomic CITs, the instructions to subjects were often similar to the following exemplar (from Furedy & Ben-Shakhar, 1991):

> *Subjects tested under the high motivation condition were told that the experiment was designed to test how well they can conceal their chosen card and avoid detection. They were told that the task is difficult and only people with superior intelligence, strong will and emotional self control could succeed. They were requested to try and avoid detection and were promised a bonus of 1 Shekel ($0.75 at the time of the study) for a successful performance of the task.*

Instructions used in more recent studies from the same lab, such as Klein Selle, Verschuere, Kindt, Meijer, and Ben-Shakhar (2015), similarly, were:

> *You are suspected of having committed a crime. To find out if you are guilty or innocent of the theft, you will take a polygraph test during which we will measure your physiological responses…The test is based on the theory that our physiological responses change when we recognize the items related to the theft. Therefore, your goal is to conceal your knowledge of the items related to the theft and to appear innocent. If you will succeed to come out as innocent in the test, you will get a bonus of 10 NIS [$3.00 US]"*

There appear to be three elements of the motivational manipulation in these instruction sets: Subjects are instructed to (1) defeat the test, (2) achieve this defeat and appear innocent by controlling physiological/emotional responses which accompany "guilty knowledge" recognition, and (3) expect a financial reward for successfully beating the test. One notes, however, that in these two examples (and in many other studies from this eminent laboratory), all the motivational elements are combined such that a positive effect of motivation cannot be unambiguously attributed to any single element, nor combination of elements. In transposing motivational elements for a study of motivational manipulations on the P300-based CTP, our lab decided to study these elements singly and in combination, in both the forensic and malingering scenarios separately, as suggested in the diagram of groups already run or yet to be run shown in Fig. 6.2.

This figure shows three pairs of groups: (1) A baseline simply guilty or simply malingering group (SG/M); (2) the same SG/M group, but told to beat the test and look innocent; (3) the same group as in 2, but additionally, given specific instructions for defeating the CIT. Note that each group can be offered a financial bonus ($$$$) or not be offered a financial bonus (No $$) for successfully defeating the test. However, it is noted that for the guilty control groups (SG/M), the paid condition is represented in blue because it makes little sense to offer a financial incentive without pairing it to some aspect of test performance. However, in the SG/M group there really is nothing it can be paired with without introducing a confound (e.g., one could offer SG/M subjects a reward for being especially accurate in the target—nontarget part of the CTP trial, but then comparisons with other groups would be confounded). Thus, we have no plans to run financially incentivized SG/M subjects, and so there are five groups shown in black in Fig. 6.2 to be run for the malingering and forensic scenarios, a total of 10.

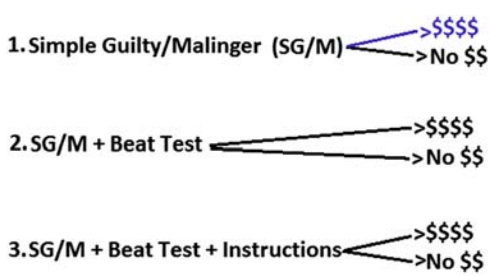

Figure 6.2 Three levels of incentive in CITs; each row/group can be run paid ($$$$) or not paid (No $$).

STUDY 1

We have now published the first study of the 10 shown in Fig. 6.2. We ran the bottom row (3) with the malingering scenario (Rosenfeld, Labkovsky, et al., 2017; Rosenfeld, Ward, et al., 2017). Thus, there were two groups of malingerers (n = 20, 18), both instructed to beat the test, and *how* to beat the test—by making mistakes on only about half the subject-chosen items in the CTP, thereby resembling actual malingerers in field studies. The members of only one of these groups (the $$$$ group) were additionally, offered a financial reward for succeeding in beating the test. Thus, this experiment tested the possibly incremental effect of pure financial incentive, combined with other incentives that were equalized between groups. There were two types of probe tested for each subject, (1) a semantic memory probe, which was the subject's birth date as in Figs. 6.1 and 6.2, and (2) the episodic memory probe exemplified by the experimenter's name learned by the subject upon arrival in the lab. The Test of Memory Malingering (TOMM; Tombaugh, 1996), a study-test protocol, and the current gold standard for tests of memory malingering (Martin, Schroeder, & Odland, 2015; Sweet, Benson, Nelson, & Moberg, 2015), was used to validate that both groups malingered, yet performed differently, so as to confirm a behavioral effect of the financial incentive.

Using the Hilsabeck, Gordon, Hietpas-Wilson, and Zartman (2011) norms, there was no question that the two groups malingered, as no subject scored greater than 92% correct responses. Indeed, both groups scored less on average than 52% correct; yet nevertheless, there were clear differences between groups: The unpaid subjects scored about 45% correct and 49% incorrect, whereas the paid subjects scored about 51% correct and 45% incorrect. This was a significant interaction ($P < .02$). The result shows that the paid group has more honest than malingered responses, but that the unpaid group, in contrast, has more malingered than honest responses. This is consistent with the notion that the *paid* malingering group is paying more attention to malingering instructions (than the *unpaid* group), by being more careful about not malingering too much.

Another strong behavioral performance difference between the two groups was seen in the differing numbers of omit trials (trials in which the time limit lapsed without either an honest/correct or dishonest/incorrect response). We did a t-test on the numbers of omit trials, old and new trials combined, and paid versus unpaid groups. The result was a significant t-value, $P = .03$. Paid participants (Ps) omitted significantly fewer trials than

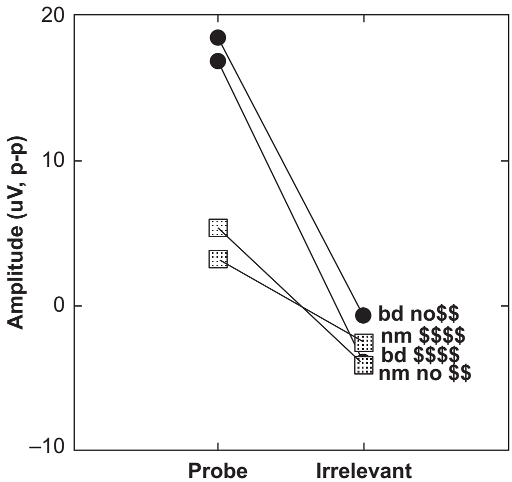

Figure 6.3 Computed P300 amplitudes as a function of group ($$$$ vs. No $$), memory type, nm or name versus bd or birthday, and stimulus type, probe versus irrelevant.

unpaid Ps, suggesting that paid Ps are working harder to follow malingering instructions and thus attending more to the trial's stimulus events than the unpaid Ps.

Despite these clear and expected effects of financial incentive on behavioral performance (in the TOMM), Fig. 6.3 below shows little suggestion of financial incentive on peak-to-peak (p-p) P300 amplitude[1].

The semantic, self-referring birth date (bd) produces steeper slope lines (probe to irrelevant) than the name (nm), but within information type (bd vs. nm) there appears to be no effect of financial incentive.

These qualitative visual impressions were supported by a three-way mixed analysis of variance (ANOVA) on the factors: group (paid vs. unpaid), stimulus type (probe vs. irrelevant), and information type (nm vs. bd). The main effect of group was far from significant with $F(1,36) = 0.58$, $P = .453$, with the Bayes Factor[2] favoring null at 2.5. The within-subject factor of memory type (bd > nm) was significant, $P < .001$, with the Bayes Factor decisively favoring the alternative hypothesis at 3333 (This result was similar to what Ellwanger et al., 1996; reported using the 3SP.).

[1] We measure amplitude as P300 peak to subsequent negative peak, as in Soskins, Rosenfeld, and Niendam (2001).

[2] For 2-level variables we obtain Bayes Factors from http://pcl.missouri.edu/bayesfactor. For higher level ANOVAs, we do Bayesian ANOVAs in JASP (https://jasp-stats.org/).

Likewise, the main effect of stimulus type (probe vs. irrelevant) was also $P < .001$, with the Bayes Factor again decisively favoring the alternative at 25,593. Most importantly, the interaction representing the *CIT effect* (probe-minus-irrelevant difference) as a function of group and the main effect of incentive group (paid vs. unpaid) were both n.s., $P > .4$, with the Bayes Factors supporting the null at 2.91 and 2.5, respectively. Also, stimulus type did interact with memory information type (averaging across incentive groups) at $P < .001$, with the Bayes Factor strongly supporting the alternative at 379,424. This interaction shows that the CIT effect (probe-irrelevant difference) is greater in the semantic nm condition than in the episodic bd condition, as suggested by Fig. 6.3.

We typically use the bootstrap test (Efron & Tibshirani, 1994; Rosenfeld & Donchin, 2015; Rosenfeld, Ward, Meijer, & Yukhnenko, 2016) to diagnose guilt (knowledge) within individuals. Thus we can compare accuracies within an incentive group by comparing numbers of knowledgeable diagnoses, paid versus unpaid groups. There was no significant accuracy difference as a function of financial incentive between the paid and unpaid groups, $P = .896$, Bayes Factor favoring the null at 3.09. These bootstrap data are fully consistent with the amplitude data (Fig. 6.3) and demonstrate the lack of effect of additional (incremental) *financial* incentive on the P300s of subjects in the malingering protocol, who were told to beat the test, and also told how to do so.

STUDY 2

P300 is used as a recognition index in both the malingering and forensic scenarios, and because we had completed two studies of the effect of financial motivation on P300–in the 3SP (Ellwanger et al., 1996) and in the CTP (Rosenfeld, Labkovsky, et al., 2017; Rosenfeld, Ward, et al., 2017; as just described above)– and shown in both these malingering studies that the financial incentive does not have an effect, it was tempting to argue that such incentive would have no incremental value in diagnosing knowledge possession in the *forensic* scenario. However, as noted above, the instructions to subjects clearly differ in these two protocols, so that to find out the effect of financial incentive in the forensic scenario, one really needs a novel independent experiment. Thus, the next CTP experiment we did was exactly like the previously described malingering study, in terms of payoff matrix and motivational manipulations, but it used a forensic scenario involving a mock crime, rather than the malingering scenario. Thus it too was structured as in the third row of Fig. 6.2, but rather than feigning the inability to recall a personal detail (e.g., a birthdate) or an episodic memory (e.g., the experimenter's name), these new subjects were told to commit a mock crime:

> *Go into room 203E, the last door on your left nearest the window as you enter the lab. In room 203E, as you enter, there will be a set of 8 drawers on your left. In the topmost drawer on the left, you will find a padded envelope with a valuable item inside. Open the envelope, take it out, hold it in your hand and rotate it as you examine it from all angles, then put it in your pocket and exit the room without letting the experimenter know which item it is. Return to the room where you signed the consent form.*

The valuable item was a watch for half the subjects and a bracelet for the other half within each of the two groups, the paid and the unpaid groups, who were both told to beat the test and told how to beat the test:

> *In the test, several items will be presented on this screen to you including the item you are suspected of taking. The test is based on the theory that your brain wave responses get bigger when you recognize an item related to the crime. But your goal is to somehow beat this test and look innocent. Therefore, your goal is to conceal your knowledge of the item related to the crime and appear innocent.*

The average ERPs (at Pz) in the two groups are shown in Fig. 6.4.

A plot of the computed probe and irrelevant P300 amplitudes in these two groups (as in Fig. 6.3) is shown below in Fig. 6.5.

The probe-minus-irrelevant differences of p-p P300s in the unpaid group averaged 6.6 μV, as opposed to 6.3 in the paid subjects. This difference was not significant at $P = .214$, with a Bayes Factor of 2.92 favoring null. The CIT effect, measured as the interaction of stimulus type

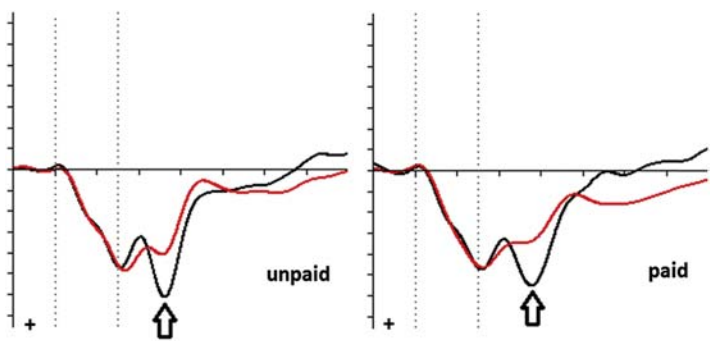

Figure 6.4 Average probe (black) and irrelevant (red [gray in print version]) ERPs in the paid and unpaid groups (n = 16 in each). Arrow shows P300. Horizontal tick marks are 200 ms apart; vertical tick marks are 2 μV apart; and vertical dotted lines show onset and offset of stimuli.

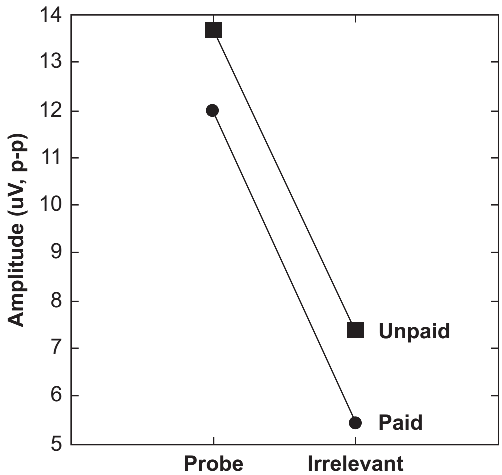

Figure 6.5 Computed P300 amplitudes as a function of group (paid vs. unpaid) and stimulus type (probe vs. irrelevant).

(probe vs. irrelevant) x group was likewise, not significant ($P = .136$), with a Bayes Factor at 1.23 in the null direction, but not adequate to allow a firm conclusion. Thus, as in the first study, we found here no evidence of an incremental effect of financial incentive in the forensic scenario.

STUDY 3

In the next experiment reported here, we returned to the malingering scenario, and, referring to Fig. 6.2, before, we compared the unpaid simple malingering group (SM) in row 1 to the paid malingering group in row 2 (B$) instructed to beat the test (but not told *how* to do this). Again, we used the TOMM test to confirm malingering and to show that the two differentially incentivized groups behaved differently. The table below shows the results in terms of percent of responses in various stimulus—response categories, as a function of group (SM vs. B$), response type (correct/honest vs. incorrect/malingered), and stimulus type, in which old and new refer to previously seen versus novel stimuli in the testing phase of the TOMM.

	Correct		Incorrect	
Group	**Old%**	**New%**	**Old%**	**New%**
SM	46.546	51.182	46.728	42.09
B$	37.09	58.000	54.818	35.636

It is clear that, again, both groups malingered and, as instructed by suggestion, hovered around 50% correct–incorrect classification for both old and new test words. (Of course, in this truly easy test, a nonmalingering group scores well above 80% correct.) It is also seen that the differences between old and new response percentages for both honest (correct) and malingered (incorrect) responses are greater in the B$ group than in the SM group. These effects were statistically confirmed: Old versus new difference percentages were not significantly different ($P > .35$) in the SM group for both correct and incorrect response categories. In contrast, the old–new difference for correct responses differed ($P = .009$), Bayes Factor (BF) = 5.6 supporting alternative for the B$ group. For corresponding incorrect responses in B$, $P = .019$, BF = 2.94 favoring alternative.

Yet, despite these group behavioral differences, Fig. 6.6, below, shows similar old–new, probe-minus-irrelevant, P300 differences within a memory-type category, semantic birthday versus episodic experimenter name.

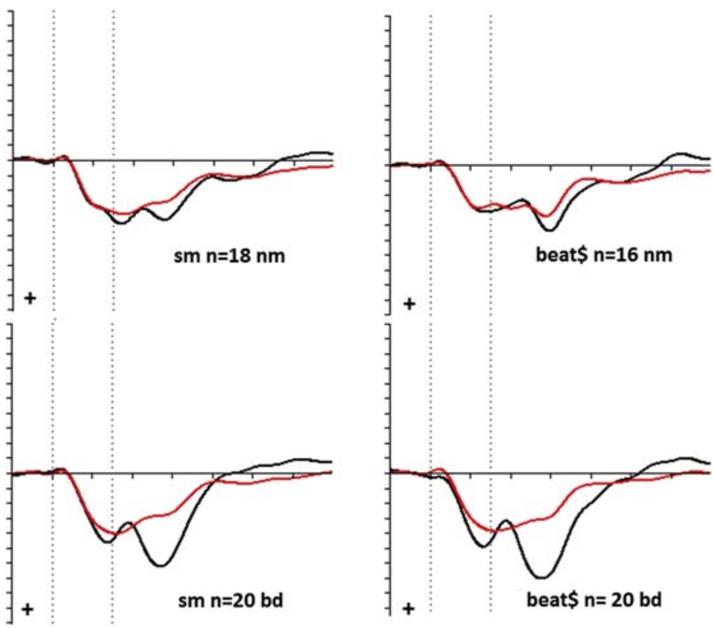

Figure 6.6 Probe (black) and irrelevant (red [gray in print version]) P300s in SM ("sm") and B$ (beat$) groups. Vertical tick marks are 2 μV apart; horizontal tick marks are 200 ms apart. Vertical dotted lines as in Fig. 6.4.

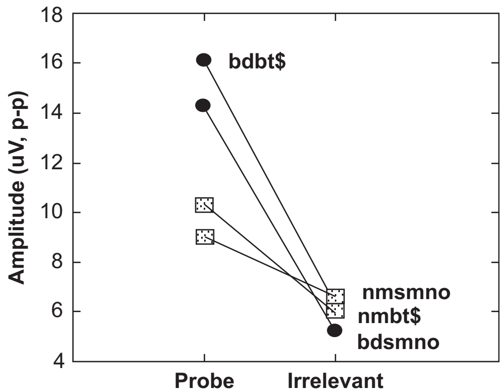

Figure 6.7 Computed P300 amplitudes as a function of group (B$ = "bt$" vs. SM = "sm"), memory type (nm or name vs. bd or birthday), and stimulus type (probe vs. irrelevant). *bdbt$*, birthday—bt$; *bdsmno*, birthday—simple malingering—nonpaid; *nmbt$*, name—bt$; *nmsmno*, name—simple malingering—nonpaid.

The computer-calculated values based on Fig. 6.6 are shown later in Fig. 6.7 (which resembles Fig. 6.3, the first malingering study reported earlier):

Here again, the critical CIT effect difference between groups, which is the interaction of groups with stimulus type (probe vs. irrelevant), was nonsignificant (ns) at $P = .796$, with a Bayes Factor favoring null at 3.9. Thus again, there is no effect of incentive group on probe-irrelevant P300 difference. The group effect was also ns, $P = .657$, BF = 2.8 favoring null. As usual, the effects of stimulus type along with memory type, as well as their interaction, was $P < .001$, with BF > 50, favoring alternative.

Indeed, now we could compare the birthday P300s from the least-motivated simple, unpaid malingering group from Fig. 6.7 ("bdsmno") with the most-motivated paid malingering group in Fig. 6.3 ("BD $$$$"). The result of the comparison, importantly, was an ns interaction of CIT effect × groups, at $P = .94$, BF = 3.7 favoring null. Likewise, the effect of groups was ns at $P = .586$, BF = 2.8 favoring null. Main effects of stimulus type, memory type, and their interaction were again $P < .001$, with BFs > 12 favoring the alternative.

Ultimately, we did a 4 (groups) by 2 (stimulus types) by 2 (memory types) **Bayesian** ANOVA, using all the four malingering groups we ran in both Figs. 6.3 and 6.7. Again, the interaction of CIT effect × (4) groups was ns at $P = .93$ with BF favoring null at 22.6, and the groups effect was

$P = .872$, with BF favoring null at 25. Again there were $P < .001$ effects of stimulus type, memory type, and their interaction, all with BFs > 100 (favoring alternative). To firmly conclude that incentives fail to affect malingering P300s, we still have one more malingering group to run, the malingering group told to beat the test, but not paid, nor instructed about this task. We do not expect an effect of the simple instruction to beat the test with neither "how to" instructions, nor financial incentive, because this same incentivized group *when paid* looks no different than the simple malingering group (likewise unpaid). We are thus tempted to conclude that motivation and incentive do not affect P300s in the malingering CIT scenario.

STUDY 4

The last experiment reported here is similar to the study reported in Fig. 6.7, but is based on a forensic mock crime (rather than a malingering) scenario. That is, we compare an unpaid simply guilty (SG) group in a mock crime, as previously, with a group motivated to beat the test as in Figs. 6.4 and 6.5, but with no pay or instructions. Thus, the only difference between these groups was the suggestion in the latter group to conceal guilt and beat the test as before:

> *In the test, several items will be presented on this screen to you including the item you are suspected of taking. The test is based on the theory that your brain wave responses get bigger when you recognize an item related to the crime. But your goal is to somehow beat this test and look innocent. Therefore, your goal is to conceal your knowledge of the item related to the crime and appear innocent.*

We fully expected, based on all the previously described studies, that there would again be no effect of the motivational manipulation calling on subjects to beat the test. However, Fig. 6.8 suggests otherwise:

It appears that the manipulation of telling mock-crime subjects to try and beat the test resulted in enhanced P300 waves. The 2 (groups) × 2 (probe vs. irrelevant) ANOVA on these data (P300, p-p) produced the usual large ($P < .001$, BF > 800 favoring alternative) effect of the stimulus type. This time, however, the effect of groups was also significant; $P < .02$, with BF favoring the alternative at 3.52. The motivation to beat the test enhanced both probe and irrelevant P300s. But, most importantly, the key CIT effect × group interaction on the p-p P300s was not significant ($P = .17$, BF = 1.4 favoring null, but not strongly supportive, being close

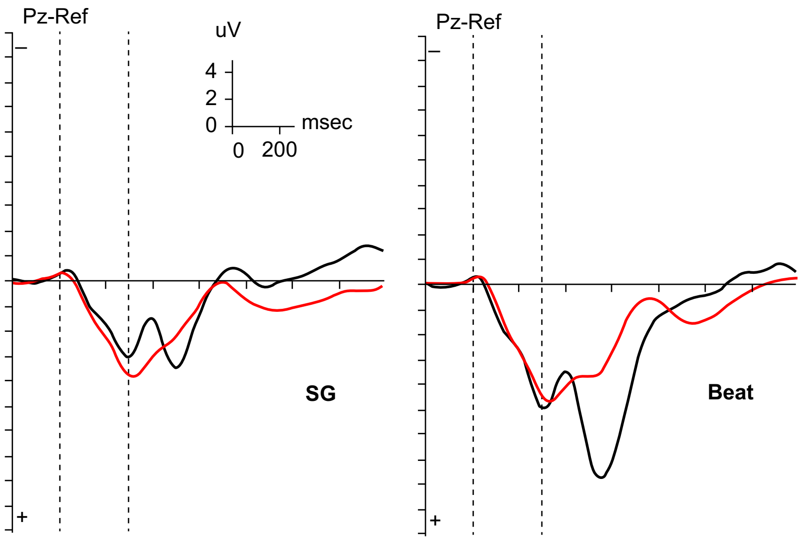

Figure 6.8 P300 waveforms for SG (left, n = 16) and motivated ("Beat," right, n = 15) groups. Probe is black, irrelevant is red (gray in print version). Vertical line as in Fig. 4.

to 1.0). Supporting the lack of motivational effect, group differences regarding bootstrap detection rate were clearly *ns*, t = 0.225, BF = 2.9 in the null direction. Thus, although the motivational manipulation enhanced both probe and irrelevant P300s, it did not affect detection of concealed information.

SUMMARY AND CONCLUSIONS

It seems rather clear that in the malingering scenario, none of the three motivational elements listed in Fig. 6.2 has an effect. Of course, this figure mandates that there is one further group to run in the malingering scenario: the group told to beat the test with neither financial incentive nor instructions as to how to beat the test, as in Row 2 of Fig. 6.2, *unpaid*. As described previously, we have already shown that the P300s of the group in Row 2 of Fig. 6.2, *paid*, show no effect of financial incentive in comparison to the simple malingering (SM) group, so it seems rather unlikely that reducing incentive via an unpaid group will have an incremental effect compared to the SM group.

In contrast, in the forensic scenario, although there is no additional effect of financial incentive in the comparison of two groups motivated to beat the test and instructed how to do so (Fig. 6.2, row 3), there does appear to be an effect of instructions to beat the test, even with no financial reward (Row 2 of Fig. 6.2, *unpaid*), in comparison to a simply guilty (SG) group. This effect, however, is not on detection accuracy, but on P300 amplitudes of both probes and irrelevants. In the forensic scenario, we also have one further group to run: the group in Row 2, Fig. 6.2, paid to beat the test. We do not anticipate a difference between this group and the same group unpaid, as financial incentive, by itself, has had no demonstrated effect in all these studies. Thus, the sole complexity we anticipate having to account for is the difference between the effect of simply asking a subject to beat the test in the malingering (no effect) versus forensic (apparent effect) scenarios. This detection-irrelevant difference could be attributable to differences in attentional and task demands.

There is a confounded and unintended, trivial interpretation of the differing results in the two scenarios: The beat-the-test group in the malingering scenario reported here was paid for success in beating the test, but the forensic subjects were not paid to beat the test. It is thus possible that the malingering subjects worked harder to beat the test than did the forensic subjects, and were thus subjected to greater demand. Thus, whereas the forensic subjects would be attending more to stimuli in the test-beating condition, leading to larger (probe and irrelevant) P300s in that condition (compared to SG subjects), any attentional effect of the test-beating instructions could be cancelled by the greater demand in the malingering subject. But assuming that this trivial explanation does not account for the data, there are still other attentional and demand-related explanations for the differences:

In the malingering scenario, it is clear that instructions on how to beat the test clearly differ from the test-beating instructions in the forensic scenario: Malingering subjects are manipulated to make errors on only half the items, whereas mock-crime subjects are manipulated to not react to any items in a unique manner. The former task appears more demanding; subjects must keep track of—attend to—their bogus error rates for both probe and irrelevant stimuli, whereas the mock-crime subject has no such requirement. This difference however, does not explain the lack of effect of motivation in the comparison of SM subjects and malingering subjects asked to beat the test, but with no instructions as to how to beat the test (Row 2, Fig. 6.2). However, the results of the TOMM test, given after the P300 CTP tests in Study 3 section (earlier), offer a clue to explaining the results. They suggest clearly that during that test, even uninstructed subjects in the B$ group performed clearly differently than the SM subjects. The result table is reproduced here:

	Correct		Incorrect	
Group	**Old%**	**New%**	**Old%**	**New%**
SM	46.546	51.182	46.728	42.09
B$	37.09	58.000	54.818	35.636

Recall, as seen in this table, that the differences between old and new response percentages for both honest (correct) and malingered (incorrect) responses were greater in the B$ group than in the SM group. It is also seen that the B$ group makes most errors with old words, and is more often correct with new words. (A similar but small and ns trend is also seen for SM subjects.) These data suggest that the psychological tendency which the instructions to beat the test apparently elicited during the TOMM test—the self-imposed tendency to respond differently to familiar versus novel stimuli—was likely in effect during the preceding CTP test. (No possibly supportive behavioral data are available in the CTP, as subjects respond identically to probes and irrelevants in the CTP, Part 1.) On the other hand, in the forensic scenario, the instructions would seem to encourage responding similarly—i.e., minimally—to all stimuli (see previous examples in Introduction section). It appears that (even self-imposed) differential responding would be more difficult than uniform responding, such that the malingering instructions, therefore, generate more demand, apart from financial incentive effects.

However, a more complete account of the difference between effects in the forensic versus malingering scenarios must also account for why there is an enhancement of the P300s in only the test-beating condition of the former. Again, we suggest that the instruction to beat the test increases attention to all stimuli in both scenarios, which would ordinarily increase P300s in groups attempting to beat the test in both scenarios. However, there is additional demand for differential responding in the malingering scenario that could cancel the P300-increasing effect of increased attention. Thus, there is no P300 difference between SM and beat-the-test groups in the malingering scenario, but there is the P300 enhancement attributable to the sole attentional effect in the beat-the-test group in the forensic scenario.

This hypothesis could be supported by reaction-time (RT) data. One would expect a decrease in RT from SG to forensic test-beating subjects, along with increased attention, but not in the SM to the B$ group in the malingering scenario, in which increased demand hypothetically cancels increased attention. Indeed, in the malingering scenario, group average RT changes in ms were trivial (389−372 ms for BD stimuli and 363−364 ms for name stimuli), whereas in the forensic scenario, the change was greater, 405−365 ms. However, these were all independent groups, and perhaps this was why there was no statistical confirmation for these effects. One could compare only the two beat-the-test groups in the two scenarios—a confounded comparison anyway because as noted earlier, one of these groups was paid, and the other was not—and with a highly variable index such as RT, this comparison was ns. To compare the changes from SG to the test-beating condition in both scenarios, one probably needs to do a repeated measure study, and this will have to be done in the future. It would have to involve the same beat-the-test condition for both scenarios—either paid or unpaid. Indeed, there would otherwise be a confound which, as just noted, exists in the comparisons suggested here.

It is surprising that financial incentive has no incremental effect in either scenario once subjects are told to beat the test, and told how to do so. This may be because our proffered award of $10 (US) for beating the test may be too small to interest our mostly well-off undergraduates at a prominent private university. Or it may be that the intellectual challenge suggested by inviting subjects to beat the test may be more motivating than financial reward. This is an empirical question requiring further research. Nevertheless, it is reasonable to finally conclude that the effect of financial reward is less in the P300-CIT (forensic and malingering scenarios) than in the autonomic CIT, because in the latter, comparably small reward amounts do affect detection when added to instructions to beat the test, and in instructions on how to beat the test.

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CHAPTER 7

Detecting Deception and Concealed Information With Neuroimaging

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INTRODUCTION

Although there is more than one way to define deception and lying, in this chapter both terms will be used as synonyms, and they will be defined as an attempt to convince someone else to accept as true something the liar believes is untrue. Deception is not a unitary construct, and this definition covers many deceptive situations, from outright lies to the mere omission of information (Vrij, 2008). This definition also includes concealed information situations in which someone wants another person to incorrectly believe that he or she does not have certain information (e.g., someone who denies knowing certain classified information he or she is not supposed to have, or a criminal denying knowledge of crime items).

Human societies have attempted to understand and detect deception for a long time for two main reasons. First, deception is a common and pervasive social behavior (DePaulo, Kashy, Kirkendol, Wyer, & Epstein, 1996; Serota, Levine, & Boster, 2010), so we need to understand deception to fully understand human social behavior. Second, even though deceptive behaviors can be altruistic, often they have negative consequences for individuals and societies (Vrij, 2008), so it is important to find methods to detect such behaviors to prevent or limit their adverse effects.

The methods and paradigms used to investigate and detect deception have ranged from behavioral observation to psychophysiological monitoring, from text analysis to brain imaging (Raskin, Honts, & Kircher, 2014). Despite this broad range of methods and paradigms, studies on deception can be organized along a continuum. At one end of the

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continuum there are more theoretical studies that focus on the cognitive and neural mechanisms of deception, typically at the group level of analysis. Questions that might be examined at this level are whether certain cognitive processes such as working memory or response inhibition are routinely engaged during deception (Christ, Van Essen, Watson, Brubaker, & McDermott, 2009). At the other end of the continuum the focus is more applied, usually on methods to detect deception in single subjects. Typical questions at this level are about the accuracy with which it is possible to tell if a suspect is lying about having committed a specific crime, and the dependence of such accuracy on realistic parameters (e.g., time elapsed since committing the crime, emotional state at the time the crime was committed, and so on). This chapter will review some of the literature on using neuroimaging methods to study deception and to detect it, and will discuss some of the key issues in the field.

DECEPTION AS A NEUROCOGNITIVE FUNCTION

Like all our other cognitive activities, deception is carried out by our brains as we interact with other social agents, which is why it makes sense to turn to neuroscience and to examine the brain to understand deception and to provide potential ways to detect it. For example, episodic and semantic memories required to generate lies (as well truths) are stored in our brains, thus we can leverage what is known about the neuroscience of memory systems. Critically, there are a number of methods from cognitive neuroscience that researchers can use to collect rich spatiotemporal signals from the brain noninvasively, as detailed next, and these signals can be used to try to determine signatures of deception.

There are numerous cognitive theories and models of deception, varying in scope and detail, including Zuckerman's Four-Factor Theory (Zuckerman, DePaulo, & Rosenthal, 1981), Information Manipulation Theory (McCornack, 1992, 1997), Interpersonal Deception Theory (Buller & Burgoon, 1996), Working Memory Model of Deception (Zuckerman et al., 1981), and Activation-Decision-Construction Model (Walczyk, Roper, Seeman, & Humphreys, 2003). Despite their differences, most cognitive theories and models agree on the principle that lying typically, though not always, is associated with greater cognitive load and engagement of social cognitive processes than is truth telling. If we unpack this principle, producing lies typically is associated with a number of neurocognitive processes, though different types of lies may engage different subsets of such processes. First, we must decide whether to lie or not; this may be a process based on a lengthy and explicit cost/benefit analysis, including complex moral and social computations, if there is enough time. Or it may be a very quick and implicit process in the case of lies that have to be generated without warning, and in real time. Second, once we decide to lie, we need to generate the content for the lies. This involves (1) retrieving information from episodic memory and reactivating information from semantic memory so that we can generate plausible deceptive scenarios, (2) maintaining and manipulating relevant information in working memory to ensure consistency during the ongoing session, and (3) encoding this information in long-term memory in order to be consistent in future sessions (especially with novel lies). Third, we need to express or output the lie, usually by means of verbal behavior. This involves inhibiting the corresponding honest response (which is coincidentally retrieved) as well as other potential deceptive responses, and managing the overall social interaction in order to come across as truthful.

Most of these processes have a strong cognitive control component, so the first prediction is that lying should engage prefrontal regions (critical for cognitive control processes) more than telling the truth (Miller & Cohen, 2001; Spence et al., 2004). A second general prediction is that lying should generally engage brain regions involved in social cognition more than truth-telling (Frith, 2007; Mar, 2011).

Note that the exact boundary conditions of these principles are still being delineated (Burgoon, 2015) because there are clearly some situations in which lies may not be associated with higher cognitive load or increased social cognitive engagement than the corresponding truth. For example, a highly rehearsed lie may be associated with lower cognitive load and less engagement of social cognitive processes than the corresponding truth, especially if this truth is about an event that occurred long ago. Likewise, a complex truth that could easily be misunderstood by the other person may lead to higher cognitive load and more engagement of social cognitive processes than a simple lie (Walczyk, Harris, Duck, & Mulay, 2014).

In large part for feasibility reasons, the paradigms used in most neuroimaging studies have focused on a small subset of these processes, especially memory, response monitoring and inhibition processes.

DECEPTION PARADIGMS

The vast majority of paradigms that have been used to investigate deception in neuroimaging studies are variants of differentiation of deception or concealed information paradigms.

Differentiation of deception paradigms contrast conditions that differ in whether the responses to be made are truthful or deceptive (Furedy, Davis, & Gurevich, 1988). In these paradigms, pairs of matched questions are created and participants respond deceptively to one member of the pair, and honestly to the other. If the questions are properly matched and counterbalanced across participants, comparing deceptive and honest conditions should reflect neural processes that are uniquely engaged by deceptive responses, relative to honest responses, so these paradigms have been typically used in group studies investigating theoretical issues. However, matching questions is usually problematic, which is why a variant of this paradigm (the Sheffield Lie Test) uses the same question but asks participants to answer it either truthfully or deceptively in different blocks, depending on a cue (Spence, Kaylor-Hughes, Brook, Lankappa, & Wilkinson, 2008).

Concealed information paradigms, on the other hand, are based on Lykken's original ideas (Lykken, 1959) and attempt to determine if a person possesses memories about events or items of interest but deceptively claims not to possess them. In these paradigms, infrequently presented items of interest that only deceptive participants should be able to recognize (e.g., items relevant for a crime, usually referred to as probes) are compared to frequently presented control items (usually referred to as irrelevants); that is, items that neither deceptive nor honest participants should be able to recognize (e.g., an item that could have been plausibly present at the crime scene, but was not). By definition, probes and irrelevants differ from each other in many more ways than just deception (for example, probes are also more salient than irrelevants as they are infrequent familiar items), which is why these paradigms are not well suited to investigate deception processes per se and they have been used mostly with applied goals in mind.

With a handful of exceptions (e.g., Greene & Paxton, 2009; Sip et al., 2010; Spence, Kaylor-Hughes, Farrow, & Wilkinson, 2008) participants in studies using both of these paradigms have been instructed to deceive, making it difficult to assess some of the more interesting deception processes mentioned earlier, such as deciding whether to lie or not, or devising a lying strategy. A few of these studies have employed mock-crime scenarios in order to try to increase the ecological validity of the paradigms (e.g., Kozel, Johnson, et al., 2009; Peth et al., 2015), though participants were still instructed to lie and knew that the entire situation was fictitious. This raises the question of whether such mock-crime paradigms really bring us closer to ecologically valid situations or whether radically different paradigms should be devised (e.g., Ginton, Daie, Elaad, & Ben-Shakhar, 1982).

NEUROIMAGING METHODS

The main cognitive neuroscience techniques used to investigate and to detect deception have been neuroimaging ones (primarily functional magnetic resonance imaging [fMRI]), the focus of this chapter, and brain recording, mostly electroencephalography (EEG). Additional neuroscience-based methods have been employed to investigate deception, including magnetoencephalography, positron emission tomography (PET), near-infrared spectroscopy (NIRS), and brain stimulation techniques such as transcranial magnetic stimulation (TMS) and transcranial electrical stimulation (TES). However, these methods have been used in only a handful of studies and their findings have not been replicated, so they will not be discussed here (Abe et al., 2006; Karton & Bachmann, 2011; Mameli et al., 2010; Priori et al., 2008; Seth, Iversen, & Edelman, 2006; Verschuere, Schuhmann, & Sack, 2012).

As a neuroimaging technique to study cognitive processes, PET predated fMRI during the late 1980s (Petersen, Fox, Posner, Mintun, & Raichle, 1988). However, it was only after the advent of fMRI in the mid-1990s that neuroimaging methods began to be used to investigate deception. fMRI measures changes in regional cerebral blood flow produced by neural activity (Logothetis & Wandell, 2004). Traditionally, statistical analyses have focused on univariate methods, and brain activation to specific classes of events has been estimated by time-locking the fMRI time series to the onset of the events of interest and by averaging at least tens of trials in order to improve the signal-to-noise ratio (Dale, 1999). More recent analysis methods have enabled researchers to examine multivariate patterns in the data and to take into account single trial effects (Tong & Pratte, 2012).

Analyses of event-related fMRI time series are conceptually more complex than those used for EEG because the fMRI signals are due to hemodynamic changes that unfold over tens of seconds and so are much slower than the actual neural changes measured with EEG (see Chapter 10). Thus, there is significant signal overlap between temporally adjacent trials that needs to be taken into account in the statistical models (Dale, 1999). Furthermore, the low temporal resolution of the hemodynamic signals makes it difficult to implement promising EEG paradigms, such as the Complex Trial Protocol discussed in Chapter 10, that require the rapid presentation of stimuli (Rosenfeld et al., 2008). However, in contrast to EEG methods, fMRI has outstanding spatial resolution, so it can determine the location of brain processes in space with exquisite precision (on the order of a few cubic millimeters). Therefore, fMRI should be the ideal tool to detect pure deception processes (if they exist), as they should be supported by distributed sets of spatially specific neural generators in our brains.

fMRI has been used to study deception since 2001 (Spence et al., 2001), and tens of studies have been conducted on the topic since then (Lisofsky, Kazzer, Heekeren, & Prehn, 2014), as reviewed in the next section.

NEUROIMAGING FINDINGS

Instead of discussing a large set of neuroimaging studies individually, it is more efficient and informative to focus on the results of recent quantitative meta-analyses of the literature. Specifically, three meta-analyses of neuroimaging studies of deception have been published in peer-reviewed journals over the last few years (Christ et al., 2009; Farah, Hutchinson, Phelps, & Wagner, 2014; Lisofsky et al., 2014).

The studies included in these meta-analyses used both variants of the differentiation of deception and concealed information paradigms. Although there is substantial variability in the pattern of activation from study to study (Christ et al., 2009), these meta-analyses converge in reporting a cluster of frontoparietal regions that are more engaged by deceptive than honest responses (Fig. 7.1). Using the Brodmann area (BA) parcellation scheme of the human cortex, these regions include the anterior cingulate and surrounding medial prefrontal cortex (BA 24, 32, 8); the ventrolateral prefrontal and insular cortex, bilaterally (BA 44, 47, 48, 13); portions of the left precentral, middle, and superior frontal gyrus (BA 6, 9, 46); and the inferior parietal lobular and supramarginal cortex, bilaterally (BA 39, 40, 7).

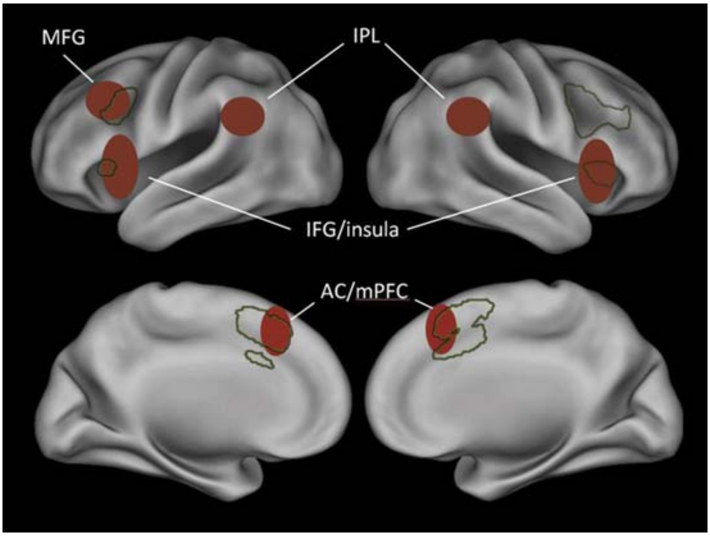

Figure 7.1 In red [gray in print version] are activation foci typically found in meta-analyses of neuroimaging studies of deception: *AC*, anterior cingulate; *IFG*, inferior frontal gyrus; *IPL*, inferior parietal lobule; *MFG*, middle frontal gyrus; *mPFC*, medial prefrontal cortex. The *outlined areas* indicate regions with base rates higher than 0.15.

These meta-analytic findings need to be qualified by mentioning two important limitations. First, they have included only published data, which is problematic due to file drawer issues (Rosenthal, 1979). In other words, results from unpublished studies (e.g., because of null effects or because of results that are difficult to interpret or inconsistent with the existing literature) are not included in these meta-analyses. Second, with one exception, discussed later (Lisofsky et al., 2014), they have ignored potential systematic variability across studies by collapsing results from different types of paradigms (Gamer, 2014). The result is that some regions that are engaged only in a subset of paradigms may not show up in the final results. For example, the amygdala is engaged by deception in some studies (e.g., Ofen, Whitfield-Gabrieli, Chai, Schwarzlose, & Gabrieli, 2017) but not consistently enough to be statistically significant in the overall meta-analyses. Similarly, there is evidence that the type and content of lies affects the resulting pattern of neural activation (Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003; Ito et al., 2012). There is also some metaanalytic evidence that the findings of concealed information tests

(CITs) and differentiation of deception are quite similar (Gamer, 2011). However, only a small set of studies was included in the concealed information meta-analysis, likely violating the assumptions of the activation likelihood estimation meta-analytic framework.

Despite the limitations, these meta-analyses clearly show that there are some large and systematic neural differences between lying and telling the truth across studies. This is an important point that at times has been misunderstood in the literature. For example, McCornack et al. have incorrectly claimed that "no consistent differences exist between the brain scans of liars versus truth tellers during discourse production" (McCornack, Morrison, Paik, Wisner, & Zhu, 2014, p. 368). The key question raised by these meta-analytic results is not whether there are neural differences between lying and truth-telling (there are), but whether the resulting patterns of activation reflect deception-specific or general-purpose processes.

Specificity of the Neural Patterns

The question about specificity of the results has both theoretical and applied implications. On the theoretical side, it is much more difficult to interpret neural patterns with poor specificity, because they could be due to a large variety of cognitive processes (note that the term specificity here is not used in the signal detection theory sense). For example, it's been difficult to determine the precise role of the ventrolateral prefrontal cortex in cognition (e.g., Levy & Wagner, 2011). Furthermore, low specificity of the neural patterns has applied implications for the vulnerability of the methods to cognitive countermeasures (Ganis, Rosenfeld, Meixner, Kievit, & Schendan, 2011), as discussed later in this chapter, because low-specificity neural patterns can also be elicited by intentionally engaging in nondeceptive cognitive processes during the test (e.g., by intentionally altering the perceived salience of stimuli), thus generating false positives.

The question of whether deception is an independent neurocognitive function with a unique neural substrate versus a combination of more general functions that have been studied classically by other subfields in cognitive psychology is an ontological one (Lenartowicz, Kalar, Congdon, & Poldrack, 2010) about the fundamental building blocks of cognition. These types of questions are not unique to the field of deception research. For example, a similar question pervades the field of creativity research: is creative cognition unique or does it rely on the same processes normative cognition relies on, perhaps just applied to a different domain (Abraham, 2013)? Addressing these types of ontological questions is somewhat easier for relatively simple functions such as auditory processing, but it is much more difficult for a complex and multifaceted cognitive function such as deception.

The prefrontal regions found in the deception meta-analyses are part of the general-purpose salience and control networks that have been identified by using intrinsic connectivity analyses of resting state fMRI datasets (Seeley et al., 2007). The salience network, which includes the anterior insula, the dorsal anterior cingulate, and the temporoparietal areas, is thought to be engaged each time there is a behaviorally relevant change in the environment. In contrast, the control network, which includes lateral prefrontal and posterior parietal regions, is thought to deploy and configure neural resources as a result of having detected such a change. Both networks are engaged by a large number of tasks. Thus, according to these initial observations, the prefrontal regions found in the deception meta-analyses are not specific for deception, but they may be engaged during deception just because deceptive statements tend to be more salient and tend to engage cognitive control processes more strongly than truthful statements.

A more formal, though still limited investigation of this question was carried out in a meta-analysis by Christ et al. (2009), which also indicates that most of the prefrontal regions engaged by deception are also engaged by general-purpose cognitive control processes. This was demonstrated by overlapping the results of the deception meta-analysis with those of additional meta-analyses of three classes of cognitive control processes: working memory, task switching, and inhibitory control. Results showed that the left inferior frontal gyrus (BA 44) and anterior insula, the right inferior frontal gyrus (BA 6/44/45) and insula, the left precentral gyrus/middle frontal gyrus (BA 6), the right anterior cingulate (BA 24/32), the right inferior parietal lobule (BA 7/39), and parts of the right middle frontal gyrus (BA 9/10/46) were engaged not only by deception, but also by one or more of these cognitive control tasks. Although these types of general-purpose processes are engaged during most types of deception, they are also engaged by many other cognitive functions that do not involve deception (e.g., manipulating information in working memory while devising a lie, inhibiting representations of the truth, and so on), and so these brain regions are not specific for deception.

A more systematic approach to the question of specificity involves using the concepts of forward and reverse inference, as well as employing large fMRI databases (Poldrack, 2011; Yarkoni, Poldrack, Nichols, Van Essen, & Wager, 2011). These concepts are important to understand the mapping between cognitive and neuroscientific levels and taxonomies. A forward inference involves going from the cognitive level (e.g., conflict monitoring) to the neuroscientific level (e.g., activation in anterior cingular cortex). Thus, a forward inference is the probability that a pattern of neural activation (e.g., anterior cingular cortex) is elicited by a certain mental state (e.g., conflict monitoring). This type of information is obtained in neuroimaging studies, for example, by manipulating conflict level and by determining the brain regions in which activation follows the manipulation.

It is very easy to fall into the trap of reading a forward inference backward, and to infer incorrectly that a certain cognitive process is engaged by a certain pattern of brain activation just because this pattern of activation is typically elicited by that cognitive process. An example of this fallacy would be inferring that conflict monitoring processes are engaged in a certain experimental condition just from the finding that portions of the anterior cingular cortex are activated by that condition. This logic is incorrect, because multiple cognitive states may actually generate that same pattern of brain activation: going from the neuroscientific to the cognitive level entails a reverse inference, calculating the probability that a certain mental state is present, given that a certain pattern of neural activation is observed. According to Bayes' rule (Lee, 2012), a reverse inference requires knowledge of the corresponding forward inference, as well as of the base rates of engagement of the involved mental states and patterns of activation (Poldrack, 2011; Yarkoni et al., 2011).

As mentioned, knowledge about the forward inference is provided by neuroimaging data. On the other hand, estimating base rates requires using information from large neuroimaging databases. The base rate of a brain region's activity is the a priori probability of that region being active. If a brain region is activated by many different tasks, then the base rate for that region will be relatively close to 1 (it would be exactly 1 if the region were activated by any task), which means that observing activation in this region conveys relatively little information about what specific cognitive state elicited it. At the other extreme, if only a single task engages this region, then the base rate for this region will be close to 0, and so observing activation in this region would reveal with very high probability the cognitive state that generated it.

Estimates of base rates for the entire brain were calculated using NeuroSynth, a platform for large-scale, automated synthesis of fMRI data, which relies on a large database of fMRI studies (Poldrack, 2011; Yarkoni et al., 2011). These base rate maps show that the prefrontal regions found in the deception meta-analyses described earlier coincide with regions with the highest base rates in the brain (about 0.2, in this dataset, meaning that 20% of all 3500 studies in the database elicited activation in those regions). These include the anterior cingulate and surrounding medial prefrontal cortex, the anterior insula and parts of the ventrolateral prefrontal cortex, and large portions of the dorsolateral prefrontal cortex (Poldrack, 2011; Yarkoni et al., 2011). Therefore, these regions are engaged by a multitude of different cognitive tasks, and so inferring the presence of deception from their activation is problematic (Fig. 7.1).

There are also two brain regions in the deception meta-analyses that have lower base rates and do not overlap with regions engaged by any of the cognitive control tasks used in the meta-analysis by Christ et al. (2009). These are the inferior parietal and supramarginal foci mentioned earlier, which have an average base rate of about 0.1 or less. What could be the role of these parietal regions? One meta-analysis may provide some insights into this issue (Lisofsky et al., 2014). In this meta-analysis, the studies were divided according to whether the paradigm had low or high social interactivity. An example of a paradigm with low social interactivity is the fMRI study by Nose, Murai, and Taira (2009). In this concealed information study, participants were instructed to lie about which card they had chosen and the social component was minimal, in that participants were simply told to perform the task calmly as the investigator tried to determine which card they had picked.

An example of a paradigm with high social interactivity is the one used in a study by Greene and Paxton (2009). In this study, there was a cover story in which participants thought they would be taking part in an experiment on parapsychology involving predicting the outcome of a virtual coin, with remuneration amount contingent on performance. In one condition (opportunity-to-lie), participants had the opportunity to lie because on each trial they reported the accuracy of their guess after the actual coin toss, whereas in another condition (no-opportunity-to-lie) participants could not lie because they had to report their guess before the coin toss. Using the binomial distribution, participants were then divided into a lying group (participants who reported correct guesses more than 75% of the time) and a truthful group (participants who reported correct guesses around the expected chance level of 50%). The effect of deception was assessed by examining the difference in brain activation between the opportunity and no-opportunity conditions in the lying group. The social aspect of this study was clearly stronger than in the other study because participants could spontaneously decide if and when to lie to earn more money and they could try to devise strategies not to appear deceptive (e.g., by not lying on too many trials) based on what they thought the investigator might think.

Critically, the meta-analysis found larger deception effects in four brain regions in the high- rather than low-social interactivity groups of studies: the dorsal anterior cingulate, the right temporoparietal junction, and the left and right temporal poles (Lisofsky et al., 2014). The increased engagement of the dorsal anterior cingulate during deception in socially interactive paradigms may simply reflect the cognitive control role of this region, required by the stronger conflict between deceptive and honest responses when people can decide how to respond and they are expected to behave honestly. In contrast, the right temporoparietal junction and the temporal poles have been implicated in moral judgment and inferring the mental states of others (Mar, 2011; Olson, Plotzker, & Ezzyat, 2007), so their increased engagement may reflect more directly the greater social interactivity requirements of the deception tasks. The engagement of these regions, however, is also not specific for deception.

In sum, the neuroimaging evidence is consistent with the principle that deception is generally associated with increased cognitive control and social cognitive processes. However, the evidence so far also indicates that the patterns of activation are not specific for deception and can be elicited by a number of other general-purpose processes. This aspect of the findings generally agrees with theoretical proposals such as Information Manipulation Theory, suggesting that both lying and truth-telling emerge from more general cognitive processes during communication events (McCornack et al., 2014).

Note that overlap logic discussed here is based on univariate methods that may miss subtle details of the spatial patterns of neural activation. In other words, it is possible that deception elicits unique spatial patterns of activation within broad regions that are shared with general-purpose functions. One way to investigate this issue is by using multivariate pattern analyses (MVPA), methods that provide more sensitive measures of spatial similarity useful to determine whether two conditions engage the same neural populations (Tong & Pratte, 2012). MVPA methods assume that cognitive processes are carried out in a distributed fashion in the brain, examining and comparing the distribution of brain activation across many voxels (Haxby et al., 2001). This type of analysis has been carried out in a handful of studies to try to discriminate activation to deceptive and honest responses (Davatzikos et al., 2005; Peth et al., 2015), but so far it has not been carried out systematically to address the issue of the uniqueness of deception as a cognitive function.

DETECTING DECEPTION WITH NEUROIMAGING

A key issue for any potential applications of neuroimaging methods is whether they are sufficiently accurate for detecting deception in single cases. Given the low specificity and relatively high variability of the neuroimaging findings mentioned earlier, how can we expect to successfully detect deception in single individuals using neuroimaging methods? On the one hand, there may not be neural patterns that are specific for deception per se. On the other, even if such patterns existed, they may not generalize across deception situations.

In order to address these issues, researchers have adopted two strategies. With regard to specificity, potentially applied research has largely ignored the issue under the implicit logic that we only need to identify patterns of neural activity that correlate sufficiently well with deception: neural patterns that are not specific for deception can still be used to detect deception within constrained paradigms. With regard to variability, researchers interested in quantifying single subject accuracy have focused on simple variants of differentiation of deception paradigms (e.g., Davatzikos et al., 2005; Kozel, Johnson, et al., 2009; Kozel et al., 2005; Kozel, Laken, et al., 2009; Langleben et al., 2016; Monteleone et al., 2009) and CITs (e.g., Cui et al., 2014; Ganis et al., 2011; Nose et al., 2009; Peth et al., 2015) to try to maximize paradigm uniformity. Note that the typical pattern of neural activation found when contrasting probes and irrelevants in CIT paradigms seems to be a subset of those patterns identified in the deception meta-analyses (Gamer, 2011), though the exact details vary from study to study. This is consistent with the idea that neural responses to probes relative to irrelevants reflect some combination of the same salience detection and cognitive control processes engaged by many other deception tasks.

Accuracy of Deception Detection With Neuroimaging Methods and Current Limitations

Almost all neuroimaging studies that have quantified classification performance have used simple accuracy measures averaging hit and correct rejection rates (Cui et al., 2014; Davatzikos et al., 2005; Ganis et al., 2011; Jin et al., 2009; Kozel, Johnson, et al., 2009; Kozel et al., 2005; Kozel, Laken, et al., 2009; Langleben et al., 2016; Monteleone et al., 2009; Nose et al., 2009). The average accuracy rate for all studies is around 82% (Ganis, 2015).

Importantly, the most extensive and rigorous study to date using both guilty and innocent groups and a variant of the differentiation of deception paradigm showed an accuracy of only 66%, mostly because of low specificity (Kozel, Johnson, et al., 2009). Such low accuracy rates are probably due to the intrinsic limitation of these paradigms due to the difficulty of properly matching crime and noncrime questions (Furedy, Gigliotti, & Ben-Shakhar, 1994), and suggesting that the accuracy achievable with these paradigms would not be better even with more sensitive statistical methods.

In contrast, a recent fMRI study using a CIT paradigm and signal detection theory analyses on whole-brain multivariate data reported an area under the ROC curve (AUC) of 0.98 (Peth et al., 2015), indicating high discrimination (AUC varies from 0.5 to 1.0), and suggesting that CIT paradigms together with multivariate analyses may be more promising for forensic applications.

Focusing on the CIT only, the average AUC for fMRI studies ($N = 4$) is 0.94 (Meijer, Verschuere, Gamer, Merckelbach, & Ben-Shakhar, 2016). This is numerically higher than the average AUC for CIT studies that have used skin conductance responses, which is 0.85 (Meijer, Selle, Elber, & Ben-Shakhar, 2014).

However, even if it was possible to achieve perfect accuracy with neuroimaging methods under ideal circumstances, there are at least three limitations that seem difficult to overcome.

Distinguishing Guilty Knowledge From Mere Knowledge

One reason why neuroimaging is especially promising is that it measures tens of thousands of time series from the brain, and these multivariate signals can then be analyzed with machine learning algorithms to identify subtle differences in the neural signatures between deceptive and honest cases. In contrast, with skin conductance, for example, researchers usually collect only a single time series, so the range of analyses that can be conducted is much more limited because there is no spatial component to the data. Polygraphic measures such as skin conductance (Gamer, 2010; Gamer, Kosiol, & Vossel, 2010) have not been able to distinguish systematically between guilty knowledge (i.e., knowledge individuals acquired while committing a crime) and mere incidentally acquired knowledge (i.e., knowledge individuals acquired through other means, such as being a simple witness or due to a media leak) so the hope was that this would be possible by using richer neuroimaging measures.

An fMRI study tested this idea directly by comparing brain activation in three groups: guilty action, guilty intention, and informed innocent (Peth et al., 2015). Participants in the guilty action group carried out a mock-crime scenario involving the theft of money and a CD and were subsequently tested. Participants in the guilty intention group were instructed to carry out the mock-crime scenario, but they were stopped just before engaging in it and immediately tested. Finally, participants in the innocent group were informed about crime details engaged in some errands involving some of the same items that were used for the mock-crime scenario. Thus, the main difference among the groups was the context in which the information was acquired, and the rationale for the study was that neuroimaging may be able to pick up subtle differences in brain activation due to contextual effects. Analyses involved both traditional univariate measures and multivariate methods. Results showed that multivariate analyses using information from the whole brain were generally very accurate in classifying known and unknown items (though not uniformly so across conditions), with an area under the ROC curve of 0.98 for distinguishing known items in the guilty action group from unknown items in the informed innocent group. However, it was not possible to discriminate reliably above chance between known items in the different groups. Therefore, even using information from the whole brain and more sensitive multivariate analyses, it is not possible to determine if an individual has crime information due to taking part in the crime, versus having mere knowledge of it.

Deception Countermeasures

In realistic situations, potential suspects are likely to be motivated to beat deception detection procedures by using countermeasures. A classic countermeasure that works with the Control Question Test and polygraphic measures involves increasing arousal intentionally by biting the tongue right after control questions, so as to reduce the difference between comparison and relevant questions (Honts, Raskin, & Kircher, 1994). Physical countermeasures of this type do not work with fMRI because it is very easy to spot motion artifacts.

However, mental countermeasures that rely on inducing specific changes in the pattern of brain activation during certain parts of the scan can be highly problematic as they may be difficult to detect. Indeed, fMRI work on this topic has shown that mental countermeasures can drastically reduce the accuracy of deception detection methods during a modified CIT (Ganis et al., 2011). This was not very surprising, given the low specificity of the patterns of brain activation for deception. In the main condition of this study participants lied about their own date of birth whereas in a second condition they were instructed to use countermeasures during a subset of the irrelevant dates. The countermeasures consisted of specific actions (imperceptibly moving the index finger, middle finger or left toe) to be carried out upon seeing three of the irrelevant dates, as done in previous EEG work (Rosenfeld, Soskins, Bosh, & Ryan, 2004). The main purpose of these actions was to increase the saliency of the irrelevant dates in order to make them more similar to the probes. When participants with concealed information used these countermeasures, sensitivity fell from 100% to 33%, indicating that these methods are quite vulnerable to cognitive countermeasures. Note that even though this countermeasure involves making specific imperceptible movements with one's fingers and toes in response to irrelevants, it is not a physical countermeasure in the classic sense. This is because there is only covert movement involved and the covert movement per se is not the reason why the countermeasure works, in contrast to the direct increase in physiological parameters brought about by physical countermeasures such as pressing your toes to the floor, or biting one's tongue. This point is important, because at times this countermeasure has been misinterpreted as a physical countermeasure that simply produces a motion artifact in the fMRI data.

Recent fMRI work using standard face recognition tasks indicates that attentional and memory countermeasures can have a strong effect on neural signatures that are critical for CIT paradigms as well (Uncapher, Boyd-Meredith, Chow, Rissman, & Wagner, 2015). This work showed that multivariate analyses of whole brain activation can discriminate well above chance hits (correctly recognized old faces) from correct rejections (correctly rejected new faces) in single individuals. However, the accuracy of the discrimination was reduced to chance by using memory and attentional countermeasures. On the one hand, patterns of brain activation associated with a new face could be made to resemble that of an old (recognized) face by using a memory countermeasure consisting of associating the new face with similar faces already in memory and in responding as if it was an old face. On the other, brain activation associated with an old face could be made to look like that of a new face by using an attentional countermeasure consisting of diverting attention away from the recognition experience and focusing instead on peripheral perceptual details of the old face, and by responding as if it was a new face (Uncapher et al., 2015). These attentional and memory countermeasures appear to be effective also in standard CIT paradigms (Hsu & Ganis, 2017).

Distinguishing the Truth From What One Believes Is the Truth

An important question is whether neuroimaging methods can distinguish situations in which someone correctly remembers something that really happened (hits) from situations in which someone mistakenly remembers something that did not happen (false alarms). At first sight, neuroimaging paired with multivariate analyses should be in an excellent position to be able to make these fine discriminations because memories are represented in our brains as distributed patterns of neural activation. However, research using standard recognition paradigms has shown that this may not be the case (Rissman, Greely, & Wagner, 2010) because the pattern of neural activity elicited by old items correctly believed to be old (hits) seems to be indistinguishable from that of new items incorrectly believed to be old (false alarms). In this study, this phenomenon could only be investigated for low confidence items, since there were not enough new items participants believed they had seen before with high confidence. However, such low confidence situations may not be uncommon in real situations with long delays between the events of interest and the time of testing.

SUMMARY AND CONCLUSIONS

The neuroimaging findings summarized in this chapter clearly indicate that deception manipulations are associated with replicable patterns of neural activation in frontoparietal networks that can be used both to understand deception processes and to potentially detect them. However, a number of potential issues remain.

First, the vast majority of neuroimaging studies of deception have been conducted using simple laboratory paradigms that minimize the effect of social cognitive processes, starting with instructing participants to lie. Given the complexity of the phenomena at hand, this approach is justified, but progress in this area will require devising new deception paradigms that are more ecologically valid.

Second, it is not clear that any of the observed patterns of neural activation are specific for deception, as similar patterns can be elicited by many other tasks that do not involve deception. Progress toward addressing this issue will involve carrying out systematic studies comparing deceptive and nondeceptive tasks using multivariate analyses that can identify potentially subtle differences in the spatial patterns of activation.

Third, this lack of specificity is one of the reasons why neuroimaging methods are vulnerable to cognitive countermeasures, since neural patterns elicited by deception can be emulated by many other cognitive processes. Progress on this issue will require systematic studies to determine if it is possible to at least identify neural patterns indicating countermeasure use.

Fourth, the accuracy of neuroimaging methods for potential applications is still quite low, on average, and not different from that of much less expensive traditional psychophysiological methods. However, there is some evidence that new methods of analyses of neuroimaging data may substantially improve deception detection accuracy. More research will be needed to confirm these findings and to determine whether they generalize to the field.

Finally, the question remains as to whether advances in neuroimaging methods will be able to distinguish between guilty and mere knowledge, to detect cognitive countermeasure use, and to discriminate between neural representations of events that really happened and events someone incorrectly believes happened.

In sum, deception and deception detection research should continue exploring the full potential of neuroimaging methods by devising novel paradigms and analyses techniques, in parallel with more traditional methods.

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SECTION 3

Ocular Applications

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CHAPTER 8

Detecting Concealed Knowledge From Ocular Responses

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INTRODUCTION

Although the total visual field (i.e., the area for a given fixed head position, where visual signals could be captured by the eyes) spans up to 200 degrees in the horizontal and 120 degrees in the vertical dimension, the area that allows for a fine-grained visual processing with high acuity is very small in humans. The so-called fovea lies at the center of the retina and covers only a small area of approximately 2 × 2 degrees. Thus, in order to allow for a detailed and comprehensive visual representation of the surroundings, we move our eyes approximately three times a second in order to process information from different areas of the visual field. These rapid gaze shifts are called saccades (see Fig. 8.1). Interestingly, such information-seeking eye movements are influenced not only by the low-level properties of the visual scene but also by the observer's mental state. For example, different tasks (Borji & Itti, 2014; Yarbus, 1967) and individuals (Mehoudar, Arizpe, Baker, & Yovel, 2014) generate completely different scanning patterns even when the visual stimulus is identical. In addition to modulating saccades, cognitive processes and mental states also influence other types of oculomotor behavior. First of all, this applies to periods of relative gaze stability (i.e., fixations; see Fig. 8.1) that enable detailed processing of visual input between saccadic eye movements. In addition to low-level stimulus characteristics (Parkhurst, Law, & Niebur, 2002), fixation number and duration were found to depend on motivational states or cognitive operations (Tatler, Hayhoe, Land, & Ballard, 2011). Additional oculomotor acts primarily support other functions, but studies have indicated their susceptibility to cognitive processes. For example, the pupil, which is mainly involved in adjusting the amount of light that enters the eyes, was also found to change its size in accordance to various

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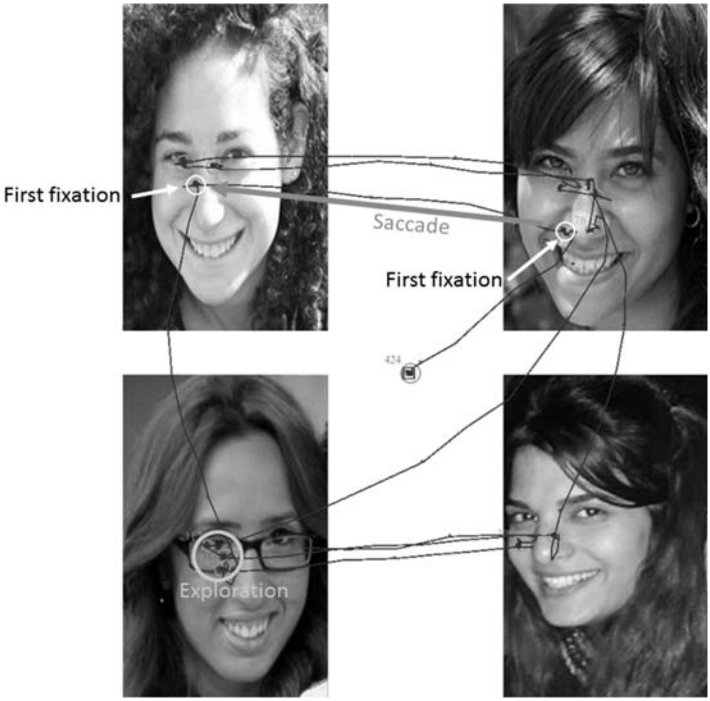

Figure 8.1 Illustration of one participant's scanning pattern of a parallel display of faces. All gaze position samples (one every millisecond) are plotted in black. The *long lines* represent very fast eye movements termed saccades. Fixations consist of a collection of samples on approximately the same location, interspersed between saccades. Fixations are indicated as *circles*, with their diameter being proportional to the duration of fixation. The scanning pattern starts from the middle of the screen and the first fixations on the two faces shown in the top row are indicated by *white circles*. The overall exploration behavior of the face at the bottom left is circled in gray (the four women provided consent for displaying their pictures here).

cognitive processes such as processing load (Kahneman & Beatty, 1966) and attentional demands (Gabay, Pertzov, & Henik, 2011). The pupil's sensitivity to cognitive processes is presumed to reflect fluctuations in the locus coeruleus—norepinephrine system (Aston-Jones & Cohen, 2005), which controls physiological arousal and vigilance. The number of blinks, which lubricate the eyes, was found to be correlated with dopamine levels in the brain, and can reveal cognitive processes underlying goal-directed behavior (Eckstein, Guerra-Carrillo, Singley, & Bunge, 2017).

The links between cognitive processes and oculomotor behavior have been studied for at least two centuries (e.g., Wade, 2015; Wells, 1792) but in recent years, several researchers have examined systematically whether eye movements could be used as a reliable indicator of deception and information concealment. The fact that, similar to other nonverbal cues, oculomotor behavior is often elicited in the absence of awareness (presumably because of the involvement of subcortical pathways; Spering & Carrasco, 2015) bolsters its prospects in such applications. As documented, observers even find it hard to identify their own scanning pattern among others' scanning patterns (Võ, Aizenman, & Wolfe, 2016). Another issue that highlights the promise in using oculomotor measures is the relative ease of tracking the eyes even from a distance, making it very appealing to practical settings. Even unobtrusive recordings of gaze patterns are possible when one accepts some reductions in data quality due to unrestricted head movements or abbreviated calibration procedures (Ohno & Mukawa, 2004). Therefore, it is not surprising that theories and products have emerged that promise accurate and easy ways to detect deception from oculomotor measures. In the next section, we will critically discuss one prevailing theory that aims to describe a clear and simple relationship between eye movements and deception. Then we will review the scientific literature about the use of the various oculomotor measurements described earlier in a more scientifically based method for revealing crime related information—the Concealed Information Test (CIT).

NEUROLINGUISTIC PROGRAMMING

Neurolinguistic programming (NLP) is an approach to communication and personal development that was developed in the 1970s following an examination of the techniques used by several influential therapists at the time. NLP is believed to utilize specific, transferable skills and techniques that lead to efficient human interactions (Bandler & Grinder, 1975). One facet of NLP claims that there is a strong relationship between different directions of eye movements and types of cognitive processes. Moreover, many NLP practitioners claim that it is possible to gain useful insights into whether someone is lying from observing the direction of their eye movements. According to this view, people move their eyes toward their upper left side when visualizing a remembered event while movements toward the upper right side suggest the construction of an event that was not experienced. The former case would thus reflect truth-telling whereas the latter would indicate lying (Gray, 1991). Although many studies in the last 40 years consistently failed to find supporting evidence for this hypothesis (e.g., Elich, Thompson, & Miller, 1985; Witkowski, 2010), such ideas are still prevalent nowadays as indicated by a substantial amount of hits when conducting online searches using "lie detection", "NLP", and "eye movements" as search terms. A recent study has looked specifically at the alleged link between deception and eye movements and did not find any supporting evidence. Both undergraduate students who were instructed to lie, as well as liars in high stakes public settings, were found to exhibit a similar number of eye movements to the upper left and upper right sides (Wiseman et al., 2012). Thus, there is currently no evidence for accurate detection of deception using the NLP procedure.

The fact that the eye movement-deception association advocated by NLP was not observed does not necessarily indicate the absence of any interaction between deception and oculomotor behavior. The EyeDetect (http://converus.com/eyedetect-lie-detection/) product was introduced as an eye-tracking technology to detect deception. This product was pitched to the US authorities as a potential solution to "fears about Syrian and Iraqi immigrants" (Neighbor, 2016) and grounded on several scientific studies that analyzed gaze position during reading of true and false statements regarding the examinee's involvement in illicit activities. Several reading-related measurements as well as pupil size were found to differ between the deceptively denied relevant and truthfully answered control statements. This led to a promising classification accuracy of approximately 85% (see Cook et al., 2012; as well as Chapter 9), but notably, this procedure resembles some characteristics of the so-called Relevant–Irrelevant test (RIT), which was severely criticized in the literature because of relying on improper control questions that can be easily identified by all examinees (Horowitz, Kircher, Honts, & Raskin, 1997). Moreover, all empirical studies on EyeDetect came out of a single research group and therefore further evaluation by other research groups is warranted.

Overall, the aim of revealing deception using eye movements is somewhat clouded by a host of methodological problems that are not unique to eye movements. Specifically, the type of interrogation procedure seems essential to allow for a valid assessment of whether a specific question was answered deceptively or truthfully. Methods that rely on the RIT or its advancement, the so-called Comparison Question test, have been extensively criticized in the scientific community due to various issues, including improper control questions (Lykken, 1974; Meijer, Verschuere, Gamer, Merckelbach, & Ben-Shakhar, 2016). Studies have demonstrated that eye movements might be more promising in a different setting that relies on detecting familiarity with specific visual information. In this context, an assessment of oculomotor behavior might be a sensitive tool to detect concealed crime-related information. After reviewing the literature about the interrelation of eye movements and memory processes in general, we will specifically focus on such applications based on the CIT.

HOW MEMORY AFFECTS EYE MOVEMENTS

About 20 years ago, the group around Neil Cohen began conducting a series of studies to show how eye movements are affected by previous experience. In their seminal experiments, they showed that famous faces were visually explored differently than novel ones. Specifically, famous faces were scanned using a smaller number of fixations with less regions sampled as compared to nonfamous faces (for illustration of visual exploration behavior see Fig. 8.1). These effects emerged early in the viewing period (i.e., within the first seconds) and did not depend on the explicit task of providing familiarity judgments (Althoff & Cohen, 1999). Subsequent studies demonstrated that this eye movement—based memory effect also occurs for recently learned faces (Heisz & Shore, 2008) as well as complex scenes (Ryan, Althoff, Whitlow, & Cohen, 2000) and can even be observed during the first fixation, which tends to be longer for familiar as compared to novel stimuli (Ryan, Hannula, & Cohen, 2007).

Another series of studies showed that eye movements reflect memory for relations and associations between items, both in the spatial as well as the temporal domain. For example, when distinct elements of a complex scene were manipulated after an initial encoding phase (e.g., by deleting or adding objects), they received more and longer fixations during a subsequent test period (Ryan et al., 2000; Ryan & Cohen, 2004). This effect also occurred when using artificial parings of faces and scenes (Hannula, Ryan, Tranel, & Cohen, 2007). In this latter study, participants learned associations between single faces and background scenes in an encoding period. In a subsequent test period, one background scene was presented together with three faces. If the previously paired face was present in the display, it received an increased amount of fixation time already 500—750 ms after stimulus onset. In addition to spatial information, the temporal order of fixations also seems to be represented in memory such that scan paths tend to be reproduced when exploring previously learned object constellations (Ryan & Villate, 2009).

Interestingly, several studies have shown that such eye movement—based memory effects can occur in the absence of awareness. Thus, participants were found to fixate edited image regions more, even when they did not recognize that an object was added, exchanged, or deleted in this region (Hollingworth, Williams, & Henderson, 2001; Ryan et al., 2000; Ryan & Cohen, 2004). Moreover, modulations of oculomotor behavior were found to precede explicit memory judgments (Hannula et al., 2007) and also allowed for predicting item selection in recognition tasks (Hannula, Baym, Warren, & Cohen, 2012). On this basis, it was suggested that eye movements might inform explicit memory decisions (Hannula et al., 2007). The implicit nature of these memory effects also sparked intense research in the domain of neuropsychology, especially with respect to studies on amnestic patients. It was observed that although patients with amnesia following damage to the hippocampus (and adjacent medial temporal lobe structures) showed eye movement–based memory effects for previously displayed stimuli, they failed to exhibit relational, or associative, memory in studies using image manipulations between encoding and test phases (Hannula et al., 2007; Ryan et al., 2000).

To sum up, memory seems to have a substantial impact on visual exploratory behavior. On the one hand, previously memorized information is explored less (e.g., fewer fixations, less regions sampled) as compared to novel stimuli in sequential viewing conditions. On the other hand, when familiar and nonfamiliar stimuli are presented simultaneously, the former attract gaze early after stimulus onset (e.g., more and longer fixations). This link between memory and oculomotor behavior seems highly relevant for the detection of concealed information in suspects.

OCULAR MEASURES IN THE CONCEALED INFORMATION TEST

More than half a century ago, David Lykken (1959) proposed to identify criminal offenders by using a radically different approach than popular methods for detection of deception that were used at the time and are still used by law-enforcement agencies today. While measuring galvanic skin responses, he confronted participants who committed a mock crime with specific crime-related details that were embedded into a series of equally plausible alternatives. By comparing the response strength to crime-relevant and neutral test items, he was able to correctly classify 100% of innocent participants who were ignorant of the crime-related details and 88% of the guilty examinees. Since this test specifically relies on detecting knowledge instead of deception, it was originally termed the Guilty Knowledge Test.

Nowadays it is more frequently referred to as the Concealed Information Test (for a review see Verschuere, Ben-Shakhar, & Meijer, 2011). Traditionally, CIT examinations involve measures of autonomic nervous system activity (e.g., electrodermal, respiratory, and heart rate responses; Gamer, 2011), but other measures related to the central nervous system (Gamer, 2014; Rosenfeld, Hu, Labkovsky, Meixner, & Winograd, 2013) or even behavioral responses (Suchotzki, Verschuere, Bockstaele, Ben-Shakhar, & Crombez, 2017) have also been shown to allow for a valid detection of concealed information. Because of this link between memory processes and oculomotor behavior, the measurement of eye-tracking data in CIT examinations has recently sparked interest within the scientific community. Since the effects of memory on eye movement behavior can occur very rapidly and uncontrollably, even in the absence of conscious awareness (Hannula et al., 2010), eye movements afford a powerful tool for detecting memory of crime-related events. The first promising studies in this domain will be reviewed in the remainder of this chapter.

Serial Display of Items

Modulations of oculomotor behavior for stimuli presented serially at fixation typically reveal different memory-related eye-movement effects compared to effects triggered by parallel presentation of several stimuli simultaneously. The typical CIT procedure involves the sequential presentation of items and therefore we start with describing the influence of concealed knowledge on oculomotor measures in such designs. In one study, faces were presented sequentially to participants who had to classify them either as familiar or as unfamiliar (Millen, Hope, Hillstrom, & Vrij, 2017). Among these faces, some were completely unfamiliar, some were only recently learned, and some were highly familiar either because of showing celebrities or because of close personal relationships. Overall, familiar faces were accompanied by a less elaborate scanning pattern consisting of fewer fixations, less regions sampled, less independent clusters of fixations on specific facial features and less fixations on inner regions of the faces (i.e., eyes, nose, and mouth). This pattern also occurred when participants were instructed to conceal knowledge about familiarity by categorizing such faces as unfamiliar. It was, however, significantly more pronounced for deeply learned information (i.e., celebrities and close personal relationships) and largely absent for recently learned faces. Effect sizes for the comparison of concealed knowledge to neutral items (i.e., truthful responses for unknown faces) were medium to large for such highly salient faces.

Using a conventional sequential presentation of CIT items, Peth et al. could demonstrate similar effects within an ecologically more valid mock-crime procedure. In this study, concealed items were also scanned less elaborately as compared to neutral alternatives (Peth, Kim, & Gamer, 2013). This was evidenced by a smaller number of fixations in conjunction with longer fixation durations (see Fig. 8.2). Interestingly, these effects endured after the end of stimulus presentation and were also evident within a 5 s window after stimulus offset when only a blank screen was shown, indicating temporal expansion of memory effects on scanning patterns. Such effects, however, were mainly restricted to central details of the mock crime and partly affected by the participants' arousal during the mock crime, and the time interval between the mock crime and the CIT examination. To calculate the validity of these measurements in differentiating guilty from innocent examinees, the area under the receiver operating characteristics (ROC) curve (AUC) was calculated. This area value varies between 0 and 1 with 0.5 indicating chance classification and 1 reflecting perfect separation of

Figure 8.2 Illustration of the fixation patterns of one guilty (i.e., knowledgeable, upper row) and one innocent (i.e., unknowledgeable, lower row) examinee for the sequential presentation of one crime-related (R) and four neutral CIT items (N1 to N4, items shown in the middle row). Pictures were shown for 5 s each and participants were free to explore the display. *Circles* indicate fixations with the diameter being proportional to fixation duration. It can be clearly seen that the guilty examinee showed a substantial reduction in the number of fixations along with an increase in fixation duration on the relevant item (leftmost item). The innocent examinee did not show such reduced exploration of the crime-related detail. *(Data were taken from Peth, J., Suchotzki, K., & Gamer, M. (2016). Influence of countermeasures on the validity of the concealed information test.* Psychophysiology, 53*(9), 1429–1440. https://doi.org/10.1111/psyp.12690.)*

both groups. Validity estimates (only for central items across all guilty groups) for fixation duration (AUC ≈ 0.67) and number (AUC ≈ 0.72) were smaller compared to autonomic physiological data (AUC ≈ 0.95; acquired simultaneously in the same experiment) but still allowed for a valid differentiation of guilty and innocent examinees. The general pattern of results was replicated using a different mock crime (and correspondingly also a different set of stimuli) but in this case, a reduced exploration accompanied with an increase of fixation durations was evident only during stimulus presentation and no carryover effects to the period after stimulus offset were observed (Peth, Suchotzki, & Gamer, 2016). Validity estimates in this latter study were slightly larger than in the previous study for fixation duration (AUC ≈ 0.73) and number (AUC ≈ 0.83), but again fell below the validity of autonomic physiological data (AUC ≈ 0.88).

Parallel Display of Items

While the conventional CIT procedure employs a serial presentation of items, eye-tracking measures encourage the use of parallel presentation of stimuli to induce visual exploration behavior. Parallel presentation is impractical when using conventional measures as it is presently very difficult to distinguish between the physiological responses to the different stimuli that are displayed simultaneously. However, parallel display of relevant and neutral CIT items does enable the examination of oculomotor behavior with respect to the different items in the display. For example, gaze position was found to be disproportionally directed toward previously encoded faces in comparison to unstudied faces, reflecting the existence of stored representations in memory (Hannula et al., 2012). Interestingly, total amount of direct fixation time even distinguished previously studied faces from faces mistakenly identified as studied. Therefore disproportional fixation time may reflect a relatively pure index of past experience that is not influenced by explicit response strategies or motivations (Hannula et al., 2012). Somewhat constraining the applicability of these findings to CIT, Hannula et al. (2012) instructed their participants to identify the studied face in the display, hence, recognition and response intention could not be differentiated. Moreover, such explicit recognition is not conceivable in field conditions where guilty examinees would try to hide their knowledge. Such concealment was examined in another study that used a more appropriate design for CIT examinations. Six faces were displayed simultaneously in each trial and participants had to select one of them in a simulated police lineup scenario. In one of the conditions one of the faces was a known face, and the participants had to conceal that knowledge and select another face because this person was previously introduced as a friend. The total fixation duration on the concealed faces (familiar, but not selected) was still significantly longer than fixation duration on the nonselected unfamiliar targets (Schwedes & Wentura, 2012). Using the total fixation time as a critical measure of concealed information, 91.9% of unknowledgeable participants and 64.9% of knowledgeable examinees were correctly classified. In a subsequent study, participants accomplished a virtual mock crime that involved stealing six objects. This study replicated the previously observed longer fixation of concealed information that occurred early after stimulus onset (with the second fixation). Furthermore, by using a gaze-contingent presentation of stimuli (i.e., a stimulus is only revealed when the corresponding location on the screen is fixated), it was demonstrated that this effect does not seem to be purely driven by gaze attraction following parafoveal relevance detection but rather reflects deeper stimulus processing after the first detection of critical items (Schwedes & Wentura, 2016). In this latter study, validity estimates ranged between AUC = 0.61 and AUC = 0.69.

Other eye tracking studies have used slightly different approaches to reveal concealed knowledge, building on the findings that gaze is attracted by deviations between the current visual input and the stored memory representation (Hannula et al., 2010; Ryan et al., 2000). In one study, a group of participants assembled a realistic improvised explosive device. Later, the device was displayed but a few central parts were missing. Those participants who assembled the device before fixated on these modified areas of the image more than twice as long as naive participants (Derrick, Moffitt, & Nunamaker, 2010). A simple threshold on the amount of fixation time on the altered regions led to 100% classification accuracy of knowledgeable and unknowledgeable participants. A similar design was used to reveal concealed information of one's identity. Four participants lied about their identity and presented a fraudulent document with their incorrect data during a simulated border screening. During the screening interview, imposters fixated on the incorrect fields (e.g., date of birth) of their documents twice as long as innocent participants (Elkins, Derrick, & Gariup, 2012). Note that the last two studies (Derrick et al., 2010; Elkins et al., 2012) were not published in peer-reviewed journals and involved only a small number of participants. Therefore, any conclusions should be taken with caution, but this line of research seems to be promising and deserves future exploration.

Additional Ocular Measures

Besides providing information on eye movements and fixation positions, eye-tracking systems also record the occurrence of blinks as well as the pupil diameter. Both measures have also been exploited by CIT studies. Regarding blink frequency, it was demonstrated that blinking rate is reduced following the presentation of crime-related details to knowledgeable examinees and a discriminant analysis solely based on this measure allowed for correctly classifying 75% of guilty and 77% of innocent examinees (Leal & Vrij, 2010). While an early study found a rebound effect with increases in blinking rate following the offset of critical CIT details (Fukuda, 2001), two more recent studies reported an opposite pattern with decreased blinking rates even up to 5 s following stimulus offset (Peth et al., 2013, 2016). Interestingly, these delayed effects seemed to be more reliable as compared to differences in blinking rates during stimulus presentation and yielded validity estimates around AUC $\approx$ 0.72. Whereas eye-movement characteristics (number and duration of fixations) were moderately correlated with autonomic responses in the CIT, such correlations could not be observed for the number of blinks (Peth et al., 2013). This finding led to hypothesizing that differential psychological processes underlie the pattern of different ocular responses. Whereas the fixation measures might be more related to an orienting response triggered by recognized CIT items, blinking rates might better reflect cognitive load induced by the recognition of crime-related details or inhibitory processes aiming to monitor or control bodily responses in order to effectively conceal item recognition.

Changes in pupil diameter were also used to infer concealed knowledge in CIT examinations. The width of the pupil can be adjusted by modulatory influences of the autonomic nervous system. Whereas the parasympathetic system can induce a pupil constriction, opposite effects can be triggered by increases in sympathetic activation. In the CIT, it has been observed that the presentation of concealed details elicits a larger pupil dilation as compared to neutral alternatives in knowledgeable examinees (Bradley & Janisse, 1981; Janisse & Bradley, 1980; Lubow & Fein, 1996; Seymour, Baker, & Gaunt, 2013). Although this effect might be used to differentiate between guilty and innocent examinees, it is important to note that pupil diameter is strongly influenced by the amount of light that enters the eyes, thus making it necessary to carefully control visual stimulus material or to use auditory stimulation in the CIT. Furthermore, it has been demonstrated that pupil responses are tightly correlated with skin conductance data (Bradley, Miccoli, Escrig, & Lang, 2008). Therefore, it might be sufficient to record one of these measures in CIT examinations (for further details on autonomic measures in the CIT, see Chapter 1).

Nonvisual Saccades

Most of the research on saccadic eye movements incorporates a visual display that subjects scan. However, saccades are also observed when people are not inspecting any visual stimulus. Studies have shown that the rate of such nonvisual saccades depends on the amount of memory demands required by the task (Ehrlichman & Micic, 2012; Ehrlichman, Micic, Sousa, & Zhu, 2007) and occur even when participants are seated in complete darkness. Tasks that require more difficult retrieval of information from long-term memory (e.g., name words that have a similar meaning to a specified word) can produce more than twice as many saccades as tasks that involve easier retrieval of overlearned material (e.g., the alphabet) or no retrieval demands at all (e.g., press a clicker whenever a specified sequence is detected in an auditory presented sequence of letters).

When a person is asked about specific details of his or her invented alibi but he or she neither constructed nor rehearsed a well-prepared script in memory, there should be a need for an exhaustive search in long-term memory when this person tries to provide a coherent statement. This may be accompanied by increased rate of nonvisual saccades. On the other hand, if the alibi is true, a simple memory search is expected to retrieve the details, leading to a low rate of saccades. Interestingly, a neuroimaging study suggests that even if the alibi is well planned it might still elicit an increased level of saccades since telling a planned lie resulted in a different pattern of brain activity compared to telling the truth, but with some overlap with telling a spontaneous lie (Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003). The authors argued that planned lies still require more demands from long-term memory compared to the truth because planned lies are grounded on less established memory representations.

A study found that the rate of saccades was indeed larger when participants lie about their opinions. The increase was comparable to the increase found between tasks with different requirements regarding long-term memory recruitment (Ehrlichman et al., 2007; Vrij, Oliveira, Hammond, & Ehrlichman, 2015). The parsimonious explanation for these results is that telling a spontaneous lie requires more extensive long-term memory retrieval than truth-telling (Ganis et al., 2003), and saccadic eye movements are positively related to these search processes (Ehrlichman & Micic, 2012). The number of saccadic eye movements in planned lies fell in between those for truths and spontaneous lies, and did not differ significantly from either of them, somewhat constraining the applicability of such tests in situations involving well-planned lies.

FUTURE DIRECTIONS

Oculomotor measures incorporate great promise in detecting memory representations. In recent years, more and more studies that rely on memory research tried to assess the predictive value of oculomotor measures in revealing concealed memories. In light of advances in eye-tracking hardware and software development, this avenue of research has promising prospects in being implemented in practical settings. However, more research is needed in order to better understand the cognitive and neural mechanisms behind variations in different ocular measures related to information concealment, and we lack studies that explore the potential of these measures in fieldlike situations.

First, it is currently unclear which responses reflect pure familiarity and which are related to inhibitory processes linked to the act of concealment. The study of physiological measures in the CIT has started to address similar questions by modifying the instructions (e.g., by requiring participants to conceal vs reveal crime-related information; Klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2016, 2017) or by examining response fractionation in autonomic, neural, and behavioral measures (Suchotzki, Verschuere, Peth, Crombez, & Gamer, 2015). Similar studies are desirable for dissociating these processes in ocular responses.

Second, relying on oculomotor responses opens the door for using parallel as opposed to serial visual displays (which have been used with traditional physiological measures). Indeed, a few oculomotor CIT studies have used parallel displays, but their results are not easily comparable due to variations in different experimental parameters such as the number of stimuli in the display, durations, and tasks (Schwedes & Wentura, 2012, 2016). More direct comparisons between different experimental paradigms are required in order to refine and improve the procedures and reach higher detection accuracy.

Third, although laboratory studies provided evidence for a successful detection of concealed information from ocular measures, their validity still may be limited and falls below the detection accuracy of autonomic, electrocortical, and neuroimaging measures (Meijer, Selle, Elber, & Ben-Shakhar, 2014; Meijer et al., 2016). On the one hand, this could be related to the experimental paradigms of previous studies that were optimized for autonomic rather than eye-tracking recordings (Peth et al., 2013, 2016). On the other hand, standardized procedures to score and aggregate eye-tracking data are still missing. Thus, although information concealment seems to have broad effects on different indices of visual exploratory behavior (e.g., the number, duration, and spread of fixations; the number of regions sampled and revisited; saccadic properties) and additional ocular measures (e.g., blinking rate, pupil width), algorithms are still lacking for combining this information optimally with respect to differentiating knowledgeable from unknowledgeable participants or suspects.

Fourth, in contrast to autonomic, electrocortical, and neural measures, eye movements can be controlled voluntarily, at least to some extent. For CIT applications in field settings, this might impose a significant threat to the validity of the test since examinees might try to alter their pattern of responses in order to appear innocent. Although such countermeasures are also known for other response systems (Ben-Shakhar, 2011), eye movements might be a more direct target for these manipulations. In fact, in basic memory studies, it was shown that participants can sometimes voluntarily suppress early orienting toward memorized faces (Ryan et al., 2007). Interestingly, however, such a don't-look instruction led to an active avoidance of scanning familiar stimuli. Since the CIT does not make assumptions on the direction of differences but rather relies on identifying any differentiation between relevant and neural items, such a pattern would also speak for a recognition of specific stimuli and thus result in the examinee being classified as knowledgeable. It is currently unclear to what degree participants can voluntarily alter their pattern of eye movements in order to simulate a nonsystematic scanning as seen in innocents. One study, however, indicated that countermeasures aiming to enhance the salience of neutral CIT items for eliciting larger autonomic responses to these stimuli also affect eye movement patterns (Peth et al., 2016). Interestingly, physical and mental countermeasures were found to differentially modulate ocular responses, therefore it remains an interesting question for future research whether a combination of different oculomotor indices might (partly) compensate for reductions in validity of single measures.

Finally, most studies on oculomotor behavior in the CIT have been conducted in the laboratory. This situation enables careful control of encoding processes as well as of the stimuli needed for the CIT examination. Since eye movements are also affected by basic visual properties, it remains an important challenge for field situations to select adequate CIT items. Before using ocular responses for detecting concealed knowledge in forensic contexts, future studies are warranted to validate the currently available findings in more ecologically valid situations. First attempts have been made (Derrick et al., 2010; Elkins et al., 2012) but additional studies are certainly required before drawing strong conclusions on the utility of this novel technique for revealing concealed information in field applications.

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CHAPTER 9

Ocular-Motor Deception Test

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The present chapter summarizes the theoretical assumptions that guided development of the Ocular-Motor Deception Test (ODT), the logic that underlies its relevant-comparison test format, and empirical evidence of its criterion-related validity. The chapter then outlines areas in need of research including mechanisms responsible for observed effects on ocular-motor measures and generalizability. Elsewhere, Hacker, Kuhlman, Kircher, Cook, and Woltz (2014) summarize the physiological basis of ocular-motor measures and psychological factors other than deception that can affect those measures.

OVERVIEW OF THE OCULAR-MOTOR DECEPTION TEST

The Ocular-Motor Deception Test (ODT) is an automated psychophysiological test for deception designed for use in a screening environment. A computer presents voice-synthesized instructions followed by written true/false test statements concerning the examinee's possible involvement in illicit activities. The computer informs examinees that if they do not answer quickly and accurately, they will fail the test. The computer then presents a single true/false statement in the center of the screen. The examinee reads the statement and presses a key to answer true or false. Half a second later, the computer presents the next statement. While the examinee reads and responds to test items, a remote eye tracker records eye movements and changes in pupil size 60 times per second (60 Hz). The computer measures response times and error rates, extracts features from recordings of gaze position and pupil size, combines its measurements in a logistic regression equation to compute the probability of deception, and classifies the individual accordingly.

The ODT uses a test format known as the Relevant Comparison Test (RCT). The RCT includes statements about the two relevant issues (R1 and R2). The RCT uses the difference between reactions to the two sets of relevant statements to determine if the examinee was truthful or deceptive

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Table 9.1 A Subset of Test Statements for an Ocular-Motor Deception Test

Type	Statement	Expected answer
Neutral	The sky is blue on sunny days.	True
R1	I was uninvolved in the theft of the $20.	True
R2	I copied the credit card information from the computer.	False
R1	I admit to stealing the cash that was in the secretary's purse.	False
Neutral	I am reading this on a day that is not Sunday.	True
R2	The stolen credit card information is not in my possession.	True
Neutral	Trees that grow in the forest are never harvested for lumber.	False
R2	I made a copy of the professor's credit card.	False
R1	I did not leave the office until I had taken the $20 that was in the purse.	False

to either of the relevant issues. Each relevant issue serves as a control for the other. If the examinee reacts more strongly to statements concerning one of the two issues, the ODT classifies that person as deceptive about that relevant issue. Examinees who show little or no difference in reactions to the two sets of relevant statements are classified as truthful to both issues.

True/false statements about neutral topics are intermixed with the R1 and R2 statements. We designed the neutral statements to require relatively little cognitive effort and an opportunity for recovery from reactions to the prior statement. Table 9.1 contains a portion of a sequence of statements in an ODT.

RATIONALE UNDERLYING THE OCULAR-MOTOR DECEPTION TEST

The ODT is based on two assumptions: it assumes that deception is cognitively more demanding than telling the truth, and it assumes that deception is associated with emotional arousal. The cognitive workload hypothesis appears throughout the literature on deception detection techniques (e.g., Johnson, Barnhardt, & Zhu, 2005; Kircher, 1981; Raskin, 1979; Steller, 1987; Vrij, Fisher, Mann, & Leal, 2006). All examinees must comprehend the test statement, evaluate its relationship with autobiographic memory, and make a motor response. In addition, a deceptive individual must distinguish between two classes of test items: statements answered truthfully and statements answered deceptively. When they recognize a statement as inculpatory, they must inhibit the correct, truthful answer and issue an incorrect, deceptive one, and they must do so consistently, quickly, and accurately over the course of the test. Whereas truthful individuals should attend similarly to the two sets of relevant statements, we expect deceptive individuals to invest more mental effort when they process potentially incriminating statements. While they perform the task, deceptive individuals also may self-monitor their performance for signs that they are revealing their deception, for example, by answering too slowly or by making mistakes.

The recruitment of mental resources to accomplish these additional cognitive and meta-cognitive activities could explain effects on pupil dilation, eye movements, response time, and error rates. For instance, pupil size has been found to covary with level of difficulty on cognitive tasks such as mental arithmetic (Ahern & Beatty, 1979; Bradshaw, 1968), rehearsal of digit strings (Kahneman & Beatty, 1966; Klingner, Tversky, & Hanrahan, 2011), sentence processing (Just & Carpenter, 1993), letter processing (Beatty & Wagoner, 1978), and lexical tasks (Hyönä, Tommola, & Alaja, 1995). Consistent with the cognitive workload hypothesis, deception has been associated with pupil enlargement (Berrien & Huntington, 1943; Dionisio, Granholm, Hillix, & Perrine, 2001; Heilveil, 1976; Lubow & Fein, 1996), and evoked pupil reactions have been found to discriminate between truthful and deceptive individuals in common polygraph test formats (Bradley & Janisse, 1981; Webb, Honts, Kircher, Bernhardt, & Cook, 2009). Research on eye movements have shown that the number and duration of fixations increase and intersaccade differences decrease when people experience difficulty reading text (Rayner, 1998; Rayner & Pollatsek, 1989). If deceptive individuals find it more difficult to read and respond to inculpatory statements, eye movement reading patterns could be diagnostic. Finally, Seymour et al. have published several studies showing effects of concealing information on response times (Seymour & Fraynt, 2009; Seymour & Kerlin, 2008; Seymour, Seifert, Shafto, & Mosmann, 2000). Consistent with the increased workload hypothesis, deception was associated with longer response times.

In addition to association with increased cognitive workload, the ODT assumes that deception is associated with emotional arousal. Whether examinees are truthful or deceptive, they are likely to believe there is a chance they will fail the test, and if they fail, they will experience negative consequences. Whereas deceptive examinees are expected to be most concerned about the subset of relevant test items answered deceptively, truthful examinees should be equally concerned about both sets of relevant statements. Differential concern over the consequences of detection for one or the other relevant issue could contribute to interaction effects on pupil and other physiological measures that distinguish deceptive from truthful individuals. The research by Bradley and Janisse (1981) and Webb et al. (2009) is consistent with the idea that emotional stimuli are associated with sympathetically mediated pupil enlargement (Bradley, Micolli, Escrig, & Lang, 2008), and there is substantial literature on effects of deception on other sympathetically mediated measures in concealed information (Ben-Shakhar & Furedy, 1990; Elaad & Ben-Shakhar, 2006) and probable-lie deception tests (Kircher & Raskin, 2001).

RELEVANT COMPARISON TEST

We originally proposed the RCT as a new polygraph test format for use at ports of entry to screen travelers for trafficking of drugs or transporting explosives (Kircher, Kristjansson, Gardner, & Webb, 2012). The Computerized Screening System (CSS) was not conceptualized as a primary screening system. Rather, we thought it might be used as a secondary or tertiary assessment if there was reason to believe that a passenger posed a threat to other travelers or infrastructure. We tested the CSS in a mock-crime experiment. Some guilty participants transported what appeared to be illegal drugs ($n = 119$), other guilty participants transported a device that appeared to be a bomb ($n = 111$), and a third group was innocent of both crimes ($n = 124$). All participants were instructed to deny involvement in either crime and were promised and paid a monetary bonus if they could pass the test. A laboratory assistant attached the physiological sensors and ran a computer program that presented prerecorded auditory instructions and relevant questions about the drugs (e.g., Did you take illegal drugs from a locked cabinet?), relevant questions about the bomb (e.g., Did you put a bomb in a flight bag?), and neutral questions (e.g., Is this the year 1996?).

Deceptive answers to questions about drugs (R1) or explosives (R2) were associated with increases in skin conductance, systolic blood pressure, diastolic blood pressure, total peripheral resistance, and pupil diameter (PD); and decreases in finger pulse amplitude and respiration, but there were no effects on stroke volume or cardiac output. On cross-validation, mean accuracy of classification into drugs, bomb, and innocent groups was 67.5%. Although an accuracy rate of 67% represents a 34% improvement in accuracy over the chance probability of a correct decision for three groups (33%), decision accuracy was insufficient to recommend use of the CSS as a supplemental screening system at ports of entry.

THE RELEVANT COMPARISON TEST AND RELEVANT—IRRELEVANT TEST

Except in rare circumstances, an RCT would be problematic for specific-incident testing because it would be difficult to identify a credible, unrelated comparison issue for the particular matter under investigation. Reid (1947) once suggested that so-called "guilt-complex" questions about a fictitious crime could serve as a control for the relevant issue. Unfortunately, in an actual criminal investigation, people usually are well aware that they are suspected of involvement in a particular crime long before they are asked to take a polygraph test. By that time, it would be difficult to convince them that they are suspects in another crime. Even if it were possible to convince examinees that the authorities suspect them of a fictitious crime, the value of the guilt-complex question would be short-lived given the ready availability of information about various polygraph techniques on the Internet. Knowing that one of the relevant issues on the test is fictitious would likely cause innocent examinees to focus more on questions that address the real crime, leading to high false-positive rates. For these reasons, though conceptually sound, the guilt-complex question is impractical and rarely used (Ben-Shakhar & Furedy, 1990; Krapohl & Shaw, 2015).

The RCT is not well suited to specific-incident criminal investigation, but it might be used for screening applications. Currently, the US federal government relies on the polygraph for preemployment screening of applicants for positions in law enforcement and for periodic tests of employees with security clearances (DoDPI, 2002). In 2011, over 90% of polygraph examinations conducted by the US Department of Defense were for screening rather than criminal investigation (Office of the Under Secretary of Defense for Intelligence, 2011). Although most agencies use probable-lie or directed-lie polygraph formats for these applications, some still use a test format known as the Relevant—Irrelevant (RI) test (Krapohl & Rosales, 2014). The RI screening test includes questions about several relevant topics such as illegal drug use, past criminal activity, and falsification of the job application. The test also includes questions about irrelevant (neutral) topics such as "Are the lights on in this room?" Applicants who are deceptive to any one or more of the relevant issues are likely to perceive those questions as threats and react more strongly to them than to questions about neutral topics. However, because the relevant questions are easily identified as more important to the outcome of the test than irrelevant questions, truthful subjects also are likely to be more attentive to the relevant questions and react more strongly to them, resulting in high false-positive error rates.

Consistent with these predictions, Horowitz, Kircher, Honts, and Raskin (1997) conducted a mock crime experiment and compared reactions to relevant questions to those produced by neutral questions. They correctly classified 100% of deceptive but only 22% of truthful participants. Subsequently, Krapohl and Rosales (2014) obtained similar results in a field study of the RI test. They reported 81.5% correct decisions on deceptive cases but only 47% correct decisions on truthful cases.

Although there is good reason to expect that the RI test will have low accuracy on truthful cases when reactions to relevant and irrelevant questions are compared, it is not clear that all field polygraph examiners who use the RI test format make decisions based on such comparisons. Indeed, there are no formal rules for evaluating the polygraph protocols from RI tests (Bancroft, 2015). Some examiners might compare reactions of relevant questions to those of irrelevant questions, whereas others might compare reactions to different relevant questions. It may be that accuracy on truthful cases was higher in the Krapohl and Rosales study than in the Horowitz et al. experiment because some field examiners based their decisions on comparisons of reactions to different relevant questions. Lack of standardization and variability in the procedures examiners use to decide if a person was deceptive on the test limits the reliability and validity of the RI polygraph test. Nevertheless, if polygraph examiners were to base their decisions on comparisons of reactions to relevant questions, then the RI format would share some essential features with the RCT.

APPLICATIONS OF THE OCULAR-MOTOR DECEPTION TEST

Similar to the RI test, the ODT is designed to screen applicants for employment or to conduct periodic assessments of individuals subject to some restrictions, such as government employees with security clearances or people on parole or court-ordered restrictions. In contrast to the RI test and all other polygraph tests, the ODT does not require a trained polygraph examiner. The ODT takes less time than a polygraph test, and it is less invasive because it does not require attachment of surface electrodes or other sensors to the examinee. For a given application, the pretest information, instructions, test items, analysis, and interpretation of the data are standardized.

Because the ODT is faster and less costly than a polygraph test, an agency might use it at the front end of a screening program to reduce the number of applicants that move on to the next more costly stage of screening. There might be an advantage in using the ODT in tandem with the polygraph to minimize the risk of a particular type of error. For example, if the goal were to minimize the risk of false positive errors, and each of two independent tests had a false positive rate of 20%, then the risk that a truthful person would fail both tests would be $0.2 \times 0.2 = 0.04$, or only 4%. Of course, we do not know the extent to which ODT and polygraph outcomes are independent, and a reduction in the risk of one type of error (false positive) would increase the risk of the other error (false negative). Thus, if the two independent tests each had false negative rates of 20%, then the probability that a deceptive person would fail the first test and fail the second test would be 0.8×0.8, or 64%. Stated differently, there would be a 36% chance that a deceptive person would pass at least one of the two tests and continue on as a candidate for employment. The false positive error rate on truthful individuals would be only 4%, but 36% of deceptive individuals would pass through the screening system. Still, if the ODT and polygraph were at least partially independent, then use of the ODT and polygraph in combination could reduce the risk of a particularly undesirable decision error.

MOCK CRIME LABORATORY RESEARCH ON THE OCULAR-MOTOR DECEPTION TEST

We have conducted a series of mock crime laboratory experiments to determine if ocular-motor measures discriminate between truthful and deceptive people, and we borrowed those procedures from our laboratory research on polygraph techniques (Podlesny & Raskin, 1978). Realistic mock crime experiments produce diagnostic effects on electrodermal, cardiovascular, and respiration reactions that are similar to those obtained from actual suspects in specific-incident criminal investigations (Kircher, Horowitz, & Raskin, 1988; Kircher, Raskin, Honts, & Horowitz, 1994).

In our ODT experiments, we recruit participants from the university campus or the general community for pay and randomly assign them to guilty and innocent treatment conditions. Guilty participants commit a mock crime and then lie about it on the test. In one experiment, we instructed one group of guilty participants to take $20 from a secretary's purse and another group to download credit card information from a professor's computer. In other experiments, to simplify the procedures, we told all participants that guilty subjects committed one of two crimes, but in actuality, guilty participants committed only one crime. Because truthful and deceptive examinees in field settings usually are highly motivated to pass the test, we promised all participants a monetary bonus that would double their pay if they were able to pass the test.

OCULAR-MOTOR DECEPTION TEST ADMINISTRATION

Examinees were seated at a computer with a keyboard in a small room without windows and indirect lighting. Over the years, we have used several different eye trackers. In our last several experiments, we used a remote 60-Hz eye tracker that was affixed to the bottom of the computer monitor (SMI REDm, Sensomotoric Instruments, Berlin). The examinees placed their chin in a chin rest positioned approximately 70 cm from the monitor. To calibrate the eye tracker, the examinee gazed at an illuminated disk that appeared in several locations of the screen. Calibration was necessary to determine where fixations were in relation to the text.

The computer informed examinees with written and audio-based instructions that they would be tested about two relevant issues. The computer instructed the examinee to read and answer each true/false statement by pressing one of two keys on the keyboard. The computer also informed them that the test was based on the idea that it is more difficult to lie than to tell the truth, that deceptive people respond more slowly and less accurately than truthful people, and it was in their best interest to answer all the statements as quickly and accurately as possible. We provided this information because we believe that the effects of deception on cognitive load would be reduced if examinees chose to take a long time to consider each statement before they answered.

The standard ODT consisted of a set of 48 test statements: 16 statements concerning one relevant issue (R1), 16 statements concerning the other relevant issue (R2), and 16 neutral statements. The expected, exculpatory answer was True to half of each type of statement (e.g., I did not take the $20 from the secretary's purse.) and was False to the remaining statement (e.g., I am guilty of taking the $20 from the secretary's purse.). The test began with two neutral statements to give the examinee an opportunity to orient to the task. Thereafter, we ordered statements such that no two statements of the same type appeared in succession. The computer presented a written statement in black font on a gray background on a single line in the middle of the screen beginning on the left side. We used black font on a gray background to minimize effects of changes in illumination on the pupil. The examinee read the statement and pressed a key to answer True or False. The examinee's answer appeared on the right side of the monitor adjacent to the text for 500 ms, at which time the computer replaced the statement with the next item. When the examinee completed the block of 48 statements, the computer presented a brief unrelated task to clear working memory of the test statements. For example, examinees might have been asked to indicate if each of 10 simple arithmetic statements was true or false (e.g., $4 + 5 = 8$). The computer then presented the 48 ODT statements again in a different order. This process was repeated a total of five times. Altogether, the eye tracker provided recordings of gaze position and left and right pupil size at 60 Hz for 80 R1 statements (16 statements × 5 repetitions), 80 R2 statements, and 80 neutral statements. The speed at which examinees answered the statements typically varied between 2 and 4 s.

Cook et al. (2012) described an experiment in which all guilty participants were deceptive to statements about the theft of cash from a purse. The control issue was the theft of an exam from a professor's office. Mean change in pupil size is shown in Fig. 9.1 for 4 s following the onset of the neutral, cash, and exam statements. As predicted, guilty participants (left) reacted more strongly to cash than exam statements, whereas innocent

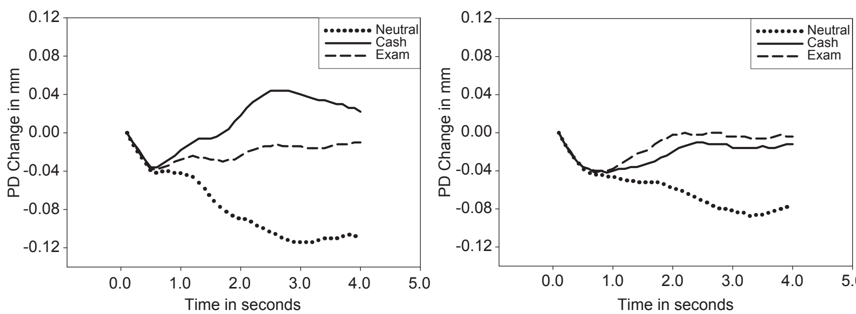

Figure 9.1 Mean change in pupil diameter (PD) from statement onset for guilty (left) and innocent participants (right).

participants (right) showed little difference between cash and exam statements. The mean change in PD associated with deception was less than 0.1 mm but is evident with signal averaging.

FEATURE EXTRACTION

For each test item, the computer extracted a set of physiological, reading, and behavioral measures. Depending on the particular eye tracker we used at the time, we recorded PD from only the right eye or from both eyes. The computer extracted two features from each signal independently. Prior to feature extraction, we replaced data losses due to eye blinks with interpolated values and smoothed the signal with a 0.5 s Savitsky-Golay filter that used linear and quadratic components to predict the midpoint of a sliding 0.5 s interval. The computer then transformed the smoothed time series of PD samples to standard scores. From the standardized signal, the computer extracted the area under the evoked pupil response. Integration of the area under the curve began at a low point that followed statement onset and lasted until the pupil response curve returned to the initial low point or to the end of the 4 s interval, whichever occurred first (Kircher & Raskin, 2001). The second feature was the level (mean) of the standardized response curve from 0.5 s before the examinee's answer to 0.5 s after the answer.

Reading was characterized by measures derived from eye fixations on the test statement. To compute fixations, we used an algorithm developed by the Applied Science Laboratory (Bedford, MA). Briefly, the computer scanned the 60 Hz series of horizontal and vertical gaze positions for periods of little movement in either direction, where movement was measured in degrees of visual angle. Periods of quiescence less than 100 ms or greater than 1000 ms were considered outside the acceptable range and were not considered fixations (Rayner, 1998). The algorithm used the mean of horizontal and vertical samples that met measurement criteria for a fixation to determine the X and Y coordinates for the fixation on the computer screen. The duration of each fixation in ms was based on the number of samples; that is, (number of samples/60) × 1000 (Cook et al., 2012).

The computer derived measures of reading behavior from fixations that fell within the area of interest. *Number of fixations* was a count of the fixations in the region of interest. *First pass duration* was the sum of fixation durations for all fixations that occur in the forward direction (left-to-right) in the region of interest before a fixation fell outside the region of interest. First pass duration was a presumed measure of lexical processing during which the reader determined the meaning of words. *Re-read duration* was the sum of durations of fixations in the region of interest that followed leftward saccades and may reflect higher-order cognitive activities, including readers' efforts to resolve comprehension failures (Hacker et al., 2014).

Behavioral measures included response time and errors. *Response time* was the time in ms from the appearance of the test item on the computer monitor to the moment the examinee pressed a key to answer True or False. *Errors* were proportions of test items of a given type answered incorrectly.

Periods during which a person is deceptive have been associated with reductions in eye blinks, whereas periods following deception have been associated with increased blink rates (Leal & Vrij, 2008, 2010; Marchak, 2013). During an eye blink, the eye tracker loses its image of the eye and there is a brief period of data loss. When the eye opens, the eye tracker reacquires the signal and resumes storage of gaze position and pupil size.

In our experiments, we measured the number of times we lost data over a 3 s interval prior to the examinee's answer (*item blink rate*), and again for 3 s after the examinee answered (*next item blink rate*). Because two statements of the same type never were presented in immediate succession, when the examinee was deceptive on the ODT, a statement that was answered truthfully always followed a statement that was answered deceptively. We expected that deceptive individuals would show a reduction in blink rates on incriminating items followed by an increase on the next item; and we expected that truthful individuals would show little difference among statement types.

Statistical adjustments for individual differences are common in psychophysiological research. As noted earlier, we transformed pupil size in mm to standard scores within item blocks. Although we have not observed an advantage to standardizing reading measures, we did divide each reading measure by the number of characters in the statement to adjust for differences in the length of test items. For response time, we transformed raw response times for the 48 items within each block to standard scores. Finally, we transformed the proportion of incorrect answers to R1 and R2 statements for the entire test to a z-test statistic for the difference between proportions.

DISCRIMINATING FEATURES

The computer calculated the mean of its 80 measurements of a given feature for each statement type (neutral, R1, and R2). With three levels of statement type, there were two degrees of freedom, and we could compute two orthogonal contrasts. Since Patnaik (2015), we have focused exclusively on the (R1-R2) contrast to reduce the number of measures and minimize opportunities to capitalize on chance when we construct multivariate decision models.

RELIABILITY AND VALIDITY OF OCULAR-MOTOR MEASURES

Table 9.2 reports internal consistency statistics (Cronbach's alpha) for the various ocular-motor measures from two dissertation experiments (Patnaik, 2015; Webb, 2008). For each participant, we computed a value for each (R1-R2) feature contrast for each block of 48 test items, and used alpha to assess the extent to which measurements from the five repetitions were consistent. If one presentation of test items suggested that the subject was deceptive, did the remaining four presentations of test items also suggest that the person was deceptive?

Table 9.3 reports validity coefficients for the various features in four mock-crime experiments, three of which were dissertation projects (Osher,

Table 9.2 Reliability Coefficients in Laboratory Experiments

	Webb (2008)[a]	Patnaik (2015)[b]	Mean
Pupil diameter			
Area under the curve	0.609	0.615	0.612
Level at answer	0.465	0.510	0.488
Reading			
Number of fixations	0.528	0.627	0.578
First pass duration	0.508	0.540	0.524
Reread duration	0.494	0.397	0.446
Behavioral			
Response time	0.397	0.329	0.363
Error rate	0.184	0.209	0.197
Blink rate			
Item blink rate	0.391	0.182	0.287
Next item blink rate	0.251	0.351	0.301

[a]Webb's (2008) dissertation experiment was reported as Experiment 2 in Cook et al. (2012).
[b]Patnaik's (2015) dissertation experiment has not been published.

Table 9.3 Validity Coefficients in Laboratory and Field Studies of the Ocular-Motor Deception Test

	Osher (2006)[a]	Webb (2008)[b]	Patnaik (2015)	Patnaik et al. (2016)	Kircher and Raskin (2016)[c]	Mean[d]
Sample size	40	112	80	145	154	
Pupil size						
Area under the curve	**0.550**	**0.464**	**0.586**	**0.546**	**0.484**	**0.517**
Level at answer	NA	**0.523**	**0.585**	**0.587**	**0.536**	**0.556**
Reading						
Number of fixations	**−0.555**	**−0.529**	**−0.406**	−0.139	**−0.202**	**−0.310**
First-pass duration	−0.075	**−0.530**	**−0.253**	**−0.452**	−0.074	**−0.301**
Reread duration	**−0.562**	**−0.489**	**−0.342**	**−0.192**	**−0.287**	**−0.332**
Behavioral						
Response time	**−0.489**	**−0.480**	**−0.497**	**−0.544**	**−0.474**	**−0.499**
Error rate	NA	0.057	0.093	0.056	**−0.370**	−0.071
Eye blink rate						
Item blink rate	NA	−0.071	**−0.388**	**−0.260**	−0.059	**−0.175**
Next item blink rate	NA	0.079	−0.088	0.049	0.023	0.025

Bolded validity coefficients were statistically significant at $P < 0.05$.
[a]One condition in Osher's (2006) dissertation experiment was reported as Experiment 1 in Cook et al. (2012).
[b]Webb's(2008) dissertation experiment was reported as Experiment 2 in Cook et al. (2012).
[c]Field study of applicants for government positions with n = 83 truthful and n = 71 deceptive applicants.
[d]Significance of mean correlation was based on total available sample size (N = 531 or 491).

2006; Patnaik, 2015; Webb, 2008), and one a field validity study (Kircher & Raskin, 2016). The validity coefficients were point-biserial correlations between the (R1-R2) contrast and deceptive status, where deceptive status was coded 0 if the examinee was truthful and coded 1 if the examinee was deceptive to the R1 issue. These correlations indicate the extent to which the feature discriminated between truthful and deceptive individuals. The squared point-biserial correlation is equivalent to the estimated η^2 measure of effect size. The results in Table 9.3 represent only standard testing conditions, as described earlier, and are neither exhaustive nor representative of our research on alternative test protocols that yielded inferior results.

Although the reliability coefficients presented in Table 9.1 for the various features were lower than those commonly reported for established psychological tests, they were similar to those obtained for automated polygraph systems (Kircher et al., 2012). As compared to reliability coefficients, the validity coefficients in Table 9.2 provide more information about the usefulness of ocular-motor features for detecting deception. A validity coefficient indicates the extent to which the variable discriminates between groups of truthful and deceptive individuals. The correlation of the variable with the dichotomous criterion is the figure of merit with regard to its criterion-related validity (Nunnally, 1978). Nevertheless, the low reliability values indicate that we might improve the diagnostic validity of all the available ocular-motor measure with better test construction, longer test length, improved instrumentation, or better algorithms. For example, item blink rate was not highly correlated with deceptive status ($r = -0.175$), but it also was not reliably measured ($alpha = 0.287$). If we can develop an algorithm that distinguishes bona fide eye blinks from other failures of the tracker to monitor the eyes, we should be able to improve the diagnostic validity of this measure. Although response time is highly correlated with deceptive status, we might increase its correlation with deceptive status by measuring response time from the first fixation in the area of interest, rather than from when the computer presents the statement. In general, the reliability data suggest that there is significant room for improvement in test construction, administration, instrumentation, or analysis.

Examination of the mean validity coefficients indicate that the pupil measures were more diagnostic than reading, behavioral, and blink rate measures. The (R1-R2) contrast for response time was almost as diagnostic as were the pupil measures. On average, error rates were not diagnostic, but in the field study, error rates were moderately correlated with deceptive status. Blink rate measures were the least predictive of deceptive status. The

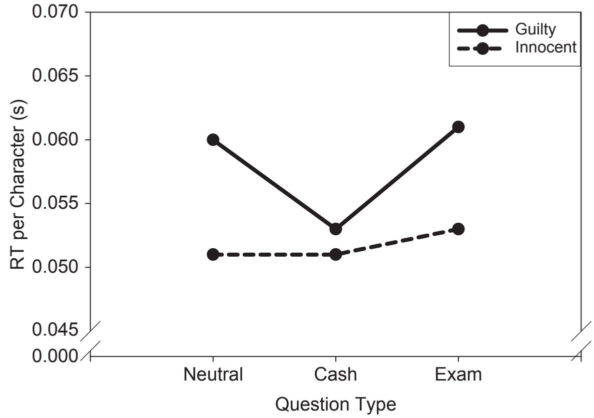

Figure 9.2 Response time for guilty and innocent groups per question type.

results also indicate that the effects on pupil size and response time were consistent across experiments and settings. Effects of deception on reading, error rate, and blink rate measures were more variable.

The two pupil measures correlated positively with deceptive status. Whereas truthful people reacted similarly to relevant and control statements across all measures, deceptive individuals reacted more strongly to relevant statements, as illustrated in Fig. 9.1. For all other measures, the correlations were negative. As compared to truthful subjects, deceptive individuals made fewer fixations, spent less time reading, and spent less time rereading relevant than control statements. Results from Webb's (2008) dissertation experiment illustrate the general nature of this effect. Fig. 9.2 shows that her guilty participants, on average, took longer than innocent participants to answer. However, when guilty participants were deceptive to cash items, their response times were shorter than when they answered truthfully to neutral and exam (control) items. This pattern of results suggests that deceptive examinees invested more mental effort in processing the relevant than control statements, as indicated by increases in PD and a reduction in blink rate to cash items. I believe they did so because they wanted to make a rapid response when they were deceptive to avoid detection. The later effect was evident in measures of response time, number of fixations, first pass duration, and reread duration.

DECISION MODELS

To classify individuals as truthful or deceptive, we used a logistic regression equation or discriminant function to compute the probability of deception from a subset of optimally weighted ocular-motor measures. If the probability of deception exceeded 0.5, we classified the person as deceptive; if the probability was less than 0.5, we classified the person as truthful. The weights for measures in the decision model were optimal in the sense that they attempted to maximize the percentage of individuals classified correctly.

Kircher and Raskin (2016) summarized the accuracy of classifications using our standard mock-crime protocol and standard ODT. Those results are reproduced in Table 9.4. The decision models yielded approximately 86% correct classifications in the original, standardization sample, and 83% correct when tested on independent samples (cross-validation). Generally, accuracy was higher for innocent (84.1%) than for guilty participants (82.1%). We attributed the relatively poor performance on cross-validation in the Osher (2006) study to the small number of participants and small subject-to-variable ratio.

Table 9.5 summarizes results from nonstandard conditions (Kircher & Raskin, 2016). Osher (2006) found that serial presentations of individual test statements (Table 9.4) yielded better ocular-motor data than did the simultaneous display of multiple test statements (Table 9.5). Webb (2008) found that sex did not moderate the effects of deception on ocular-motor measures, whereas higher motivation to pass the test and semantic simplicity in phrasing of test statements improved the diagnostic validity of some ocular-motor measures.

Together, the USTAR and Patnaik (2013) studies indicated that test statements that referred directly to the matter at hand (I did not take the $20.) produced stronger reactions in deceptive individuals than did statements that indirectly asked if the person falsified their answers on a pretest questionnaire about their involvement in the crime (I did not falsify my answers on the questionnaire about the $20.). In the NSA studies, we recruited employees and tested them about minor security violations. The studies used a nonstandard protocol because we relied on self-report for ground truth, and we were not permitted to provide meaningful incentives to government employees to pass the ODT. The agency did allow us to offer participants 1 h of release time to participate and a second hour of release time if they passed the test. In addition, most of the participants were federal polygraph examiners who may have participated because they were curious about a new technology for credibility assessment, not because they were trying to earn an hour or two of release time.

Table 9.4 Percent Correct Decisions Under Standard Conditions in Mock-Crime Experiments

Experiment	Independent variables	N	n_G	n_I	Guilty	Innocent	Mean	$Validation_G$	$Validation_I$	Mean
Osher (2006)[a]	Issues; serial format	40	20	20	85.0	85.0	85.0	85.0	70.0	77.5
Webb (2008)[b]	Sex; motivation; difficulty	112	56	56	82.1	89.2	85.7	89.3	80.4	84.9
Patnaik (2013)[a]	Direct interrogation	48	24	24	83.3	95.8	89.6	83.3	83.3	83.3
Patnaik (2015)[a]	Distributed item types; pretest feedback; postresponse interval	80	40	40	82.5	90.0	86.3	80.0	90.0	85.0
Patnaik et al. (2016)[c]	Language; culture	145	82	63	84.1	87.3	85.7	81.9	87.5	84.7
Middle East[d]	Language; culture	112	51	61	80.4	88.5	84.5			
Middle East[e]	Language; culture	101	52	49				75.0	85.7	80.4
Standard Protocol		638	325	313	82.8	89.0	85.9	82.1	84.1	83.1

[a]Validation results were obtained with the leave-one-out procedure.
[b]We used the decision model based on Patnaik et al. (2016) to classify participants in Webb's (2008) dissertation.
[c]The decision model based on Webb's (2008) dissertation was used to classify participants in Patnaik et al. (2016).
[d]The decision model was developed on this Middle Eastern sample.
[e]The decision model was tested on this Middle Eastern sample.

Table 9.5 Percent Correct Decisions Under Nonstandard Conditions in Mock-Crime Experiments

Experiment	Independent variables	N	n_G	n_I	Guilty	Innocent	Mean
Osher (2006)	Issues; parallel format	40	20	20	70.0	95.0	82.5
USTAR[a,b]	Pretest questionnaire; issues	71	47	27	59.6	77.8	68.7
NSA[a,c]	Standardization	94	51	43	72.5	88.4	80.5
NSA[a,c]	Validation	60	34	26	50.0	80.8	65.4
Patnaik (2013)[a]	Indirect interrogation	48	24	24	58.3	79.2	68.8
Patnaik (2015)[a]	Blocked	80	40	40	77.5	85.0	81.3
Nonstandard Protocols		393	216	180	65.3	84.5	74.9

[a]Unpublished.
[b]Utah Science, Technology, and Research Initiative.
[c]National Security Agency.

Patnaik (2015) found that the standard sequencing of neutral, R1, and R2 statements yields more accurate outcomes than does the presentation of several items of the same type in sequence. Patnaik also found that feedback about speed and accuracy on a pre-ODT practice test and lengthening the interval between the answer and the presentation of the next item had no discernible effect on outcomes. Patnaik et al. (2016) found that the effects on ocular-motor measures were similar for tests administered to university students in their native language in the United States and Mexico. The experiments conducted in the Middle East required modification of the software to present Arabic text from right to left. Accuracy rates on cross-validation in the Middle East were lower than those obtained in the United States and Mexico, particularly for guilty participants. Although the differences in decision accuracy between Middle Eastern and Western participants were not statistically significant, we found it necessary to reduce the number of repetitions of test statements for measures of pupil response to achieve near-comparable levels of accuracy for Arabic-speaking participants as for English- and Spanish-speaking participants. It is possible that differences between Middle Eastern and Western cultures or their languages moderated the effects of deceptive status on ocular-motor measures.

FIELD STUDY OF THE OCULAR-MOTOR DECEPTION TEST

We are interested in developing a screening test, but in our laboratory experiments, we ask participants to commit a specific mock crime. The effect sizes on ocular-measures in the laboratory are encouraging, but questions can be raised about the generalizability of these effects to field settings for screening applications.

To address these concerns, we conducted a field validity study of the ODT that evaluated applicants for positions in the Mexico attorney general's office, immigration, and federal police (Kircher & Raskin, 2016). We compared reactions to statements about recent use of illegal drugs (R1) to statements about either corruption or affiliation with a religious terrorist organization (R2). We had ground truth on the issue of corruption because it involved communication with ODT test developers, and we assumed that no applicants were affiliated with a religious terrorist organization because the base rate of that activity is very low. Confirmation of deception on the ODT was based on admissions of illegal drug use by applicants during a subsequent polygraph test, or the applicant failed a hair or urine test for prohibited substances ($n = 71$). We planned to use negative hair and urine test results to establish that applicants for positions at immigration had been truthful on the ODT. However, of the 35 applicants at that organization who confessed, 32 passed the urine test (91% false negatives) and 24 passed the hair test (69% false negatives). Therefore, we had no confidence that a person who passed the drug tests was, in fact, truthful on the ODT; urine and hair tests miss far too many deceptive individuals.

Since passing a drug test was inadequate to establish conclusively that an applicant was truthful on the ODT, we created a second ODT and administered it to applicants for positions in immigration to determine if they had committed espionage (R1) or sabotage (R2). We assumed that all the tested individuals were truthful in their answers to both relevant issues because the base rates of deception on those issues are very low, especially for people who have had no prior government employment and no apparent access to state secrets or equipment ($n = 83$).

To develop and validate a decision model with the field data, we extracted ocular-motor measures from the eye tracker data and used linear regression to select a subset of four measures to distinguish between the confirmed truthful and deceptive groups. We then used the selected variables in a five-fold validation of a logistic regression model to classify cases as truthful or deceptive. To conduct the five-fold validation, we partitioned

Table 9.6 Accuracy Rates for Five Independent Subsamples

	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Mean	Mean
	N = 30	N = 30	N = 31	N = 31	N = 32		N = 154
Truthful	75.0	87.5	88.2	88.2	100.0	87.8	86.1
Deceptive	100.0	71.4	85.7	78.6	86.7	84.5	

the sample of 154 field cases into five random subsamples such that each subsample consisted of approximately 20% of the deceptive cases (n = 14 or 15) and 20% of the truthful cases (n = 16 or 17). The first subsample of 14 truthful cases and 16 deceptive cases (N = 30) was removed, and a decision model was created with the remaining truthful and deceptive cases in subsamples 2, 3, 4, and 5 (N = 124). We used that decision model to classify the holdout sample of 30 cases and recorded the percent correct for truthful and for deceptive cases in the holdout sample. The second subsample then was set aside (N = 30), a new decision model was developed with the remaining cases in subsamples 1, 3, 4, and 5 (N = 124), and the accuracy of classifications was calculated for the second holdout sample. We repeated this process for the remaining three subsamples. The results are reproduced in Table 9.6.

Consistent with the observed similarity in effect sizes for ocular-motor measures in laboratory and field settings shown in Table 9.1, decision accuracy in an actual screening context with applicants for positions in the Mexican government was similar to that obtained in mock-crime experiments. On average, the standard ODT produces between 80% and 86% accuracy in laboratory and field settings.

LIMITATIONS AND AREAS OF FUTURE RESEARCH

We know little about the relative importance of cognition and emotion in the ODT. We assumed that being deceptive is cognitively more demanding than being truthful, and we attempted to design a test that would reveal the effects of cognitive workload on physiological, reading, and behavioral measures. The data generally are consistent with the cognitive workload hypothesis. However, for most people, taking a deception test is unusual, and that request often occurs when adverse consequences to the individual are associated with failing the test. Under these conditions, we can expect the general levels of arousal to increase to a greater or lesser degree depending on the individuals' deceptive status, the perceived consequences of failing the test, and their disposition. Examinees should be invested in the outcome, and we have evidence from the NSA studies and Webb's (2008) dissertation that low levels of motivation reduce accuracy. Unless the individual is motivated to pass, the relevant items will not be perceived as threats to that end. An enhanced sensitivity to the particular subset of test items that an individual perceives as threats could explain effects on ocular-motor measures just as well as differential cognitive workload. Research that explores the roles of cognition and emotion in the ODT would contribute to our understanding of mechanisms responsible for the observed effects on outcome measures.

Alone, the ODT will not mitigate practical concerns about screening large numbers of people for threats to national security that occur only rarely in the target population (National Research Council, 2003). For example, screening tests for espionage and sabotage are unlikely to be useful because the base rate of deception is so low. Even if a test is 90% accurate, about 10% of the tested population would fail it, and the vast majority of those individuals who fail the test would be innocent of the crimes. Certainly, no single test would provide a solution to the problem of identifying the rare spy in a population of people with security clearances, although a series of screens with criteria set to avoid missing the deceptive individual could be a way to reduce the pool of possible threats to national security (Krapohl & Stern, 2003). Although screening for such low probability events is problematic, other undesirable behaviors are far more common and would be candidates for a moderately effective screening technology such as the ODT.

Our field validation study revealed that the same ocular-motor measures that are most effective in mock crime experiments also are most effective when testing job applicants in a screening environment. It was encouraging to learn that the accuracy rates achieved in a field setting were at least as high as those obtained in our laboratory experiments. Moreover, the similarity between effect sizes obtained in laboratory and field settings suggest that the mock crime paradigm is an ecologically valid means of conducting research on the ODT. It remains to be seen if discrepancies between the two settings in reading and error rate measures are systematic or due to chance. More data would help.

Although the field study was important, the five-fold validation was flawed in the sense that the entire sample of confirmed cases was used to select variables for the decision model. In the five-fold validation, only the weights for the variables changed from one phase of the validation process to the next, not the variables themselves. The decision model from the current field study should be reevaluated and refined with independent and representative samples from this and other target populations.

Unpublished efforts to assess credibility with the ODT in Colombia were unsuccessful. Although the data were limited, the ODT appeared to work well when we tested well-educated people who had applied to work for an airline, but the ODT was ineffective when we tested less well-educated applicants for security companies. We hypothesized that the reading ability of applicants for security companies may have been inadequate. If a person struggles to read and comprehend the test items, those difficulties might overshadow effects of deception on our measures. Since those early efforts to conduct research in Colombia, we began to use response times and error rates to determine whether or not a person has sufficient reading ability to take the test. In addition, we are exploring alternative, audio-based ODTs that may or may not include electrodermal, cardiovascular, or respiration measures. With an audio-based format, we would lose the eye movement–based reading measures, but we might gain diagnostic information from another physiological channel. Preliminary results suggest that an audio version will work, but we do not yet know if the audio version will be as effective as the standard reading version.

Theoretically, the RCT should misclassify examinees who are deceptive to both sets of relevant statements. If examinees are equally concerned about the two relevant issues, there should be no difference in their cognitive or emotional responses to those to those issues, and the algorithm should misclassify those individuals as truthful. We conducted one laboratory study in which one of four groups was deceptive to both sets of relevant items (USTAR, unpublished). Consistent with these predictions, accuracy on deceptive individuals was near chance. However, deception to both relevant issues was confounded with several other factors that distinguished the USTAR study from our other experiments. Patnaik (2013) explored one possibility that the adverse effects on accuracy in the USTAR study were a consequence of testing participants on whether they had falsified information on a pretest questionnaire about the crime, rather than asking if they committed the crime. Asking if the participant committed the crime was more effective than asking if they lied on a pretest questionnaire about their involvement in the crime. However, we have not yet tested the possibility that the RCT does not work for examinees who are deceptive to both relevant issues, which also might explain the high false-negative error rate in the USTAR study.

One potential solution to this problem is to construct ODTs that pair a high base-rate relevant issue, such as drug use, with a low base-rate relevant issue, such as espionage. Among federal employees, both relevant issues have face validity because employees know that those issues are of concern to their employer. Although being deceptive to both issues would be no more common than being a spy, if a person is deceptive to both issues on the ODT, we would expect the person to fail the test because the consequences of failing on the espionage issue are far more severe than failing on the drug issue. We have not tested this prediction.

To date, we have conducted no research to investigate the effects of countermeasures on ODT outcomes. We are about to start a mixed-methods investigation of countermeasures against the ODT. We will provide half of the guilty and half of the innocent participants with detailed information about how the ODT works and how we use the various ocular-motor measures to make a decision. The remaining guilty and innocent participants will serve as controls and not be so informed. Following the ODT, the experimenter will conduct interviews with the participants and ask them to complete a posttest questionnaire. From those participants' reports, we will attempt to identify strategies people develop to pass the test. In subsequent research, we would train participants to use those strategies that appear to help deceptive individuals defeat the test and attempt to develop counter-countermeasures.

DISCLOSURE

The author has a financial interest in Converus, Inc. (www.converus.com), a company that has commercialized the technology described in this report. I have disclosed those interests to the University of Utah and have in place an approved plan for managing any potential conflicts that arise from involvement in Converus.

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SECTION 4

Behavioral Applications

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CHAPTER 10

Deception Detection With Behavioral Methods: The Autobiographical Implicit Association Test, Concealed Information Test—Reaction Time, Mouse Dynamics, and Keystroke Dynamics

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INTRODUCTION

Deception production is a complex psychological process in which cognition plays an important role. Being deceptive is cognitively more complex than telling the truth, and this higher complexity is reflected in alterations of the subject's behavior during a task (Vrij, Fisher, Mann, & Leal, 2008). In other words, it is possible to record behavioral changes to infer whether or not the subject who is performing a task (e.g., answering questions) is lying.

Classical paradigms have mainly investigated the response latency to a stimulus of interest (reaction time; RT) as a behavioral marker of deception (Walczyk, Roper, Seemann, & Humphrey, 2003). Many studies in the literature report that responding with a lie is generally slower than responding truthfully because lie production requires more cognitive effort. However, this principle is not always true (Van Bockstaele et al., 2012). In fact, distinct types of lies differ in their cognitive complexity and may require different levels of cognitive effort, as reflected in RTs. If the effort is minimal (e.g., the subject is simply denying a fact that actually happened) or

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the lie is overlearned (Hu, Chen, & Fu, 2012), the slowing of RTs during question responses may not occur (Van Bockstaele et al., 2012). Lies tend to differ preferentially from honest responses according to their complexity; therefore, it is necessary to engage the subject in a more complex cognitive task to further increase the liar's cognitive load and increase the likelihood of detecting dishonest responses. Although increasing the cognitive load is not always necessary for detecting lies, some methods—such as asking unanticipated questions, asking compound questions, asking subjects to recount events in reverse chronological order, asking subjects to perform dual tasks, and time-stressing the subject—have been proposed to increase liars' cognitive loads and thus facilitate deception detection (Walczyk, Igou, Dixon, & Tcholakian, 2013). Utilizing these cognitive paradigms, behavioral-based tools for deception detection have been proposed with several applications in forensic fields, such as in criminal cases and security systems. In this chapter, we review the behavioral lie detection tools currently described in the literature. These fall into two major categories:

1. Reaction-time–based lie detection techniques may be distinguished into subtechniques that embed the true memory among the alternative memory responses and subtechniques that do not require the true memory among the response alternatives. The first allows the detection of the true response between two alternatives and includes the RT-Concealed Information Test (RT-CIT; Kleinberg & Verschuere, 2015), the autobiographical Implicit Association Test (aIAT; Sartori, Agosta, Zogmaister, Ferrara, & Castiello, 2008), and the Timed Antagonistic Response Alethiometer (TARA; Gregg, 2007).
2. By contrast, the second group of techniques lets us identify a lie without including the true information among the alternatives, and is aimed at evaluating whether the subject's overt response is a lie or not. These techniques are particularly useful when no information is known in advance. Consider, for example, a subject who reports a faked identity and an examiner who has no hint about the subjects' real identity. In this case, the CIT, aIAT, and TARA may not be applied. This second type includes methods that are based on increased memory loads to highlight deception, choice RTs, and analyses of mouse and keyboard dynamics (Sartori, Orru, & Monaro, 2016).

In the last part of this chapter, we will report the benefits and drawbacks of these techniques (Table 10.2).

THE AUTOBIOGRAPHICAL IMPLICIT ASSOCIATION TEST

As mentioned before, among the RT-based techniques for identifying a true memory between a number of alternatives, the RT-CIT is one of the most used, and it will be extensively addressed in another chapter of this volume. Here, we will focus on another RT-based memory detection tool, the aIAT (Sartori et al., 2008), which is an extension of the highly influential Implicit Association Test (IAT) method (Greenwald, McGhee, & Schwartz, 1998) that is used in the social psychology literature to measure implicit attitudes. When a subject needs to respond with the same key to statements belonging to categories that are not paired in the respondent's mind, this incongruent pairing results in slower RTs. On the other hand, when statements that are implicitly associated in the respondent's mind share the same response key, the subject's answers are facilitated and the corresponding RTs are faster. The highly successful applications to forensic deception situations and malingering are obvious applications, which we will illustrate.

The aIAT (Sartori et al., 2008) is a variant of the IAT (Greenwald et al., 1998), which can be useful in detecting autobiographical memories encoded in the respondent's mind. In particular, the aIAT lets us determine which version of an autobiographical event is true, and it can be applied to different topics and for different purposes. The aIAT describes a task in which examiners request that subjects categorize stimuli appearing on a computer screen as belonging to one of two categories. Two types of stimuli are used:

1. Statements that are objectively true (e.g., "I am in front of a computer") or false (e.g., "I am climbing a mountain") for the respondent during the experimental session;
2. Statements representing alternative versions of the construct (i.e., the memory) under investigation (e.g., "I went to Paris for Christmas" vs "I went to London for Christmas") with only one of the two being true (e.g., the subject actually spent Christmas in London).

Stimuli are presented one at a time in the center of a computer screen. At the upper left and right of the screen two labels indicating categories are presented, and the participants are asked to classify each presented sentence using two response keys, one on the left and one on the right of the keyboard (buttons A and L).

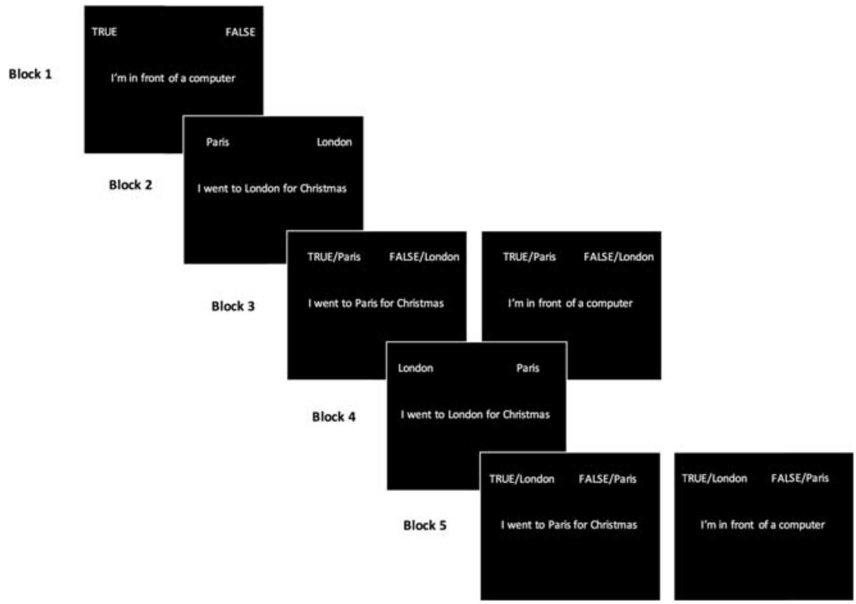

Figure 10.1 An example of the aIAT experimental procedure. Examiners ask participants to classify the stimulus (i.e., the displayed sentence) as quickly and accurately as possible by pressing a key on the left (i.e., the "A" key) or the right (i.e., the "L" key) side of a keyboard. In Blocks 3 and 5, logically true sentences and sentences related to one version of the autobiographical event (e.g., Christmas in Paris) are paired on the same response key, whereas false sentences are paired with sentences related to the other version of the autobiographical event (e.g., Christmas in London).

The aIAT is composed of five classification blocks (see Fig. 10.1): three simple categorization blocks (1, 2, and 4) and two combined categorization blocks (3 and 5).

In the simple blocks, only one stimulus type is employed, and response buttons A and L are used to classify sentences related to only two categories represented on the upper-left and upper-right of the screen (e.g., True vs False or Paris vs London). In the double blocks, both stimulus types (true/false sentences and sentences referring to Paris/London) are employed, so four categories come into play. This means that each response button is shared between two categories (e.g., the same button is used to categorize objectively true sentences and sentences referring to holidays in London).

In Block 1, participants classify only true and false sentences (e.g., "I am in front of a computer" vs "I am in front of a television"). In Block 2, participants classify only statements about the autobiographical memory (e.g., "I went to Paris for Christmas" vs "I went to London for Christmas") with the same two response keys. In Block 3 (double categorization block), true sentences and sentences related to one version of the autobiographical event (e.g., Christmas in Paris) are paired on the same response key, and false sentences and sentences related to the other version of the autobiographical event (e.g., Christmas in London) are classified with the other response key. In Block 4 (as well as in Block 2), only autobiographical events are classified; however, in this case, the classification is reversed (the category located on the left label in Block 2 is located on the right label in Block 4). Finally, in Block 5, participants classify both true sentences and sentences related to the second version of the autobiographical event (e.g., Christmas in London) with the same response key, and false sentences and the first version of the autobiographical event (e.g., Christmas in Paris) with the other key.

The logic underlying the aIAT is basically derived from the original IAT method: if two sentences sharing the same motor response are both associated with the concept of truth in the respondent's mind (congruent condition), then the subject will show faster RTs in comparison to the situation in which two sentences sharing the same response key are not associated in the respondent's mind (incongruent condition). That is, pairing a truthful autobiographical event with a certainly true sentence should facilitate responses, thus leading to faster RTs. Therefore, the pattern of RTs in the double-categorization blocks indicates which autobiographical event is either true or false.

This technique can be applied to a number of situations in the forensic field. For instance, in the case of an individual who has committed a crime (e.g., stealing a jewel), if an autobiographical statement such as "I stole the jewel" is paired with an objectively true statement (e.g., "I am in front of a computer screen"), the responses will be faster when compared to the condition in which the same autobiographical statement is paired with false statements. The reason for this difference is that the concept of having stolen the jewel is strongly associated with the concept of truth in the respondent's mind, thus leading to slower RTs when paired with false statements.

A number of validation studies (e.g., Verschuere & Kleinberg, 2017) have been carried out to test the aIAT's efficacy in both clinical and forensic applications on several constructs (see Agosta & Sartori, 2013 for a recent review)—including prior intentions (i.e., intentions for future actions; Agosta, Castiello, Rigoni, Lionetti, & Sartori, 2011), past intentions (i.e., intentions behind past actions; Zangrossi, Agosta, Cervesato, Tessarotto,

& Sartori, 2015), and detection of malingered symptoms such as whiplash (e.g., Sartori, Agosta, & Gnoato, 2007). Validation studies have confirmed the aIAT's precision in detecting true autobiographical memories, with a 91% mean accuracy (Sartori et al., 2008). A number of independent research groups have investigated the validity of the technique, in some cases only vaguely referring to the method's name (such as the IAT–eyewitness; Helm, Ceci, & Burd, 2016) or using a slightly different version of the aIAT based on seven blocks (e.g., Verschuere & Kleinberg, 2017). Moreover, the roles of many possible influential factors such as the degree of familiarity with the event (Takarangi, Strange, & Houghton, 2015), the source confusion (Takarangi, Strange, Shortland, & James, 2013), and the imaginative process (Shidlovski, Schul, & Mayo, 2014) in the aIAT's performance have been addressed. Finally, the effect of explicit instructions to fake the technique (Hu, Rosenfeld, & Bodenhausen, 2012; Verschuere, Prati, & De Houwer, 2009) has been studied, and methods for the detection of faking have been proposed (Agosta, Ghirardi, Zogmaister, Castiello, & Sartori, 2011).

NEW PARADIGMS AND TECHNOLOGIES IN LIE DETECTION: MOUSE AND KEYSTROKE DYNAMICS

Here, we report the results of recent studies that exploit the behavioral analysis of human–computer interactions to detect liars. In particular, we focus on two main emerging approaches: mouse dynamics and keystroke dynamics. Although they were born in the IT field, mainly as biometric user-authentication systems, they have recently been applied to the study of psychological processes. After a brief introduction and definition of mouse and keystroke dynamics, we describe the state of these technologies as lie detection tools, their main applications, and their future directions.

Mouse Dynamics

The term "mouse dynamics" refers to the description, in terms of temporal and spatial features, of the user's behavior with a computer-based pointing device, such as a mouse or a touchpad (Jorgensen & Yu, 2011). The first field in which mouse dynamics was applied was user authentication. The basic assumption is that each subject has a unique and distinctive pattern of mouse usage, so mouse behavior can be used as a biometric measure. Moreover, compared with other biometric measures (e.g., retinal scan, hand geometry, face recognition, fingerprints, voice recognition, etc.), mouse dynamics is less intrusive and requires no specific hardware to capture biometric information. Therefore, it is very suitable for the web environment (Jorgensen & Yu, 2011). However, being suitable for the web environment is not a feature exclusive to the mouse-tracking technique, as both the aIAT and CIT may be adapted for web administration (e.g., Verschuere & Kleinberg, 2017).

In the last decade, researchers (Freeman, Dale, & Farmer, 2011) have started to use mouse tracking as a real-time measure to understand the dynamics of mental processes. Many authors have applied hand-motor tracking to a broad range of topics—such as racial bias (Freeman, Pauker, & Sanchez, 2016), visual perception (Quétard et al., 2015), prospective memory (Abney, McBride, Conte, & Vinson, 2015), and lexical decisions (Barca & Pezzulo, 2012). These studies demonstrated that mouse tracking catches the cognitive complexity of stimulus processing when participants respond to multiple-choice questions. In short, it can provide an outline of the cognitive processes underlying a task, including processes involved in the deception production.

Duran, Dale, and McNamara (2010) conducted the first study that demonstrated that kinematic indices provide a clue for recognizing deceptions. They compared the motor trajectories of subjects instructed to lie or tell the truth about biographical information. The authors collected a series of movement parameters (onset time, total response time, trajectory, velocity, and acceleration of the movement) while the participants responded to questions that appeared on a screen by using a Nintendo Wii controller. The results demonstrated that deceptive and truthful responses can be distinguished according to response time and trajectory characteristics (e.g., the motor onset time, the overall time required for responding, the trajectory of the movement, and kinematic parameters such as velocity and acceleration). Hibbeln, Jenkins, Schneider, Valacich, and Weinmann (2014) and Valacich, Jenkins, Nunamaker, Hariri, and Howie (2013) analyzed mouse movements while participants completed online surveys to detect insurance fraud and insider threat activities, finding that guilty and honest participants showed varied mouse-usage patterns.

The kinematic analysis of mouse movements has been applied to identity verification (Monaro, Gamberini, & Sartori, 2017a). Monaro et al. (2017a) and Monaro, Gamberini, and Sartori (2017b) conducted a series of experiments to investigate mouse movement among participants who declared true or fake identities. The basic experimental paradigm was the same for all the experiments, as described by Monaro et al. (2017b). For each experiment, a minimum of 60 participants were asked to answer yes-or-no questions about their personal information by using the mouse to click on the correct alternative response on the computer screen. Half of the participants responded truthfully, whereas the others were instructed to lie about their identity by adhering to a false autobiographical profile that they had previously learned (the profile was given to the subject on a standard ID card, on which the participant's photo was pasted). Identity information could be explicitly learned during the preparation phase (expected questions—e.g., "Were you born in 1987?") or related to the given identity but not explicitly rehearsed before the experiment (unexpected questions—e.g., "Are you 30 years old?"). Moreover, control questions were asked about personal information that cannot be hidden, such as gender (e.g., "Are you female?"). The motor response was recorded using the *Mouse Tracker* software (Freeman & Ambady, 2010). We analyzed the signatures of deception in terms of temporal–spatial data and accuracy. In particular, spatial data refer to the point of maximum deviation (MD, the maximum distance between the real and optimum trajectory) and the value of the area under the curve (AUC, the spatial area between the ideal and optimum trajectories). An example of these features is reported in Fig. 10.2.

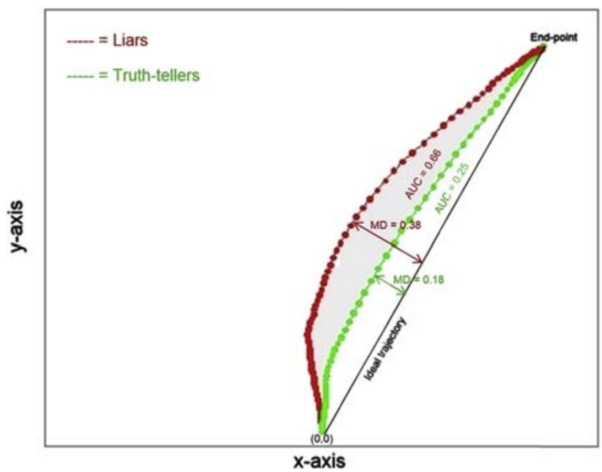

Figure 10.2 An example of the average trajectories of 20 liars (in red [dark gray in print version]) and 10 truth-tellers (in green [gray in print version]) who responded to unexpected questions about identity (Monaro et al., 2017b). The MD and AUC parameters are reported with their values.

Moreover, all of the *x* and *y* coordinates of the mouse's position over time are recorded, as are the number of direction changes in the *x* axis and *y* axis. Temporal data refer to the initiation time (time to start mouse movements after the questions appeared), RT (total response time), time to reach the point of MD, and acceleration and velocity over time. Finally, accuracy refers to the number of errors committed by the subject while responding to questions. All of these features were used to train various machine-learning classifiers and to estimate the accuracy with which it is possible to identify liars and truth-tellers. In general, all the experiments about identity detection have shown that people declaring a faked identity make a greater number of errors, take more time to complete the mouse response, and show wider trajectories (greater AUC and MD values). In sum, after running more than 10 experiments using mouse tracking and unexpected questions, we concluded the following:

1. The mouse-movement analysis of simple answers to yes-or-no questions is not sufficient to discriminate between liars and truth-tellers (unpublished data).
2. The introduction of unexpected questions induces an increase in liars' cognitive loads, which causes their response performances to worsen in terms of response time and the stability of the mouse trajectory. In short, by using unexpected questions, the authors reached an accuracy of around 95% in correctly classifying liars and truth-tellers (Monaro et al., 2017a, 2017b).
3. The technique has been shown to be very resistant to faking. Compared to other RT-based techniques, the kinematic analysis of the mouse movements let us record a variety of indicators in addition to the RT. The large number of indices collected makes it difficult to control them all efficiently, increasing the resistance of the instrument to countermeasures. In fact, Monaro and Sartori (unpublished data) demonstrated this by suggesting three specific countermeasures to the participants (reply as fast as possible, go straight to the answer, and reply slowly to easy questions) to cheat the classification algorithm, but the classification accuracy of a subject as a liar or truth-teller remained around 80%–85%.
4. The use of unexpected questions combined with the introduction of variable answer labels (not only yes-or-no questions) further improves the classification accuracy (97.5%). In other words, when participants

answer both fixed yes-or-no questions and questions from different categories (e.g., possible response labels to the question "How old are you?" might be "25" or "28"), the continuous change of the response label categories further increases the cognitive load for liars, producing a more accurate classification of liars and truth-tellers (Monaro, Fugazza, Gamberini, & Sartori, 2017).

5. The use of negative sentences slightly decreases the classification accuracy, but the accuracy remains stable at around 82% (unpublished data).

Another strategy is to induce a cognitive load in liars (vs the use of unexpected questions) using compound questions. By doing so, Monaro et al. (2017) reached a high accuracy in detecting liars' false identifications by recording both mouse movements (accuracy around 80%; unpublished data) and RTs (90% accuracy). The simple questions consisted of only one item of personal information that required a Yes response (e.g., "My name is Mary") or No response (e.g., "My name is Carol"). The complex questions were sentences composed of two or three personal pieces of information (e.g., "I am Mary, a 30-year-old from Venice"). These complex sentences required a Yes response when all the pieces of information that composed the sentence were true, whereas they required a No response when at least one of the pieces of information in the sentence was false. In other words, the participants were asked to respond Yes when the entire sentence was true and No when the sentences contained one or more pieces of false information. From a cognitive perspective, liars will have a harder time than truth-tellers in responding to complex questions. In fact, these questions require greater cognitive resources by requiring subjects to analyze each information item one by one and label each of them as true or false to later decide if the entire sentence is true or false. Because a lie is cognitively demanding, liars have fewer cognitive resources available to analyze the complex sentences and produce the right response. As a result, they will show poor performances in the task in terms of errors, response time, and mouse trajectory. The high accuracy when using compound questions was also confirmed by investigations of the veracity of autobiographical events via mouse movements and studies of malingering. Malingering refers to the condition in which the subject produces or exaggerates mental or physical symptoms to get a secondary benefit—such as financial compensation, the attention of third persons, or the achievement of other purposes (e.g., to avoid school, avoid military service, obtain drugs, or get a reduced sentence in a legal process).

Monaro et al. (unpublished data) proposed two experiments in which the participants were asked to answer questions about autobiographical events. In particular, during the experimental procedure, 90 participants were asked to answer yes-or-no questions about a holiday experience by using a mouse to click on the correct response on the computer screen. Whereas 30 participants answered truthfully, the other 60 were instructed to lie about their holiday according to a false vacation story that they had previously learned. The vacation could have been an actual holiday with faked details (30 participants) or totally invented (the other 30 participants). Some of the questions were simple (e.g., "I was in Paris"), whereas others were compounded by more than one information item ("I was in Paris with my friend Sara for Christmas"). The motor response was recorded, and mouse-tracking parameters were used to train various machine-learning classifiers. The authors obtained an accuracy ranging from 80% to 90% in classifying the autobiographical memory as truthful or untruthful. A similar experiment was conducted to investigate thefts committed during each participant's life; the authors identified liars who were guilty of theft with an accuracy of around 90% (unpublished data).

These methods may have strong practical implications, such as in identifying terrorists who enter Western countries by giving false personal information. The detection of faked autobiographical memories may resolve many open issues (especially in the forensic setting) involving the detection of alibis in criminal cases or the trustworthiness of witnesses regarding the facts. Finally, applications in insurance contexts are possible. In fact, the simulation of psychiatric disorders has had a serious impact in terms of health-care costs, both for public health and insurance. To date, few instruments have offered clinical support in identifying the simulation of psychiatric disorders. In addition, these instruments prove ineffective in identifying trained subjects, are complex to use, and require considerable expertise. For these reasons, Monaro et al. (unpublished data) proposed mouse tracking to investigate malingering. They compared the response trajectories of a group of subjects instructed to simulate depression while answering questions about their depressive symptoms with the trajectories of truly depressed patients and with control subjects. The analysis of the kinematic parameters showed statistically significant differences between the three groups, both in the shape of the trajectory over time and in the response times. Using a three-class approach classifier, the authors correctly distinguished control versus depressed versus malingerer participants with 86% accuracy.

Keystroke Dynamics

Keystroke dynamics describe the detailed timing information in the human typing rhythm: they describe exactly when each key is pressed and released while a person types on a computer keyboard, mobile phone, or touch-screen panel (Moskovitch et al., 2009; Shen Teh, Beng Jin Teoh, & Yue, 2013). The typing pattern analysis could be considered an implicit behavioral measure because users are not aware of it while interacting with the device (Giot, El-Abed, & Rosenberger, 2009). Furthermore, keystroke dynamics are unique and characteristic of each individual (Gaines, Lisowski, Press, & Shapiro, 1980; Obaidat & Sadoun, 1997). For this reason, they were widely used in previous literature as a biometric measure for security purposes, such as for user authentication (Monrose & Rubin, 1997, 2000; Zhong, Deng, & Jain, 2012) and user identification (Rybnik, Tabedzki, & Saeed, 2008; Zahid, Shahzad, Khayam, & Farooq, 2009). In the last 10 years, a large number of reviews collected all the studies written on this topic. In particular, Shen Teh et al. (2013) as well as Pisani and Lorena (2013) emphasized that the interest in studies on keystroke dynamics has increased exponentially. Some research has also demonstrated that it is possible to investigate changes in typing behavior within subjects by focusing on emotion discrimination (Solanki & Shukla, 2014).

The application of keystroke dynamics to differentiate true and deceptive statements is a relatively new field of study. Some studies have focused on detecting deception from text, but the majority of studies used a linguistic approach (Mihalcea & Strapparava, 2009) or only considered some simple features of the text rather than the rhythm of typing (Derrick, Meservy, Jenkins, Burgoon, & Nunamaker, 2013).

Mihalcea and Strapparava (2009) collected deceptive and truthful personal statements about given topics from Mechanical Turk participants. Using an automatic classifier based on psycholinguistic analysis, they distinguished between true and deceptive statements with an accuracy of 70%. Ott, Choi, Cardie, and Hancock (2011) also used Mechanical Turk to generate a data set of 400 positive, deceptive hotel reviews. These were combined with 400 positive, truthful reviews from TripAdvisor about the same hotels. Using a five-fold cross-validation, true and false reviews were used to train a learning classifier based on three approaches (genre identification, psycholinguistic analysis, and text categorization) that could distinguish deceptive reviews from truthful reviews with 90% accuracy.

Mukherjee, Venkataraman, Liu, and Glance (2013) compared the fake reviews obtained by Ott et al. (2011) with reviews classified as fake by Yelp's filtering. They concluded that fake-review detection using linguistic features is not as effective in a real-life setting and that fake reviews generated in an experimental context may not be representative of real-life fake reviews. Moilanen et al. (They Say, 2015) developed a software named *TheySay* that can measure the sincerity of a written text based on the textual sentiment analysis. Zhou (2005) explored various nonverbal and verbal behaviors (participation level, discussion initiation, cognitive complexity as well as nonimmediacy of sentences, frequency of spontaneous corrections, and lexical as well as content diversity) during a chat discussion between participants, showing that these indices could significantly differentiate deceivers from truth-tellers. Derrick et al. (2013) submitted participants to a computer-mediated interview. Prompts given by the system instructed the participants to be deceitful or truthful in response to each question. The computer system captured four main indices: response time, number of edits (basic keystrokes such as Backspace and Delete), word count, and lexical diversity. The results support the cognitive load theory, confirming that deception is positively correlated with response time and number of edits and negatively correlated with word count.

To date, very few studies have dealt with the issue of applying keystroke dynamics to lie detection (Grimes, Jenkins, & Valacich, 2013; Banerjee, Feng, Kang, & Choi, 2014). Grimes et al. (2013) proposed the keystroke-dynamics deception-detection model to explain the relationship between deceptive behaviors and keystroke dynamics. According to this model, the production of a falsehood may increase both emotional arousal and cognitive load. These increases may result in a consequent change in fine motor control, which in turn can result in deviations in typing ability, affecting the personal baseline of keystroke dynamics.

Banerjee et al. (2014) analyzed keystrokes to distinguish truthful writers of online reviews and essays from deceptive writers. Each participant wrote a truthful and a deceptive text on three topics (a restaurant review, gay marriage, and gun control). Mouse and keyboard events—including editing patterns, temporal aspects such as writing speed and pauses, and writing speed variations over word categories (e.g., nouns, verbs, adjectives)—were captured. The authors implemented a binary support vector machine (SVM) classifier that achieved a baseline average accuracy of 83.62%. By introducing keystroke features, they obtained a statistically significant improvement, ranging from 0.7% to 3.5%, of the classifier in the fivefold cross-validation.

Monaro et al. (2017) proposed applying keystroke dynamics to identity verification. The authors conceived of an identity-check task in which they instructed the subjects to respond to questions by typing free text into an edit box. This task matches the typical online form situation, in which the user has to fill out a series of fields to create a Web account. Although the authors asked the subjects to respond with a faked identity in the experimental setting, the basic idea is that in a real context, the subjects would be unaware that they are under scrutiny. During the experiment, the authors instructed 30 participants to lie about their identity according to a false autobiographical profile, which was presented on a faked Italian ID card. After the learning and recall phases for the faked identity information, the participants responded to 18 identity questions while pretending to be the people on their respective ID cards. The authors asked another 30 participants to answer truthfully. The experimental paradigm was similar to the one adopted by Monaro et al. in the previously mentioned studies about mouse dynamics (Monaro et al., 2017a, 2017b; Monaro et al., 2017). In fact, the 18 questions that were randomly presented to subjects were of three types: control (e.g., "What is your gender?"), expected (e.g., "In which month were you born?"), and unexpected (e.g., "What is your zodiac sign?"). The participants responded by writing their answers in the edit box located below the presented sentence; then, they pressed Enter to confirm the responses. For each response, a large number of keystroke and nonkeystroke features were collected—including the total number of errors committed; the interval between the onset of the sentence on the computer screen and the first key pressed; the total time from the stimulus onset to Enter being pressed; the time between the pressure on the first key and Enter being pressed; the time between the last key pressure and Enter; the number of characters pressed for the response; the average typing speed; the time stamp for each key press (down time); the time stamp for each key release (up time); the time duration between each key going down and going up (press time); the interleaving time between each key going up and the next key going down (flight time); the sum of the up and down time for two and three consecutive keys; the frequency of use for special characters (Shift, Del, Canc, Space, and the arrow keys). For each feature, the average, maximum, minimum, median, standard deviation, and variance were calculated, resulting in a final list of 62 attributes. The statistical results demonstrated that liars make a larger number of errors than truth-tellers, are slower in initiating the response, and have slower total response times. After a feature reduction, five final predictors were used to train various machine-learning classifiers (logistic, SVM, random forest and logistic model tree), obtaining a mean accuracy of 93.75% in the training and test sets for identifying a subject as a liar or truth-teller.

A very similar experiment was run by Monaro and Sartori (unpublished data), making the experimental procedure even more similar to the real context. One hundred participants filled out an online form that asked for typical information for a website subscription (name, surname, email, phone number, date of birth, place of birth, and place of residence). Each participant completed the form two times: one time with real identity information and the other time with fake identity information. After the subjects completed each form, four unexpected questions were presented to each participant. Collecting just the keystroke features of the responses to the final four unexpected questions, the authors reached an accuracy of around 90% in both the training and test sets (50% of the forms completed by participants were used as the training set, and the other 50% were used as the test set) in classifying liars' and truth-tellers' profiles. The resistance to the countermeasures of this technique has not yet been proven, but it is reasonable to think that this technique has a vulnerability to faking that is similar to that of mouse dynamics with unexpected questions.

As is clear from the topics of the studies mentioned earlier, the application of keystroke dynamics to lie detection may be a step forward for the online lie detection problem. To date, the large amount of information online raises the issue of identifying which contents are true and which are false. It was estimated that, in 2012, Facebook counted about 4 million fake accounts, which corresponds to 4% of the total Facebook profiles (Heather, 2012). Fake profiles are used for a wide range of purposes from business to social reasons— such as increasing the visibility of commercial contents, spamming, stalking, cyberbullying, or online "grooming." It is calculated that almost half of the teenagers who started an online relationship found that the partner had a fake identity, and in most cases, the partner was revealed to be an adult (Manca, 2016). The misuse of online reviews to attack business competitors, the spread of fake news for political ends, the online scams, and the hacking of online banking systems are now common phenomena that could benefit from a system that identifies false information from the user's typing behavior. Future research in lie detection should be focused in this direction, searching for a good compromise between developing more effective tools to unmask online deceptions and maintaining a good user experience during browsing and online authentication.

INCREASING SWITCH COSTS FOR DETECTING LIES

A number of studies demonstrated that switching between tasks affects performance, leading to slower RTs and higher error rates. Given that telling the truth and lying could be considered two cognitive tasks, the "switch cost" can be considered a useful marker of deception (Foerster, Wirth, Kunde, & Pfister, 2016).

Among the various experimental approaches that could lead to an increase in switch costs, one that has not been investigated in the literature is the anticipation of answer options before the question presentation. In a recent study (unpublished data), we tested the hypothesis that presenting the possible answer alternatives before the question could increase the switch cost.

Participants were randomly assigned to either a liars or truth-tellers group. All participants were required to respond as fast as possible to simple questions, choosing one of two possible answers by pressing a key (either A or L). The answer options appeared in the upper part of the screen for 1000 ms and disappeared when the corresponding question was presented. The A key referred to the upper-left answer, whereas the L key referred to the upper-right answer. Thirty-two questions were presented in the center of the computer screen. The control questions were standard questions that referred to the experimental setting and that required objective answers (e.g., "Where are you now?"), whereas answers for target questions were created ad hoc for each participant in order to test the specific personal information provided (e.g., "Giuseppe – Andrea," "What is your name?"). Truth-tellers were asked to report their actual identity information (i.e., name, surname, address, date, and place of birth and citizenship), whereas liars had to choose between two identities and then identify themselves with the chosen one.

For each question, two answers were presented. In target questions, one option was taken from the given or chosen identity profile, whereas the other was taken from a standard identity profile built by the experimenters and that was identical for all participants. Participants in the liars group showed slower RTs and an increased error rate when compared to the truth-tellers. Moreover, the two groups showed various patterns of RTs in relation to the question types: truth-tellers were faster in target questions than in control questions, whereas liars showed the opposite pattern. This result could depend on an increase in switch costs due to the anticipation of answer alternatives that could make liars more easily detectable. In addition to the standard statistical analyses, a machine-learning analysis was performed, and it showed an accuracy of 90% in classifying participants as liars or truth-tellers.

Is the switch cost enough to increase liars' cognitive loads and evoke the RT increase that is typical of the deception? To answer this question, Monaro and Sartori (unpublished data) conducted another experiment related to false identities by measuring 100 participants' RTs to simple double-choice questions. Similar to Monaro et al.'s study (2017, see earlier), half of the participants were instructed to memorize a fake identity from an ID card and lie about their biographical information, while the other half were instructed to respond truthfully with their own personal information. Questions concerning the identities (fake or real) were simple affirmations, such as "My name is Mirko" or "I'm a product specialist." In the case of liars, participants had to respond Yes when the presented affirmation matched the faked identity they had previously learned, whereas truth-tellers responded Yes when the affirmation matched their true identities. At the same time, all the subjects (both liars and truth-tellers) had to respond sincerely to control questions pertaining to the situation at the moment of the test. Control questions were affirmations related to the test situation, such as "I am taking part in an experiment" or "I'm sunbathing on a beach." Participants had to respond Yes or No by pressing, respectively, the keys A or L on the computer keyboard. Twenty control questions and 20 questions about the identities were randomly presented. In this way, during the task, a liar had to continuously and unforeseeably switch from questions that required the truth (control questions) and questions that required telling a lie (identity questions). The results confirmed that the switch cost was enough to increase liars' cognitive loads, even if this strategy received slightly lower results than other cognitive strategies (e.g., unexpected questions). In fact, when applying machine-learning algorithms to errors and RTs, it is possible to classify a subject as a liar or truth-teller with an accuracy of 85% in both the training and test sets. The cost of the switch, given by the RT difference between identity and control questions, is significantly related ($r = 0.52$, $P < 0.01$) to the experimental condition (liar or truth-teller).

INCREASING COGNITIVE LOAD FOR DETECTING LIES

The role of cognitive loads in lying has been extensively studied in the literature (e.g., Zuckerman, DePaulo, & Rosenthal, 1981; Walczyk et al., 2003; Gombos, 2006). Indeed, the decision to lie, the inhibition of the truth, and the production of the lie are all cognitively demanding processes (Vrij, 2014). We developed a paradigm derived from the combination of existing lie detection approaches, thus aiming to increase liars' cognitive loads by explicitly asking subjects to lie in response to external cues in an identity-check task.

In the first phase, examiners contacted participants and asked them to fill out a form providing their personal data and to perform a lie detection task (2 days later) with a second (blind) examiner testing whether they lied about their identities. As in the previously described experiment, the examiners randomly assigned participants to the liars or truth-tellers groups. Participants in the liars group were asked to complete a form by providing faked personal data (i.e., name, surname, as well as date and place of birth) and to lie about their identities during the computerized task that they would perform two days later. Conversely, subjects in the control group were asked to provide their actual personal data and to perform the lie detection task by simply following the experimenter's instructions.

In the second phase (after 2 days), both groups were subjected to the same experimental procedure, in which they were asked to answer yes-or-no questions presented on a computer screen by pressing two response keys (the A and L keys, respectively, of a standard computer keyboard). Items included control questions that could be true (e.g., "Are you in front of a computer screen?") or false (e.g., "Are you in front of a TV?") and target questions describing the personal data provided 2 days before as faked (e.g., "Have you provided true data?") or real (e.g., "Have you provided false data?").

The key feature of the paradigm is its combination of features derived from two previously published tasks, namely the TARA (Gregg, 2007) and the Sheffield Lie Test (Spence et al., 2001). Indeed, as in the TARA administration, participants were asked to lie about some items. In particular, they were asked to respond truthfully whenever the question was written in white and to lie (i.e., provide the opposite answer) when the question was written in red. Combining the explicit request to lie (using question color) and liars' implicit deceptive intentions, the two groups' expected performance (i.e., their responses) is shown in Table 10.1.

Table 10.1 Description of the items and the expected responses for each group

				Expected responses	
Type	**Color**	**Answer**	**Question example**	**Liars**	**Truth-tellers**
Control	White	Yes	"Are you in front of a computer screen?"	Truth	Truth
		No	"Are you in front of a TV?"		
	Red	Yes	"Are you in front of a TV?"	Lie	Lie
		No	"Are you in front of a computer screen?"		
Target	White	Yes	"Have you provided true data?"	Lie	Truth
		No	"Have you provided false data?"		
	Red	Yes	"Have you provided false data?"	Truth	Lie
		No	"Have you provided true data?"		

Moreover, following the structure of the Sheffield Lie Test, the presentation of questions followed an oddball paradigm in which there were 1/3 ratios between red and white questions and between target and control questions.

In summary, liars and truth-tellers are expected to respond in the same way to the control questions (i.e., truthfully to white questions and untruthfully to red questions). However, the expected pattern of responses differs for the target questions. In particular, although truth-tellers are expected to respond consistently with the questions' colors (telling the truth on white questions and lying on red questions), liars are expected to show the inverse pattern: lying on white questions (i.e., saying that the provided data were true) and telling the truth on red questions (i.e., saying that the provided data were false).

Interestingly, the results showed that liars were significantly slower than truth-tellers in responding to the red target questions, even though they were responding truthfully. This unexpected result could suggest that the liars did not simply tell the truth on the red target questions; this could instead show the cumulative effect of two deceptive processes: one based on group belonging and one based on question color. This effect could have led to a rise in the liars' cognitive loads, resulting in a significant increase in

RTs. The main advantage of this experimental paradigm is that the items generally refer to the information provided in the completed form; thus, this test can be tailored to various purposes (e.g., checking the truthfulness of personal data or evaluating an individual who is suspected of having committed a crime) without any further effort.

As a final remark, there are both advantages and limitations to the practical application of the lie detection techniques just presented. A list of benefits and drawbacks is presented in Table 10.2.

MACHINE-LEARNING ISSUES IN LIE DETECTION RESEARCH: METHODOLOGICAL OBSERVATIONS

In common practice, lie detection approaches focus on using single variables to detect liars. Among the variety of adopted measurements in the literature, the most frequently used are RT and number of errors. However, data analysis methods based on machine-learning algorithms allow for several variables to be considered at the same time, thus leading to a more robust detection of liars' response styles. These methods come from the integration of classical lie detection paradigms with computer science knowledge, and they represent a promising approach for lie detection research and for real-life applications of lie detection tools. Machine-learning classifiers can capture complex relationships in the data that simple linear models cannot capture, and they can classify examples as belonging to one of two or more classes (e.g., liars vs truth-tellers). However, the application of machine-learning techniques to lie detection data, and to behavioral data in general, does cause some methodological issues. First, this approach faces the problem of classification from a data-driven perspective; the analysis is grounded, not on theory, but on the specific characteristics of the data set. Moreover, machine learning requires many examples, a requirement that does not apply in traditional lie detection research, so machine learning models are prone to overfitting when applied to small data sets. A number of cross-validation techniques (e.g., k-fold cross-validation) have been developed to overcome such limitations. For example, ten-fold cross-validation has been shown to provide a good approximation for out-of-sample errors, which is why we have used this approach for all the machine-learning analyses reported here. In recent years, two of the most critical issues in the psychological sciences have been the problems of reproducibility (e.g., Ioannidis, 2005) and generalizability of results; the application of machine-learning techniques to

Table 10.2 List of benefits and drawbacks for the behavioral lie detection tools currently available in the literature

Tools	Benefits	Drawbacks
Concealed Information Test	• It has high accuracy. • It is generalizable to any topic.	• It requires the true memory as an alternative. • The subject is aware of the lie detection effort. • It is based solely on reaction time, so it is not very resistant to coaching.
autobiographical Implicit Association Test	• It has high accuracy. • It is generalizable to any topic.	• It requires the true memory as an alternative. • The subject is aware of the lie detection effort. • It is based solely on reaction time, so it is not very resistant to faking. • The complex instructions may render the online administration difficult.
Timed Antagonistic Response Alethiometer	• It has high accuracy. • It is generalizable to any topic.	• It requires the true memory as an alternative. • The subject is aware of the lie detection effort. • It is based solely on reaction time, so it is not very resistant to faking. • The complex instructions and the need to have a real alternative memory make it unsuitable for large-scale (e.g., online) applications.

Continued

Table 10.2 List of benefits and drawbacks for the behavioral lie detection tools currently available in the literature—cont'd

Tools	Benefits	Drawbacks
Mouse dynamics + unexpected questions	• It does not require the true memory as an alternative. • It is based on a large number of indices, so it is difficult to control entirely via efficient countermeasures. • The lie detection can be hidden from the subject. • It is suitable for large-scale (e.g., online) applications.	• The accuracy differs for each topic. • No current protocol is generalizable to all topics.
Keystroke dynamics + unexpected questions	• It does not require the true memory as an alternative. • It is based on a large number of indices, so it is difficult to control entirely via efficient countermeasures. • The lie detection can be hidden from the subject. • It is suitable for large-scale (e.g., online) applications. • It can be applied using free text (no multiple-choice questions).	• The accuracy differs for each topic. • No current protocol is generalizable to all topics.
Choice-reaction time + increased memory load (unexpected and complex questions, switch cost)	• It does not require the true memory as an alternative. • It is suitable for large-scale (e.g., online) applications.	• The accuracy differs for each topic. • No current protocol is generalizable to all topics. • The subject is aware of the lie detection effort. • It is based solely on reaction time, so it is not very resistant to faking.

behavioral data could help solve this issue by promoting techniques that provide some generalizability of performance.

CONCLUSIONS

In this chapter, we discussed the main behavioral methods used to detect deception. All these methods are based on the measurement of errors and latencies while the subject is responding to questions about an event under scrutiny. Two of the main methodologies in the literature, the CIT and the aIAT, have shown broad validation and generalization. However, these methodologies suffer from some important application limits. First, they require that the true memory is known. In other words, they cannot be used to determine if any answer is true or false; they can only be used to decide which of two responses is true and which is false. Second, they do not permit covert deception detection because the subjects are always aware that they are under scrutiny. Furthermore, both the aIAT and the CIT are based solely on RT, so it is very simple for subjects to train themselves and implement efficient strategies to cheat the test. Finally, both methodologies have complex instructions and need to have a real alternative memory, which makes them unsuitable for large-scale (e.g., online) applications. More recent technologies have partially addressed these limits. In the last 2 years, new techniques that are much more suitable for large-scale online applications have been developed. These new techniques are essentially based on cognitive strategies that are able to increase liars' cognitive loads, and they are combined with RT measurements and mouse or keystroke dynamics. For now, these techniques have mostly been tested on the problem of identity verification, but some studies suggest that they also are promising for more extensive applications, such as deception detection regarding autobiographical events and malingering detection. Unfortunately, the mouse and keystroke dynamics are still under study, and their usability is dependent on calibration and on the development of models that are generalizable to a wide range of fields.

In the last few years, the introduction of machine-learning algorithms to the construction of lie detection models has led to considerable advantages and innovations. Machine learning allows for complex models that take several behavioral deceit markers into account, and it permits the creation of instruments that detect liars automatically at the single-subject level. For this reason, future directions will include the integration of machine-learning algorithms into lie detection tools and applications such as online deception-detection systems.

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CHAPTER 11

Challenges for the Application of Reaction Time—Based Deception Detection Methods

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INTRODUCTION

The use of reaction time (RT)-based deception measures has sometimes been met with skepticism in the scientific community (Farwell & Donchin, 1991; Gronau, Ben-Shakhar, & Cohen, 2005; Mertens & Allen, 2008; Sip et al., 2013). It has been argued that RT measures are under voluntary control, and suspects might easily succeed in manipulating their test outcomes. Also, two meta-analyses looking at behavior that may be indicative of deception did not find significant differences between the time it takes truth tellers and liars in interview situations to initiate their responses (DePaulo et al., 2003; Zuckerman, DePaulo, & Rosenthal, 1981). Only recently, sparked by technological advancement and the now common use of computer-based assessments, RTs have been rediscovered as potentially easy and convenient deception measures. Regarding the disappointing results for RTs in the two meta-analyses of DePaulo et al. (2003) and Zuckerman et al. (1981), it has been argued that interview situations may not provide the optimal environment to assess RTs, and that computer-based RT deception detection methods in which responses are standardized, have to be given rapidly, and are averaged across multiple trials may be more promising (Verschuere, Suchotzki, & Debey, 2015). A new meta-analysis therefore reexamined the question of whether under such optimal circumstances, RTs do provide valid measures of deception (Suchotzki, Verschuere, Van Bockstaele, Ben-Shakhar, & Crombez, 2017). This meta-analysis included the most common four types of deception paradigms: the Differentiation of Deception paradigm (Furedy, Davis, & Gurevich, 1988), the Sheffield Lie Test (SLT; Spence et al., 2001), the

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RT-based Concealed Information Test (CIT) (Seymour, Seifert, Shafto, & Mosmann, 2000) and the autobiographical Implicit Association Test (aIAT; Sartori, Agosta, Zogmaister, Ferrara, & Castiello, 2008). For an illustration of the four paradigms accompanying the description provided next, together with the typically observed RT patterns, see Fig. 11.1.

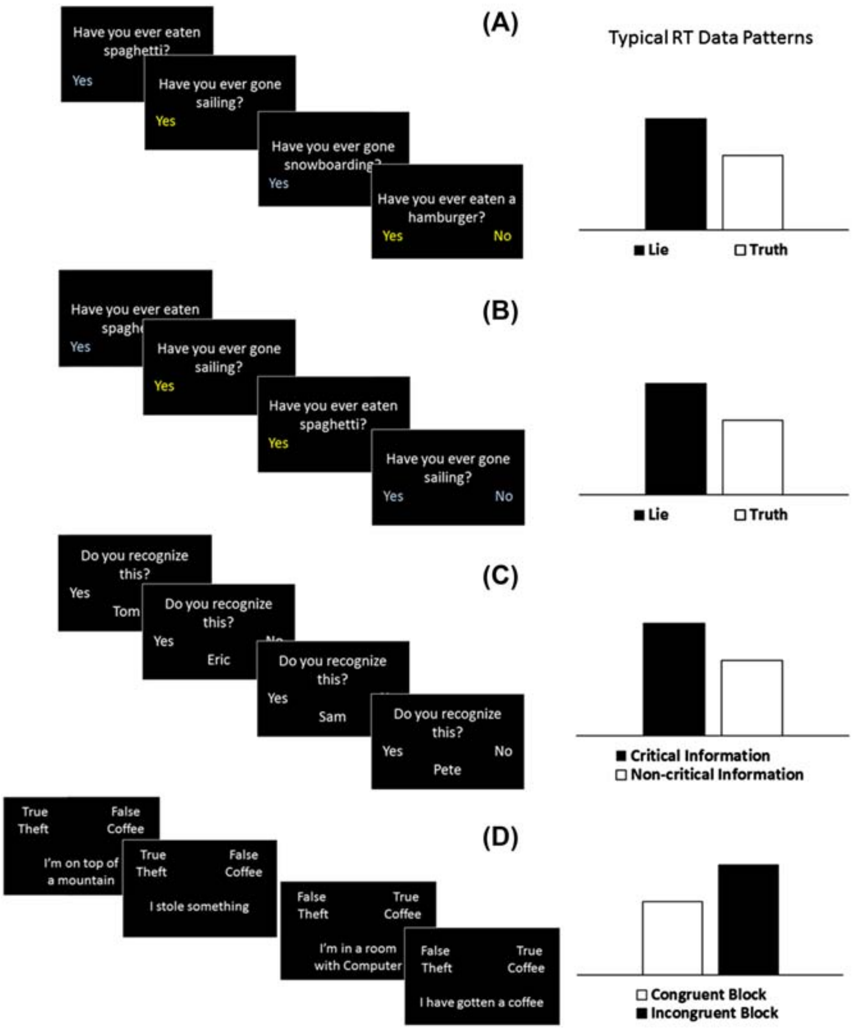

Figure 11.1 The different paradigms and the typical reaction time patterns they are expected to produce. (A) *DoD*, differentiation of deception paradigm; (B) *SLT*, Sheffield Lie Test; (C) *RT-CIT*, reaction time–based Concealed Information Test; (D) *aIAT*, autobiographical Implicit Association Test; *RT*, reaction time.

THE DIFFERENTIATION OF DECEPTION PARADIGM

The differentiation of deception (DoD) paradigm was developed by Furedy et al. (1988) to provide an experimental means to compare the physiological correlates of truth-telling and lying. It also should overcome the main problem of traditional deception detection tests (for instance, the Comparison Question Test; Reid, 1947), in which lying and truth-telling are compared on questions that differ greatly in their perceived significance, potential emotional impact, and specificity. Therefore, in the DoD paradigm, truth-telling and lying are compared to two question sets that are well-matched regarding those characteristics. For instance, in the first study using the DoD paradigm, Furedy et al. (1988) compared physiological responses while telling the truth to questions like "What is your mother's age?" with physiological responses while lying to questions like "How many brothers do you have?" An example of an RT study that used a variation of the DoD paradigm is one by Duran, Dale, and McNamara (2010). In this study, participants had to tell the truth to questions like "Have you ever eaten spaghetti?", "Have you ever gone snowboarding?", and "Have you ever played the violin?", and lie to questions like "Have you ever eaten a hamburger?", "Have you ever gone sailing?", and "Have you ever played the tuba?" Responses were given by moving a Nintendo Wii as fast as possible to a Yes or No response, and the time it took participants to do so was taken as dependent measure. As evident in this example, RTs in such paradigms can be measured in different ways. The most common mode of responding in studies using RT versions of the DoD paradigm (and also the SLT), however, is that participants are asked to give their responses via button presses (e.g., Abe et al., 2008; Ganis, Morris, & Kosslyn, 2009; Ito et al., 2012; Marchewka et al., 2012).

THE SHEFFIELD LIE TEST

The SLT is a variant of the DoD paradigm that has been developed by Spence et al. (2001) for one of the first functional magnetic resonance imaging (fMRI) studies investigating the neural mechanisms that are at play during deception. In the SLT, experimental control is maximized, and truth telling and lying are not compared to two well-matched but different question sets, but to the same question set. For instance, Spence et al. (2001) presented participants with the question, whether in the course of the day, had they done any of the following activities. Participants were then presented with alternatives like "Made your bed?" or "Taken a tablet?" Crucially, together with the question, response labels for the Yes and No responses (see Fig. 11.1) were presented on the screen in either green or red. Participants were instructed that depending on the color, they should either reply truthfully or lie. For instance, they were instructed that when the question was presented in green they should tell the truth, and when it was presented in red they should lie (the colors used may vary from study to study). In most SLTs, each question is presented equally often in both colors, resulting in a 50:50 ratio of truth-telling and lying responses (a ratio that is usually also used in the DoD paradigm). Each question thus serves as its own perfectly matched control condition. Examples of the use of the SLT to measure RTs as primary measures are studies by Debey, De Houwer, and Verschuere (2014) and Suchotzki, Verschuere, Crombez, and De Houwer (2013). The SLT in the former study used simple autobiographical questions like "Are you a student?" and "Are you outside?", and the SLT in the latter study used questions related to a previously performed mock crime like "Did you steal a CD-ROM from Bruno?" or "Did you steal a laptop from Agnes?" So although the SLT can be used with all types of questions, it is important to note here that both the DoD paradigm as well as the SLT were not originally developed as deception detection methods (Furedy et al., 1988). Rather they were developed as experimental paradigms that should allow the comparison of the fundamental dynamics and underlying mechanisms of truth-telling and lying, while controlling for potentially confounding effects of the questions. As will be explained in more detail later, in order to use those paradigms to detect deception, some adaptations would be necessary.

THE REACTION TIME–BASED CONCEALED INFORMATION TEST

The RT-based CIT is an adaptation of the traditional CIT, which measures indices of the autonomic nervous system (ANS, Lykken, 1959). The ANS-based CIT primarily relies on the orienting response (Sokolov, 1963) and thereby on the observation that information that is significant for a suspect will automatically attract attention. In forensic contexts, such significant information is typically crime-related information, and the CIT is used to measure whether or not a suspect recognizes this critical information. In a typical experimental study using the ANS-based CIT by Elaad and Ben-Shakhar (1989), participants were first asked to conceal their recognition of a number of critical personal details (i.e., their parents' names, date of birth, and street of residence) while being presented with those details among a number of other unknown and thus noncritical details (i.e., other names, dates, and streets). In this traditional CIT, stronger autonomic arousal to critical compared to noncritical details is interpreted as index of recognition.

In more recent years, in order to use RTs as dependent measures, this traditional CIT procedure has been slightly adapted. In a typical RT-based CIT, an examinee is asked whether he or she recognizes the following details (e.g., the aforementioned personal details or details that are related to a (mock) crime). Then, the examinee is again presented with a number of different details, some of which constitute critical information (e.g., the actual name of the parents or the actual place where the (mock) crime took place) and some of which constitute noncritical control information (other names and places). The suspect is instructed to actively deny recognition of each of those details, mostly by pressing a button on a keyboard designated as the No button (for an illustration of the RT-based CIT see also Fig. 11.1C). Additionally, in order to prevent suspects from automatical responding and to ensure that attention is being paid to each detail, they are usually also given a list of keywords that they should recognize and respond Yes to. Those so-called target items are irrelevant for the analysis, as here the main comparison in the RT-based CIT is the time it takes knowledgeable examinees to emit the honest No responses to the noncritical details and the time it takes knowledgeable examinees to emit the deceptive No responses to the critical details.

Examples of prototypical RT-based CIT studies are studies by Seymour et al. (2000) and by Verschuere, Crombez, Degrootte, and Rosseel (2010). In the former study, crime-related information acquired during the commitment of a mock computer crime was used as critical information (e.g., the name of a collaborator, the name if a file to be given to the collaborator, and the street in which they would meet) and non–crime-related information (other names, file names, and streets) was used as noncritical information. In the latter study, autobiographical information (first name and last name of the participant, first name of the father, first name of the mother, and birthday of the participant) was used as critical information, and nonautobiographical information (other names and dates) was used as noncritical information.

THE AUTOBIOGRAPHICAL IMPLICIT ASSOCIATION TEST

Unlike the other three paradigms, whose RT versions constitute adaptations of paradigms primarily developed for other dependent measures, the aIAT is a paradigm that has directly been developed for the measurement of RTs (Sartori et al., 2008; for a review see Agosta & Sartori, 2013). The aIAT is an adaptation of the Implicit Association Test developed by Greenwald, McGhee, and Schwartz (1998), which should detect the strength of a person's automatic association between mental representations of objects or concepts. In the aIAT, examinees are presented with statements referring to two contrasting autobiographical events (e.g., a (mock) theft and an alibi activity like going to get coffee) plus statements that are generally true (e.g., I'm sitting in a room with computers) and statements that are generally false (e.g., I'm standing on top of a mountain). Examinees have to categorize those statements as belonging to four different categories, for instance Theft, Coffee, True, and False. Crucially, always two categories are combined on one side of the screen and examinees have to press the same keyboard button for those two categories. In one test block, the Theft and the True categories would share one response button and the Coffee and False categories would share another response button. In another test block (to be completed in the same testing session), the Theft and the False categories would share one response button and the Coffee and True categories would share another response button (for an illustration of the aIAT see Fig. 11.1D). The expected result in the aIAT is that depending on which is the true autobiographical event for a given examinee, the test block in which this true autobiographical event is paired with the True category is easier and therefore RTs on this block will be faster. Different examples for the use of the aIAT are given in the first aIAT paper by Sartori et al. (2008), in which the aIAT is used to distinguish which of two cards an examinee had picked, which of two holidays the examinee had been on, and which of two drugs an examinee had used in the past.

META-ANALYTIC FINDINGS

Importantly, the meta-analysis by Suchotzki et al. (2017) revealed large effects for all four previously introduced RT deception paradigms. That means that in all those paradigms, RT differences between lying and truth-telling were large and significant (for a more detailed view on which conditions constitute the crucial comparison in each paradigm see

Fig. 11.1). More specifically, the meta-analysis revealed an average standardized paired difference (paired Cohen's *d*) between lying and truth telling of $d = 1.350$, 95% CI [0.945, 1.755] across 16 studies using the DoD paradigm ($n = 277$) and of $d = 1.287$, 95% CI [1.129, 1.446] across 55 studies using the SLT ($n = 1778$). It furthermore revealed an average standardized paired difference between critical and noncritical information of $d = 1.297$, 95% CI [1.060, 1.535] across 34 studies using the RT-based CIT ($n = 1063$), and an average standardized paired difference between the incongruent and the congruent block of $d = 0.822$, 95% CI [0.538, 1.106] across nine studies using the aIAT ($n = 189$). As a rule of thumb, Cohen (1988) proposed 0.20, 0.50, and 0.80 as thresholds for small, moderate, and large effects, respectively. So we can conclude from those results that on average and under laboratory conditions, all four paradigms produce large effects. But does it follow, therefore, that those paradigms could be directly applied in real-world contexts?

APPLIED POTENTIAL

There are several important aspects that should be considered. First, not all of those paradigms are applicable in deception detection contexts in their current form. As mentioned earlier, the DoD paradigm and the SLT have been developed to address fundamental questions about the differences between lying and truth-telling, and not as deception detection methods. In most studies using those paradigms, study participants are explicitly instructed on which trials to lie and on which to tell the truth, and no incentives exist that would motivate participants to not follow those rules. This would of course be different with uncooperative examinees that unbeknownst to the tester would switch the instructions in order to communicate the deception as the truth. Of course, the assumption would be that such behavior would simply reverse the usually obtained RT cost for lying, from which one could then infer that the condition in which it takes the examinee longer to reply would constitute the lie, and the condition in which responding is faster constitutes the truth. Unfortunately, the only study that aimed to infer the truth from an SLT is a case study with only one suspect in an actual criminal case in which ground truth (i.e., the actual truth) was not available. In this study by Spence, Kaylor-Hughes, Brook, Lankappa, and Wilkinson (2008), a suspect accused of harming her child (due to her suffering from a condition called Munchhausen by proxy) was instructed to answer the same questions once in the version of her accusers (i.e., admitting her guilt) and once in her own version (i.e., denying her guilt). The paper reports both RTs and neuronal activity, and both were elevated when the suspect admitted her guilt. But although the results of both dependent measures match and point toward the suspect's innocence, no ground truth was available to check the validity of this conclusion.

Different explanations for the result pattern are also conceivable. The investigation was done at a very late point of the investigation in which the suspect had already been interviewed many times. So denying the accusations could have been easier for the suspect due to extensive practice in doing this. Also, the behavior of harming her child—even if it occurred—could be inherently negative and unadmittable for the suspect, which might also slow responses and increase general neuronal activity on admission trials. So although both the DoD paradigm and the SLT would have the advantage that their question format can easily be adapted to a number of different situations (which is more difficult in the RT-based CIT and the aIAT), their potential use in deception detection context awaits empirical investigation.

Note that some fMRI studies have used variations of the DoD paradigm in studies in which neuronal patterns were used to attempt individual classifications of guilt and innocence (Kozel et al., 2005; Langleben et al., 2005). Within the DoD paradigm, the issue of sufficiently matching the question sets (to which participants should lie and tell the truth) remains, however, a critical issue and shortcomings of those studies are mostly due to the fact that it is very difficult to construct a matched and comparable question set to questions about a real emotional event (e.g., a crime under investigation). Therefore, the SLT may be the more promising paradigm to investigate. Such an investigation may use a mock crime design, and randomly assign participants to either a guilty or innocent group. Whereas the former group would be instructed to commit a mock crime (e.g., stealing something), the latter group might simply be instructed to perform a noncriminal alibi activity (e.g., making coffee). Both groups would then receive questions concerning the mock crime and the alibi activity and receive the same SLT instructions. Those instructions for instance could be to admit the mock crime and deny the alibi activity when questions or response labels are presented in one color, and deny the mock crime and admit the alibi activity when questions or response labels are presented in another color. The critical empirical question would then be whether the response pattern would switch between conditions, with the guilty participants taking longer to lie that is, to deny the mock crime and admit the alibi activity compared to admitting the mock crime and denying the alibi activity and with the reverse response pattern for innocent participants. Another question concerns the degree to which such a switch would not only become significant on a group level but whether the direction and the size of the effects would also allow valid classifications on an individual level.

In contrast to the DoD paradigm and the SLT, the CIT and the aIAT would not require any modifications for their use in applied settings. Similar to the ANS-based CIT, which is already used in criminal investigations in Japan, the RT-based CIT would require that enough critical information (e.g., about the crime under investigation) is available to the examiners, but has not been yet made openly available (so that innocent examinees would also recognize it). Although it has been argued that this would seriously limit its applicability, the common use in Japan with around 5000 CIT examinations yearly (Osugi, 2011) shows that properly trained police investigators and examiners in many criminal cases seem to be able to extract sufficient useful information (for an unrelated criticism of the Japanese justice system that is worth mentioning see Ramseyer & Rasmusen, 2001).

Using the aIAT in applied contexts requires the presence of two contrasting events. Although in first studies, it was also used to contrast statements regarding one event (e.g., "I stole the exam") with their negation ("I did not steal the exam"), later research showed that this practice is not optimal (Agosta, Mega, & Sartori, 2011). Therefore, in a forensic application, one always needs a contrasting event that the suspect of a crime claims to have done instead of the crime, which is not, however, an uncommon situation.

Aside from these restrictions regarding the situations in which the CIT and the aIAT would be applicable, those paradigms in principle could be used in their current form in forensic investigations. It is important to note, however, that research that has been conducted so far regarding the validity of the paradigms did not sufficiently address all factors that are relevant in such applied contexts. This includes the question of whether participants are able to fake their test results and are able to incorrectly obtain truthful test outcomes, whether the tests produce valid results also in forensic populations, how well they can distinguish between truthful and deceptive (or guilty and innocent) suspects, and whether they are grounded in scientific theory. For the remainder of the chapter, I will discuss those questions.

FAKING

The first and foremost problem of each application of deception detection paradigms is faking. Faking means that participants apply strategies (also called countermeasures) to produce a test outcome that is indicative of truthfulness. Importantly, so far most deception detection tests have been proven to be vulnerable to faking strategies (for a review on faking in ANS-based deception detection measures see Ben-Shakhar, 2011). It is specifically for RT-based measures, however, that much emphasis has been put on the fact that as a measure of behavior, they would be especially easy to fake. After all, participants could just control how fast or slow they responded on each trial, with the most promising faking strategy to slow down responses in the respective control condition. And indeed, a small meta-analysis including 17 RT-based deception detection studies in which participants were instructed to fake ($n = 348$) revealed a very small effect size, which was not significantly different from zero anymore (paired Cohen's $d = 0.13$, 95% CI [−0.17, 0.43]; Suchotzki et al., 2017). So does that mean that RT-based deception detection measures are not applicable in contexts in which examinees are motivated to fake? There are several reasons why such a conclusion seems premature.

The first is that the same meta-analysis also showed that faking seems to require explicit knowledge of the test. Simply motivating examinees to beat the test was not enough to erase RT effects. Effects did become slightly (and significantly) smaller compared to studies in which no such motivation was given ($d = 1.002$, 95% CI [0.781; 1.223] vs $d = 1.33$, 95% CI [1.19; 1.47]), yet naïve faking attempts do not seem to be sufficient to enable examinees to fake test outcomes.

The second reason is related to the studies that were included in the faking meta-analysis. In general, with 17 studies, the sample of studies was too small to distinguish between the three different paradigms (3 SLTs; 5 RT-based CITs, 9 aIATs; there were no studies investigating faking in the DoD paradigm). Additionally, studies in which RTs were not the primary measure of interest were included in the meta-analysis. Therefore, experimental parameters in those studies may not have been optimal for the measurement of RTs (e.g., pace of the stimulus presentation or speed instructions; see also Verschuere et al., 2015). And indeed, when reviewing only studies that used RT versions of the CIT and the aIAT, results seem less clear. Whereas some RT-based CIT studies seem to find no effects of faking on the test performance (Seymour et al., 2000), others found reduced yet still significant RT-based CIT effects when participants were instructed how to fake the test (Huntjens, Verschuere, & McNally, 2012). For the aIAT, results seem a little more straightforward, with faking effects in most of the existing studies (Hu, Rosenfeld, & Bodenhausen, 2012; Verschuere, Prati, & De Houwer, 2009). Yet also here, some of those aIAT effects remained significant (although correct classification rates were rather low; Agosta, Ghirardi, Zogmaister, Castiello, & Sartori, 2011).

The third reason why an abandonment of RT measures due to their potential fakeability would be premature is that in general, faking effects in the literature may be overestimated. Participants in deception detection experiments and in faking experiments are very often students, with an above-average intelligence, who are used to computer-based experiments. This does not represent the typical population on which such tests would be applied in real life and such student participants may be more capable of faking than the average examinee. Also, faking strategies are not only instructed but also often trained in experiments (e.g., Ben-Shakhar & Dolev, 1996; Honts, Devitt, Winbush, & Kircher, 1996), something that not many suspects have the opportunity to do in real life.

The fourth reason why concluding that RT measures do not have the potential to be applied due to their fakeability would be premature is that faking poses a serious problem with any dependent measure in any deception detection test. It has been demonstrated to be possible in the autonomic-based Control Question Test, in the autonomic-based CIT, in the event-related potential-based CIT (for a discussion of the latter three see a review by Ben-Shakhar, 2011). It even has been found effective in the fMRI-based CIT (Ganis, Rosenfeld, Meixner, Kievit, & Schendan, 2011), although some researchers had placed high hopes in this measure due to its most direct assessment of deception (Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003; Langleben et al., 2002). However, the discovery of their countermeasure vulnerability has not stopped researchers from further exploring those methods. On the contrary, it has stimulated a search for ways to discover or even counteract faking. For instance, for the autonomic-based CIT, the use of an additional covert measure (i.e., respiration) has been proposed, which, as participants were not told that this was monitored as well, seemed to be less vulnerable to faking (Elaad & Ben-Shakhar, 2008, 2009). For the event-related potential-based CIT, the discovery of its fakeability has led to a proposal to modify the structural properties of the test (separate the presentation of the critical item from the target detection phase), which so far has proven very resistant to faking attempts (the Complex Trial Protocol; Rosenfeld et al., 2008). For the fMRI-based CIT, new data analysis techniques (e.g., multivariate pattern analysis) are currently being explored for their ability to resist faking (Gamer, 2014; Peth et al., 2015). So as with other measures, one could argue that the discovery that RT-based deception detection measures are vulnerable to faking should inspire future research for specific ways on how to deal with this issue rather than suggest their abandonment.

Based on these arguments, it is suggested that abandoning the potential use of RT deception measures due to the observation that they may be fakeable would be premature. There are several interesting avenues for further research. First, the large heterogeneity observed in the meta-analytic sample of faking studies (with 85% of observed variance being due to real differences between studies) as well as the differing results of the single studies suggest differences in the fakeability between paradigms. It seems reasonable to assume that due to design differences between paradigms also the difficulty of faking strategies differs. For instance, in the RT-based CIT, faking requires a speeding up on trials in which critical items are shown or a strategic slowdown on trials in which noncritical items are shown. All items are usually presented randomly intermixed, requiring the participants to decide on each trial whether to slow down or not. In contrast, in the aIAT faking requires a slowdown on the entire block, pairing the true category with the crime category. Once the examinee has determined which of the two blocks this is, he or she can simply apply the strategy during the entire test block and not apply it during the other. Of course, in order to establish whether the RT-based CIT is more difficult to fake than the aIAT, a direct comparison of both tests should be conducted within one experiment. But if structural test properties were indeed the reason for the larger susceptibility of the aIAT to faking attempts, we may also look at how those structural properties could be adjusted. It would be possible, for instance, to get rid of the division between two different test blocks in the aIAT by changing the assignment of categories on a trial-by-trial basis. Thereby, the test would become more difficult, but additional cognitive load may even increase effects and hamper the use of faking strategies (for the cognitive load approach to deception detection, see, e.g., Vrij, Granhag, Mann, & Leal, 2011; see also Visu-Petra, Varga, Miclea, & Visu-Petra, 2013). A paradigm similar to such a version of the aIAT is the Implicit Relational Assessment Procedure (Barnes-Holmes et al., 2006) and its adaptation for the detection of deception would constitute an interesting avenue for further research.

Furthermore, structural differences between different versions of the same test may influence how vulnerable to countermeasures the tests are. For instance, the use of a response deadline in the RT-based CIT may further hamper faking attempts. Note, however, that in the study by Verschuere et al. (2009), a response deadline did not prevent faking in the aIAT. Future research may therefore not only compare the countermeasure vulnerability of different RT-based deception detection paradigms, but also investigate means to hamper faking and their efficiency in the different paradigms.

Aside from hampering faking, another avenue would be to aim to detect it (Verschuere & Meijer, 2014). Based on the idea that the most effective strategy to fake the aIAT is a systematic slowing in the block pairing the true with the crime category, Verschuere et al. (2009) tested whether the categorization of participants with an unusually high RT in this block (RT $>$ 1861 ms, which was the maximum mean RT of innocent participants) as fakers would increase classification accuracy. In a similar vein, Agosta, Ghirardi, et al. (2011) used the difference in RTs between the simple practice blocks (in which only two categories are practiced) and the two test blocks as an index of faking. In both studies, those faking algorithms allowed the detection of fakers only to a certain degree. However, as faking detection does not allow an inference of the actual test outcome (as also innocent suspects may employ faking to secure their test outcome), the search for faking prevention methods is slightly more desirable than the search for faking detection algorithms.

POPULATION

Another challenge for RT-based deception detection methods is that so far, there is not much research available based on populations that are (more) representative for the ones in which they would be applied (e.g., forensic populations). Typically, most studies have been conducted in student populations. Those populations are characterized by being mostly young and highly educated and, in the case of psychology students, often female and being familiar with computer-based tests. One problem for RT-based deception detection tests would be if they were not applicable or less valid in populations different from the ones typically tested. Why could that be? With being less practiced in computer-based tests, examinees from different populations could have more difficulty understanding the test principles. In those populations, RTs could be longer in general, which may obscure test results. Also, it has often been hypothesized that people with psychopathic personality traits, whose prevalence is higher in forensic samples, may have better deception skills (Assadi et al., 2006; Coid, 1998; Cooke, 1996; Hare, 2003; Hare, Forth, & Hart, 1989, pp. 25–49; Ullrich, Paelecke, Kahle, & Marneros, 2003; Verschuere, Crombez, Koster, & Uzieblo, 2006). In contrast, another possibility could also be that effects in more realistic populations are larger than in standard student populations. As will be explained later, one executive function that has been proposed to be necessary for successful deception and whose time-demanding qualities have been proposed to contribute to RT deception effects is the inhibition of the truth response (Christ, Van Essen, Watson, Brubaker, & McDermott, 2009; Spence et al., 2001). Impulsivity is a concept closely (and inversely) related to response inhibition and has been shown to be elevated in forensic populations (Morgan & Lilienfeld, 2000; Stanford et al., 2009). Higher impulsivity in forensic populations may correlate with reduced response inhibition capacities and thereby lead to larger effects in RT-based deception measures.

As mentioned earlier, research on populations different from the standard student or normal populations is very scarce and therefore does not allow any conclusions on potential reductions or enhancements of effects in RT-based deception measures yet. It does, however, point in the direction that RTs applied in different populations do in general still seem to produce significant effects. For instance, administering the RT-based CIT and the aIAT online to participants recruited via different online testing pools, several studies showed that those tests also produced medium to large effects in such more diverse populations (Kleinberg & Verschuere, 2015; Verschuere & Kleinberg, 2017; Verschuere, Kleinberg, & Theocharidou, 2015). Of course, although more diverse in terms of economic background and nationalities compared to standard student samples, those samples may still consist of people highly experienced in completing computer-based tests. The meta-analysis of Suchotzki et al. (2017) identified only four studies conducted in clinical and clinical/forensic populations. The studies conducted in a clinical population are studies by Mameli et al. (2013), who employed the SLT in patients with essential tremor and in patients with Parkinson's disease. In the SLT, participants had to respond truthfully or deceptively to questions about whether or not they had selected certain pictures from a sample of pictures. Importantly, the results revealed significant and large RT deception effects in the healthy control sample as well as the two patient samples. Jiang et al. (2013) also used the SLT with a similar picture choice procedure in a study with a sample of youth offenders with an additional diagnosis of antisocial personality disorder. In their study, no healthy nonforensic control group was tested, yet the SLT also produced large effects in the offenders with antisocial personality disorder. Finally, in a study with a sample of participants with schizophrenia, of which two thirds also had previous contact with the police, Kaylor-Hughes et al. (2011) also employed the SLT with questions about whether or not they had on this day performed a number of everyday activities. They found that it produced significant, yet in this case relatively small, effects. So although the sample of studies is too small to draw any conclusions about differences between studies using the typical student samples and studies using samples that are more representative of the populations in which deception detection tests may ultimately be used, they do provide first evidence that RT-based deception tests seem also applicable in those populations.

Future research should concentrate on comparing typical (e.g., student) samples with more realistic samples to explore differences between those samples and get an indication how much of the research results that have already been obtained in the former samples are transferable to the latter. Such research should also aim to assess variables in which both populations may differ (e.g., response inhibition capacities), to explore whether such differences may explain eventual differences in RT deception effects. And finally, research on the vulnerability of RT deception measures to faking attempts should aim to include more realistic samples, since the ability to apply faking strategies may also differ between populations (e.g., due to a differing familiarity with computer-based assessment).

THEORETICAL BASIS

Another area that requires future research is the investigation of the theoretical mechanisms underlying the different RT-based deception detection methods. In general, it has been proposed that deception requires several executive functions (Christ et al., 2009). In order to lie, the truth first must be activated in working memory. As it conflicts with the to-be-emitted lie, the truthful response must be inhibited. In order to embed a lie in a plausible context, the liar must be able to flexibly switch between truth-telling and lying. Those executive functions have been summarized in a theoretical framework of deception, the Activation-Decision-Construction-Action Theory by Walczyk, Harris, Duck, and Mulay (2014). The authors propose that deception takes place in four steps: First, similar to the aforementioned idea, it is proposed that the truth first must be *activated* in working memory. Second, a *decision* must be made whether to tell the truth or lie. If the decision is made to lie, the third step involves the *construction* of the lie (e.g., based on previously existing schemata). And finally, this lie must be put into *action*, thus the sender will try to communicate it convincingly. Aside from these four steps, the authors also emphasize the important role of theory of mind; that is, the ability to infer others' mental states, to lie successfully. Also, the theory recognizes the contribution of emotional arousal (e.g., through the act of lying and dependent on the importance of the situation), which has not been the focus of more cognitively oriented deception research (Vrij et al., 2011).

Although research results regarding the involvement of the specific mechanisms is not always conclusive (see e.g., Verschuere, Schuhmann, & Sack, 2012; Suchotzki, Crombez, Debey, van Oorsouw, & Verschuere, 2015), those mechanisms have been regarded as the most likely candidates to explain the increased cognitive load people experience during lying and the RT difference between truth-telling and lying (Suchotzki et al., 2017). This applies mostly to paradigms in which lying and truth-telling are compared to well-matched stimuli, the DoD paradigm and the SLT. However, the RT-based CIT and the aIAT also involve a contrast between truth-telling (to irrelevant information and in the congruent block) and lying (to critical information and in the incongruent block), and similar mechanisms have been proposed to be at play here. For the RT-based CIT, especially response inhibition has been proposed as crucial mechanism. Whereas empirical evidence strongly supports the idea that in the ANS-based CIT, the increased responding to critical compared to noncritical information is driven by the orienting response (Sokolov, 1963), there is also first evidence that the RT difference between the deceitful No response to the critical information compared to the truthful No response to the noncritical information is largely driven by the need to inhibit the truth in the former (Suchotzki et al., 2015; Verschuere & De Houwer, 2011). Less research has investigated the mechanisms underlying the a IAT-effect.

The test from which the aIAT is derived, the Implicit Association Test (IAT), has been suggested to measure the strength of associations between concepts (e.g., black people, gay people) and evaluations (e.g., good, bad). Its main idea is therefore that making a response is easier when closely related items share the same response key (for a meta-analysis of the IAT see Greenwald, Poehlman, Uhlmann, & Banaji, 2009; for alternative theoretical explanations see also Rothermund & Wentura, 2004). In a similar vein, the aIAT has been described as measuring the strength of associations between an event (e.g., I committed the theft/I drank coffee) and a logical dimension (true/false; Agosta & Sartori, 2013). Additionally, electrophysiological evidence strengthens the idea that the aIAT also involves similar mechanisms (response conflict, response inhibition, and response monitoring) as the ones that are active during deception (Marini, Agosta, & Sartori, 2016).

In general, theoretical deception research has increased in recent years and increased the knowledge about the processes underlying deception in general and the ones contributing to the effects in the specific paradigms. Yet results are not always straightforward and also many aspects of the model of Walczyk et al. (2014) still await empirical investigation. This is important and a major challenge for future research, as understanding the underlying mechanisms of a certain pattern of results (i.e., the RT deception effect) is crucial to predicting under which circumstances (e.g., in which population) certain tests will produce valid results and more importantly, under which circumstances they will not.

CLASSIFICATION ACCURACIES

The effect sizes presented in the meta-analysis of Suchotzki et al. (2017) are all within-subject contrasts. This is important, as there is a large individual variance in people's general RTs, and a within-subject control condition serves to control for those interindividual differences to a certain degree. It is, however, also important to look at the diagnostic efficiency of each RT-based paradigm to distinguish between lying examinees and truth-telling examinees.

In the RT-based CIT, this would mean that we would classify those as knowledgeable who show a (standardized) RT difference between critical and noncritical information (see also Fig. 11.1) and classify those as unknowledgeable who do not show such a difference. To investigate this experimentally, one usually allocates participants randomly into two groups, one knowledgeable group (that acquires knowledge, for instance, through committing a mock crime) and one unknowledgeable group (that does nothing or performs another innocent activity). There are two possibilities to report the classification accuracy for a certain test. The first is to calculate a value for each examinee (e.g., the absolute or a standardized RT difference between the two critical conditions; for the latter see, e.g., Noordraven & Verschuere, 2013) and then determine a cut-off above which we classify examinees as lying or knowledgeable and below which we classify examinees as truthful or unknowledgeable. This is very close to how a test would be used for individual classification in applied contexts. It has the disadvantage, however, that cut-offs may be determined subjectively and as they will vary across studies, results of different studies are difficult to compare.

An alternative possibility that has been recommended by the National Research Council (2003) is the use of receiver operating characteristics (ROC) curves (see e.g., Bamber, 1975; Green & Swets, 1966; Swets, Tanner, & Birdsall, 1961). The advantage of this index is its independence of specific cut-off points. Instead, the area under the ROC curve (AUC) depicts the classification accuracy across all possible cut-off points, with values around 0.50 indicating chance classification and a value of 1 indicating a perfect classification. For the RT-based CIT, summarizing available studies that report classification accuracies with specific cut-off values, Verschuere et al. (2015) reported sensitivity values ranging from 47.6% to 100% (i.e., how well the test correctly identifies guilty examinees) and specificity values ranging from 84.7% to 100% (i.e., how well the test correctly identifies innocent examinees). Two aspects are noticeable. One is the relatively large range of those values, especially for the sensitivity. The second is that as is typical for CITs in general, specificity and thereby the protection of innocent examinees seems relatively high whereas sensitivity seems to be lower, at least in some of those studies. Calculating the AUC for the available RT-based CIT studies, Meijer, Verschuere, Gamer, Merckelbach, and Ben-Shakhar (2016) report a value of 0.82. Note that both values are based on relatively small numbers of studies, with the sensitivity and specificity values being based on a sample of 6 studies and the AUC value being based on a sample of 11 studies.

In the aIAT, estimating the classification accuracy would entail that we would classify those as having performed one activity (e.g., a crime) that show a standardized RT difference between the two blocks in one direction (see also Fig. 11.1) and classify those as having performed the other activity (e.g., an alibi activity) that show a standardized RT difference between the two blocks in the other direction. To investigate this experimentally, one usually allocates participants randomly to two groups, one that performs or has performed one activity (e.g., a mock crime, a certain vacation) and one that performs or has performed another activity (e.g., an innocent activity, another vacation). The standardized RT difference is usually termed the D value and is calculated according to Greenwald, Nosek, and Banaji (2003); see also the steps outlined in Agosta and Sartori (2013). Also here, we could derive specific cut-off values from which one considers an absolute D value as meaningful and thus classify examinees as having performed one of the two activities and allows a certain margin around smaller absolute D values in which one considers a result as inconclusive.

For instance, in their review on aIAT studies, Agosta and Sartori (2013) proposed to consider all absolute D values between 0 and 0.2 as inconclusive. Using the cut-off values that were used in specific studies, Verschuere et al. (2015) report a sensitivity (i.e., in this case being correctly classified as having performed the crucial event under investigation) between 67% and 100% and a specificity (i.e., in this case being correctly classified as having performed the control event) between 7.5% and 88%. Verschuere et al. (2015) also report values for *a* ranging between 0.79 and 0.98. Also here, it is very important to note that whereas sensitivity values are based on a sample of 21 studies, specificity values are based on a sample of only 5 studies and the *a* values are based on a sample of 6 studies. As for the CIT, with the small number of studies available investigating the issue of classification accuracies, it is so far difficult to say which of the values are the more realistic ones and which the outliers. Especially important, future research is also needed to identify situational factors that have led in some studies to especially high or low classification accuracies.

In principle, classification accuracies for the DoD paradigm and the SLT would be derived as for the aIAT, in the sense that the direction of a (standardized) RT difference could be taken as an indication of which of two conditions constitutes the truth and which the lie for a certain examinee. Yet so far, aside from the single case study by Spence et al. (2008), no such study is available reporting RT results in those paradigms.

POTENTIAL PRACTICAL APPLICATIONS

In the last section of this chapter, I want to outline potential applications of RT-based deception detection methods. An application that would be closest to what is already used in the field in Japan would be to use the RT-based CIT in police investigations to find out whether a suspect possesses critical, crime-related knowledge. But what would be the advantage of using an RT-based CIT in comparison to the autonomic-based CIT? Of course, the equipment necessary for the RT-based CIT is cheaper, as one single computer suffices, and its application would be faster as there is no need to attach electrodes. But those small advantages would be relevant only if they are not outweighed by a loss of validity. Comparing validity estimates of four different dependent measures of the CIT, Meijer at al. (2016) found that compared to autonomic measures, the performance of the RT-based CIT to distinguish between knowledgeable and unknowledgeable suspects seems to be slightly lower (AUC = 0.85 compared to AUC = 0.82). Note however, that so far the validity estimate for the RT-based CIT is based on a relatively small number of studies, as there are not that many studies that used the RT-based CIT in a design in which knowledgeable and unknowledgeable subjects were compared. The question of which of the two measures produces more valid results, therefore, requires more attention (e.g., through direct comparisons like the one by Verschuere et al., 2010).

Another reason to use the RT-based CIT instead of the autonomic-based CIT would be if its resistance to faking were larger, but this also requires more investigations, as outlined earlier. Also, it may be interesting to look into using a combination of different measures, as this may distract examinees from the actual measure of interest and make it more likely that faking attempts would be tailored to one measure but less effective in the other measure. Note, however, that the pace and the protocol for the ANS-based and the RT-based CIT differ, and combining both may result in a loss of validity in both measures. A more promising option would be to combine the RT and the event-related potential-based CIT, as they use the same protocol and a similar stimulus presentation pace.

In contrast to situations in which also autonomic measures of deception could be used, RT-based testing also enables remote testing (e.g., via the Internet) and testing large groups of people at the same time. Several scenarios in which those could be advantageous are thinkable. Remote testing could be practical in situations in which the investigator cannot be physically present, for example, due to logistic and/or financial reasons (as proposed by Kleinberg & Verschuere, 2015). Testing larger groups of people via remote or direct testing could be practical in situations in which a restricted yet larger group of suspects for a certain crime can be identified. Such situations may include cases of embezzlement in a company or even rape or murder cases that have taken place at a certain event (e.g., at a party, comparable to larger scale DNA tests with potential suspects). It would also be thinkable to use such larger scale testings with the RT-based CIT (with identity details) at airports, for instance when looking for a member of a terrorist network who is expected to be traveling under a false identity.

Another use that may be possible is the Searching CIT, a variant of the CIT, in which the investigators do not know the critical item (e.g., the place of an expected attack, the hiding place of a kidnapping victim) but rather search for it by examining to which information a suspects reacts stronger (see e.g., Meijer, Bente, Ben-Shakhar, & Schumacher, 2013 for a dynamic questioning approach to extract information from a group of suspects). Especially when testing larger groups of suspects and when the matter of investigation is time sensitive, RT-based deception detection and in this case the RT-based CIT could offer a good and quick alternative to ANS-based tests. But clearly, it remains critical to compare the validity of the RT and the ANS-based CIT to make well-informed decisions about potential trade-offs between validity and the ease and speed of application.

SUMMARY

The current chapter provided a description of the most frequently used RT deception and deception detection paradigms: the DoD paradigm, the SLT, the RT-based CIT, and the aIAT. It provided estimates for their validity, both in within- as well as between-subject comparisons and identified a number of challenges that should be addressed in order to be able to consider their use in applied (e.g., forensic) contexts. Those challenges include the issue of examinees being able to fake their test outcomes, the restricted populations on which the tests have been validated so far, and the theoretical basis of the different RT effects that should be further explored. The chapter ended with some suggestions for situations in which RT paradigms may show an advantage, in the hope that those may inspire future research to address the challenges at hand.

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SECTION 5

Verbal and Interviewing Applications

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CHAPTER 12

How to Interview to Elicit Concealed Information: Introducing the Shift-of-Strategy (SoS) Approach

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Northeast Gothenburg, Sweden—late December, 2009. Nancy Tawsan, age 18, is walking home from a party. It is dark and she is alone, but the walk is supposed to be short. Halfway home she is attacked from behind. The attacker is very brutal and drags her away from the lampposts, into a wooden area. He tries to rape her, and leaves her in the snow. Nancy dies from her injures. After a few days a suspect, Hussein, is arrested. He is assessed as verbally skilled, a storyteller who has had a number of previous contacts with the police. However, never before had he been suspected of having committed a crime as serious as murder. Hussein admits to knowing Nancy, and to have been at the same party, but denies having anything to do with her death.

The investigators held some information about Hussein's whereabouts before and after the crime, but lacked information that linked him to the actual crime. It soon became clear that if unable to tie Hussein to the scene of the crime and to Nancy, it would not be possible to prosecute. The investigators reasoned, if Hussein is guilty, he will not confess, but will try to talk his way out. The investigating team invested a serious amount of time in planning before they started to interview Hussein. After a number of interviews, Hussein tied himself to the crime scene and to Nancy. He did not confess to the crime, and he continued to deny having anything to do with Nancy's death. But he admitted to having been at the scene of the crime, and that he had found Nancy dead.

So how did the interviewers make Hussein reveal self-incriminating information—information that he carefully concealed during the first

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interviews? In this chapter we will answer this question, but let us first make clear what did *not* take place. The interviewers did not exert pressure to get admissions or feed the suspect known details of the crime to obtain admissions. Nor did the suspect, for one reason or the other, become "weak" and decide to tell what happened. Furthermore, the interviewers did not suddenly stumble over an effective interview tactic. What happened in this case had nothing to do with luck. The Nancy Tawsan case came to inspire a full-scale research program on how to make perpetrators reveal rather than conceal self-incriminating information. For this chapter we will, for the first time, summarize the outcome of this program.

The program to be outlined draws on a multimethod approach, including traditional lab studies, quasi-experimental studies (involving ex-criminals), survey research (including experienced police officers), and case studies. The chapter revolves around the notion that one way to elicit concealed information from perpetrators is to play on their counterinterview strategies—specifically, to use interview tactics that eventually might result in a shift of counterinterview strategy from a less to a more forthcoming strategy. Hence, the term shift-of-strategy (SoS) approach. In order to achieve this critical shift, the interviewer needs to have insights on suspects' counterinterview strategies.

The chapter consists of two parts: the first is theoretical and the second is empirical. The first part theoretically introduces the concept of counter-interview strategies, which is followed by an overview of common verbal counterinterview strategies, including a theoretical introduction to the notion of shift-of-counterinterview strategies. For the second part we review empirical work on shifts of suspects' counterinterview strategies as an approach to eliciting concealed information. Finally, we will discuss the ethical aspects of the proposed SoS approach.

THEORETICAL BACKDROP

Suspects' Counterinterview Strategies

Broadly speaking, a counterinterview strategy is an attempt to successfully withstand an interview and to appear credible and convincing (Granhag, Hartwig, Mac Giolla, & Clemens, 2015). Counterinterview strategies come in many forms; they can be nonverbal (e.g., trying not to show signs of nervousness) or verbal (e.g., trying to tell a very detailed story). Later we will focus on verbal counterinterview strategies, but before this we will provide a provisional theoretical account. A useful starting point for understanding more about counterinterview strategies is the self-presentational perspective. Self-presentation has been defined as regulating one's own behavior to create a particular impression on others (DePaulo, 1992; Goffman, 1959). In the self-presentational view, guilty and innocent suspects share a mutual goal: to create an impression of honesty (to appear innocent). In brief, both innocent and guilty suspects will employ some form of strategy to reach the desired goal. This perspective emphasizes the motivated and goal-oriented nature of both telling and misrepresenting the truth. In view of the self-presentational perspective, attempts at creating a credible impression are efforts of self-control, and could thus be understood in the light of self-regulation theory (Carver & Scheier, 2011). Self-regulation theory is a social—cognitive framework for describing how people manage their behavior to move away from undesired outcomes (e.g., to be assessed as guilty), and to reach desired goals (e.g., to be assessed as innocent).

Both guilty and innocent suspects will invest effort in their attempts to reach their goal of being assessed as innocent, and experience distress at the prospect of failure. The major difference is that innocent suspects have grounds for their claims and that they stay within the boundaries of the truth, whereas guilty suspects do not. This has been labeled the deception discrepancy (DePaulo, 1992): innocent and guilty suspects can be expected to differ cognitively and behaviorally in several ways. First, as guilty suspects are aware that their claims of innocence are fake, they are less likely to cling to their statements. This might lead them to impressions of ambivalence and tension. Second, lying suspects' statements might be more vague and less detailed, partly because they may lack familiarity with the domain they are describing, and partly because there is a risk that they might be disproved. Third, the self-presentational view suggests that lying suspects might experience more cognitive effort and show pronounced deliberation in what they say (DePaulo, Epstein, & LeMay, 1990; Vrij, Fisher, & Blank, 2017).

Moving from the general self-presentational view to verbal counter-interview strategies, a point of departure is to acknowledge that guilty and innocent suspects differ in one critical way: the information they hold. Guilty suspects have crime-relevant knowledge, and they are motivated to conceal this information and to fabricate information so as to mask the truth. A primary threat for guilty suspects is that the interviewer will discover that the stated information is fabricated, and will come to know the concealed information. In contrast, it is rare for innocent suspects to intentionally fabricate information, and they do not typically possess information that they are motivated to conceal (Granhag, Hartwig, et al., 2015; Granhag, Rangmar, & Strömwall, 2015). Thus, innocent suspects have the opposite problem: that the interviewer will *not* come to know that they do not have crime-relevant information. Here it should be acknowledged also that an innocent suspect may, for various reasons, decide to conceal certain information, which may or may not pertain to the investigation. Clearly this might put this innocent person at risk and it might complicate the investigation.

In essence, an interview tends to activate goals in both innocent and guilty suspects. Hence, suspects will employ self-regulatory strategies to pursue their goals. Critically, because innocent and guilty suspects differ in the extent to which they are (1) in possession of crime-relevant information and (2) motivated to fabricate and conceal information, the principal difference between innocent and guilty suspects' counterinterview strategies will concern information management. This refers to what information to include and exclude in one's statement. Empirical psycholegal research provides support for the predictions that follow from the self-presentational perspective (see e.g., Tekin, 2016). Drawing on this research we can expect innocent and guilty suspects to use different verbal counterinterview strategies to reach their goals.

Innocent suspects' main strategy regarding information management is to volunteer the information they hold—to "tell the truth like it happened" (e.g., Hartwig, Granhag, & Strömwall, 2007). This strategy of being forthcoming is explained with reference to two robust findings from social psychology. First, most people have a fundamental belief in the fairness of the world (the "belief in a just world"; Lerner, 1980). Thus, innocent suspects may be forthcoming because they reason that if they provide a truthful statement, they will be believed simply because they deserve to be believed. Second, the so-called illusion of transparency shows that people tend to overestimate the extent to which their internal states are apparent to observers (Kassin, 2005; Savitsky & Gilovich, 2003). In other words, innocent suspects may believe that their "truthfulness will shine through," and if they simply provide honest accounts, any observer will "see" that they are honest.

In contrast, guilty suspects must be much more active with respect to information management. They must ask themselves, "what information should I disclose?", "what information should I conceal?", "what areas should I avoid?", and "what should I deny?" Broadly speaking, guilty suspects' main strategies regarding information management is to conceal information, and they have two general strategies at their disposal: (1) they may employ avoidance strategies (e.g., being vague about certain matters or presenting a very streamlined/simple story) or (2) they may utilize denial strategies (e.g., deny having been involved in certain activities). Psychological research shows that avoidance and escape strategies are fundamental responses to threatening stimuli (e.g., Carlson, Buskist, & Martin, 2000). The threatening stimulus in the current context is that interviewer will come to know the information that the guilty suspect is concealing.

To sum up, innocent and guilty suspects are in different mental states, and mental states guide behavior. In this case, behavior is reflected in the counterinterview strategies used. Furthermore, innocent and guilty suspects' different counterinterview strategies will result in different responses with respect to the critical background that the interviewer holds. The difference in response will be particularly pronounced if suspects are interviewed in a strategic manner, for example if using the Strategic Use of Evidence (SUE) technique (outlined later) (Granhag & Hartwig, 2015).

A further concept with relevance to the current context is perspective taking. Perspective taking refers to the cognitive capacity to consider the world from another person's viewpoint, which facilitates an anticipation of other people's behavior and reactions (Galinsky, Maddux, Gilin, & White, 2008). Perspective taking should not be confused with empathy. In brief, empathy is having another person enter your heart, whereas perspective taking is about entering another person's mind. Psychological research shows that taking the perspective of others is predictive of success in negotiations (Galinsky et al., 2008), and that perspective taking is important for interviewers (Granhag & Hartwig, 2008). For a recent and thought-provoking account on perspective taking, see Zhou, Majka, and Epley (2017).

It has been argued that interviewers often are too occupied with their own approaches and strategies and, therefore, might neglect to attend to the interviewee's strategies (Granhag & Hartwig, 2008). Most people's intuitive ability to adopt another person's perspective is limited (Davis, Conklin, Smith, & Luce, 1996), but the ability to use perspective taking effectively can be improved with training (Galinsky et al., 2008). Perspective taking in the current context may help the interviewer in planning and to conduct a strategic interview, as well as when interpreting the outcome of the interview. Specifically, an interviewer who is aware that innocent and guilty suspects often use different counterinterview strategies, can use perspective taking (1) to identify the type of counterinterview strategy used by the suspect (which might signal whether the suspect is lying or telling the truth) and (2) to receive guidance on how to generate shifts in suspects' counterinterview strategies.

Verbal Counterinterview Strategies

As mentioned, a counterinterview strategy is an attempt to withstand an interview. Researchers have started to pay attention to counterinterview strategies, both with respect to analyzing the strategies used during actual suspect interviews (e.g., Alison et al., 2014) and when developing interview protocols (Granhag et al., 2015). In brief, examples of strands of research where insights on interviewees' counterinterview strategies drive the design of interview protocols are the SUE technique for interviewing suspects in traditional law enforcement contexts (e.g., Granhag & Hartwig, 2015), the Scharff-technique for eliciting information from sources in intelligence contexts (e.g., Granhag, Kleinman, & Oleszkiewicz, 2016), and approaches for how to interview individuals who communicate verbal threats (e.g., Guerts, Ask, Granhag & Vrij, 2017).

Alison et al. (2014) identified five clusters of counterinterview strategies: (1) passive (e.g., remain silent), (2) passive verbal (e.g., claim lack of memory), (3) verbal (e.g., provide only already known information), (4) retractions (e.g., fully retract a previous statement), and (5) no comment. For the present chapter we will focus on verbal counterinterview strategies. That is, we are focused on situations in which the suspect engages in verbal communication with the interviewer. There are many different types of verbal counterinterview strategies, for example:

1. Talk, but to avoid specific topics.
2. Deny certain activities (or to hold secret knowledge).
3. Make sure that the statement provided fits with the interviewer's background knowledge.
4. Provide embedded lies (e.g., tell the truth about noncritical aspects, and within this frame of truthfulness, misrepresent critical information).
5. Engage to find out what the interviewer is after, and then withhold (or fabricate) that information.
6. Appear cooperative by providing information perceived to be already known.
7. Provide a detailed statement, although meager in terms of verifiable information.
8. Answer a question with a question.
9. Stall (e.g., I might remember more about this later).
10. Retract (e.g., What I said yesterday was not correct).

This is not a complete list of all verbal counterinterview strategies; these are merely some examples. It is also worth noting that a suspect's use of a certain counterinterview strategy might be the result of his or her own decision (the strategy is self-generated) or the result of having been trained for the situation (so-called resistance training). Furthermore, suspects may very well use several strategies simultaneously (e.g., to avoid specific topics and to provide embedded lies about other topics), and suspects may decide to shift from one counterinterview strategy to the other (e.g., from denial to appearing cooperative by providing already known information).

For this chapter we will pay special attention to suspects' shifts of counterinterview strategy—that is, the disengagement from one strategy and the adoption of another, whether between interviews or within a single interview. We will provide a theoretical account and empirical findings related to (1) how shifts can come about and (2) the consequences that might follow such shifts.

A suspect's decision to shift strategy can be due to many different factors; it might be a change in the external context (e.g., the setting or the interviewer), or a change in the suspects' internal (psychological) state (e.g., to perceive not being believed). For our chapter we will be concerned with two other reasons behind counterinterview strategy shifts: (1) shifts as a result of being informed about the initiatives that the investigators may have taken (e.g., making the suspect aware of the knowledge that the interviewer might hold), and (2) shifts as a result of what occurs during the actual interview (that is, the approaches and tactics used by the interviewer).

FROM CONCEALING TO REVEALING: EMPIRICAL FINDINGS

Preinterview Knowledge of Evidence

We have elsewhere outlined our ideas on the processes that drive suspects' information management (Granhag & Hartwig, 2015). In brief, it is common for suspects to form a hypothesis on what information the interviewer already has, and this is particularly true for guilty suspects. A suspect may be miscalibrated in two different ways: he may underestimate or he may overestimate how much information the interviewer holds. We argue theoretically that a suspect's perception of the interviewer's knowledge affects the suspect's choice of counterinterview strategy, which in turn, affects the suspect's verbal response. In its simplest form a suspect who believes that the interviewer knows nothing about what he did Sunday night (when he attempted to rape a girl in the city park) will use an avoidant strategy (not mentioning being in the park) and provide a false alibi, claiming that he was at home Sunday evening and night. Furthermore, we argue that a suspect's hypothesis about the interviewer's knowledge is open to influence and that one way to influence the suspect's hypothesis is to apply different tactics during the interview. For now we summarize our theoretical reasoning in the following way: If an interviewer succeeds in influencing the suspect's hypothesis about his or her knowledge, the suspect may decide to shift counterinterview strategy. In a strategic interview—using the SoS approach—the interviewer will have the knowledge and the tactics necessary to potentially obtain the desired counterinterview strategy shift (e.g., from less to more forthcoming), and that the shift takes place at the proper point in time (e.g., before a critical theme is introduced).

There is substantial empirical evidence that suspects adopt counterinterview strategies in response to their perception of the interviewer's knowledge about their activities (Granhag, Hartwig, et al., 2015; Granhag, Rangmar, et al., 2015). In the real world, beyond the disclosure of evidence to the suspect by an interviewer, there are many ways in which a suspect can become aware that the interviewer possesses incriminating evidence or can arrive at a hypothesis about the extent of interviewer's knowledge. For instance, a criminal offender might be aware that he or she may have been seen by CCTV cameras or that there were witnesses who may remember seeing him or her at a particular place, simply by taking note of these things at the time of the offense. A criminal might also surmise that he or she would not be questioned by the police if he or she had not discovered some incriminating evidence, and thus, might speculate as to the nature and content of that evidence. In such cases, because the suspect expects or predicts that the interviewer is relatively knowledgeable, we would predict that this expectation would influence the suspect's counterinterview strategy (Granhag & Hartwig, 2015; Hartwig, Granhag, & Luke, 2014).

It is worth noting that in such circumstances, it is not likely that the suspect has a clear, precise, or accurate perception of the evidence held by investigators. Rather, such conjectures about evidence may be relatively vague and impressionistic. That is, a suspect may believe that he or she was spotted at the scene of the crime by at least one witness, but the suspect might have only a vague impression of what that witness actually saw and could recall. One study has examined how such expectations of evidence influences suspects' counterinterview strategies. Luke, Dawson, Hartwig, and Granhag (2014) manipulated the instructions given to suspects before they were questioned about a mock bomb plot. Some suspects were informed that investigators had been to the scene where the suspect had delivered a package of explosive components and had recovered CCTV footage (but the content of the footage was not described). Other suspects were not told anything about the activities of investigators.

Innocent suspects' counterinterview strategies were invariant under either set of information: In line with past research, they tended to be highly forthcoming with accurate information about their activities. Guilty suspects, however, varied widely in response to the information about evidence. Consistent with past research, uninformed guilty suspects were highly withholding with information about their activities. Approximately half of guilty suspects who had been informed about the CCTV footage became extremely forthcoming—indeed approximately as forthcoming as a typical innocent suspect. These forthcoming guilty suspects did not admit culpability to the crime in question, but they did provide highly detailed and generally accurate accounts of many of the relevant activities (e.g., explaining that they had indeed delivered a package to the room in question, but claiming to not know the contents). The other half of the informed guilty suspects were highly withholding.

Very few (4 out of 35, 11%) informed guilty suspects were only moderately forthcoming with information. It seemed, therefore, that the evidence information manipulation produced two qualitatively different responses: some guilty suspects remained withholding, whereas others adopted a completely different, much more forthcoming strategy. We surmise that this all-or-nothing pattern of results was due in large part to the ambiguity of the information suspects were given. Ambiguous feedback makes goal pursuit challenging, as it is not entirely clear how much effort or what kind of behavioral strategy will be effective (Carver & Scheier, 1998, 2012). As such, ambiguous information often results in miscalibrated strategies (i.e., ones that overshoot or undershoot the target). Here, guilty suspects were not able to accurately guess what information the interviewer actually possessed. Equipped only with vague knowledge of the interviewer's evidence, some of the guilty suspects, therefore, opted to behave conservatively and disclose almost nothing, and others opted to behave more liberally and disclose a large amount of information.

In the real world, suspects may come to guess the interviewer's knowledge prior to an interview, with a level of precision greater than what is captured in this study. Unfortunately, to the best of our knowledge, this is the only study to have examined this important aspect of how suspects form and act on their counterinterview strategies. Future research will be necessary to provide further explorations of this issue.

To Obtain Shifts of Suspects' Strategies During the Interview

We have conducted a series of studies examining to what extent it is possible to make suspects shift counterinterview strategy (from less to more forthcoming) during the actual interview. The studies are similar with respect to three general features. First, they all reflect the same real-life scenario. In brief, consider a crime under investigation that can be divided into three different phases (themes); activities before the crime (e.g., following the victim), during the crime (e.g., interacting with the victim at the crime scene), and after the crime (e.g., changing clothes to hide possible traces). Furthermore, assume that there is a suspect about to be interviewed, and that the investigators hold evidence (background information) pertaining to two of the phases (what the suspect did before and after the crime). This evidence is not necessarily very incriminating, but raises suspicion about the suspect's involvement in the crime. The investigators lack information about the critical phase; that is, the suspect's whereabouts at the time of the crime. We believe that this scenario reflects operational reality, as perpetrators generally are more careful to conceal what they did at the time when the crime was committed, compared to what they did before and after the crime was committed.

Second, the studies are similar also with respect to the underlying theoretical reasoning. The starting point is that the suspect's perception of the interviewer's knowledge is key and that this perception is open to influence. In brief, affecting a suspect's perception of the interviewer's knowledge may result in counterinterview strategy shifts, which in turn will affect the suspect's verbal response.

Third, on a general level the studies conducted are similar also with respect to how the suspects' perception of the interviewer's knowledge was influenced. Basically, we start with the background information available in the case, and interview strategically with respect to this information. If the suspect is lying, strategic interviewing will often result in statement–evidence inconsistencies (i.e., mismatches between what the suspect claims and what the interviewer knows); these elicited inconsistencies will be presented to the suspect. The aim of presenting the inconsistencies is to make the suspect realize that his avoidant counterinterview strategies have not served him or her well (the credibility is now undermined), and that he or she therefore might profit from a change of strategy ("I will probably be better off telling what they already know").

The studies within the series are different with respect to the following features: (1) how the elicited inconsistencies were handled during the interview (see later), (2) the populations from which the participants acting as suspects were sampled (i.e., university students and ex-criminals), (3) the structure of the mock crime, and (4) the lab in which the studies were conducted (i.e., Sweden and Germany).

Before reviewing our empirical work a brief note on the SUE technique is warranted. Broadly speaking, the SUE technique offers tactics to help an interviewer optimize the value of the available background information. It offers tactical guidance with respect to (1) assessing the evidence during the planning of the interview, (2) how to pose questions during the interview, and (3) the disclosure of the evidence (when, how, and in what order). The research program on the SUE technique has been running for 15 years, and there are now 25 papers that directly or indirectly relate to the technique. The SUE technique has proven successful for eliciting cues to deceit in single suspects (Hartwig, Granhag, Strömwall, & Kronkvist, 2006) and in small groups of suspects (Granhag, Rangmar et al., 2015), as well as for suspects lying about their past actions (Hartwig, Granhag, Strömwall, & Vrij, 2005) and suspects lying about their intentions (Clemens, Granhag, & Strömwall, 2011). In an analysis of several different lie-detection techniques, the SUE technique came out as one of only two techniques assessed as ready for use in the criminal justice system (Vrij & Fisher, 2016). For a conceptual overview of the SUE technique see Granhag and Hartwig (2015), and for a meta-analysis of the SUE technique see Hartwig et al. (2014).

The empirical work reviewed next draws on the basic principles underpinning the SUE technique: (1) suspects form a hypothesis about the interviewer's knowledge, (2) this hypothesis dictates the suspect's counterinterview strategy, (3) which, in turn, affects the suspect's verbal statement (Granhag & Hartwig, 2015). Initially the SUE framework was used primarily to elicit cues to deceit (e.g., statement-evidence inconsistencies and within-statement inconsistencies), but as foreshadowed by Granhag and Hartwig (2015) the technique can also be used to elicit admissions from withholding suspects.

In the first study testing the SoS approach the participants (university students $N = 90$) were asked to perform several mock criminal tasks before being interviewed using one of three different interview techniques: (1) SUE confrontation (SUE-C), (2) early disclosure of evidence, or (3) no disclosure of evidence (Tekin et al., 2015). Basically, the SUE-C condition was expected to result in statement-evidence inconsistencies, and the prediction was that as the suspects were confronted with these inconsistencies they would (1) revise their perception of the interviewer's knowledge ("He seems to have more information than I first thought") and (2) as a consequence, shift their counterinterview strategy from less to more forthcoming ("I will probably be better off telling what he already knows"). In essence, the outcome supported our reasoning. The SUE-C interview generated comparatively more statement-evidence inconsistencies. Critically, the suspects in the SUE-C condition (vs the early and no-disclosure conditions) perceived the interviewer to have had more information about the critical phase of the crime (the phase where the interviewer actually lacked evidence) and they admitted more self-incriminating information.

For the SUE-C interview, the interviewer confronted the suspects with their inconsistencies, and then proceeded without offering the suspects the opportunity to explain these inconsistencies. In real-life situations, an interviewer is likely to ask a suspect to explain any emerging inconsistency. Hence, we conducted a follow-up study introducing the SUE-C/explain condition. Simply put, for this condition the interviewer asked the suspect to explain each inconsistency that occurred as a result of strategic interviewing. This way of interviewing is more ecologically valid as the suspects are given the opportunity to account for the discrepancy between their statement and the evidence (Walsh & Bull, 2015). We expected that for the SUE-C/explain condition, comparatively more suspects would be motivated to become forthcoming, and consequently disclose comparatively more admissions. The rationale was that these suspects (unlike the suspects in the SUE-C condition) were expected to be more motivated to restore their credibility by providing explanations for their inconsistencies. Importantly, for our first study we found that almost half of the suspects in the SUE-C condition concealed information pertaining to the critical phase (while the rest revealed at least some new information). On a speculative note, these suspects, after being confronted with the inconsistencies resulting from their withholding strategies, might have believed that they were already assessed as guilty and that striving to appear innocent was therefore futile. Thus, they remained withholding. The opportunity to explain any emerging inconsistency was expected to remedy this as the suspects could view this as an opportunity to restore their credibility. Hence, it was expected that for the SUE-C/explain condition a comparatively higher number of suspects would be motivated to maintain (or even further strengthen) their goal to convince the interviewer of their innocence.

In the follow-up study we compared three different interview techniques (Tekin, Granhag, Strömwall, & Vrij, 2016). Two techniques derived from the SUE framework (SUE-C and SUE-C/explain) were compared to an early disclosure of evidence technique. Participants (university students, $N = 75$) performed a mock criminal task divided into three phases before being interviewed (Phase 1, 2, and 3). For the SUE conditions, statement-evidence inconsistencies were elicited by strategic interviewing for Phase 1 and Phase 2 of the crime. For both SUE conditions, the interviewer confronted the suspects with these inconsistencies, underscoring that withholding information undermined their credibility. For the SUE-C/explain condition, the suspects were given the opportunity to explain each inconsistency (this was not the case for the SUE-C condition). As predicted, the suspects in the two SUE conditions (compared to the suspects in the early disclosure condition) perceived the interviewer to have had comparatively more information about the critical phase. Furthermore, the suspects in the SUE-C condition versus the suspects in the early disclosure condition disclosed more admissions about the critical phase. The SUE-C/explain condition did not result in more admissions than the early disclosure condition. In further support of our theoretical model, for both SUE conditions the suspects' perception of how much information they thought the interviewer had about the critical phase was positively and significantly correlated with the amount of information revealed about the very same phase, whereas this was not the case for the suspects in the early disclosure condition.

Our prediction—that suspects faced with the SUE-C/explain interview would be the ones most willing to offer admissions—was not supported. To reiterate, we assumed that these suspects would use the opportunity to explain their inconsistencies as a way to restore their credibility, and in fact many of them did. These suspects aimed to avoid further inconsistencies by revealing new information (admissions) for the critical phase. Critically, their admission scores matched the scores obtained for the SUE-C condition. However, a portion of the suspects in the SUE-C/explain were withholding throughout the interview: (1) they refrained from explaining their inconsistencies, and (2) they revealed fewer admissions in the critical phase (than the suspects who explained their inconsistencies). We argue that this subgroup of suspects refrained from explaining their inconsistencies because changing their initial statement was considered relatively more threatening to their perceived credibility (Hartwig et al., 2014). It should be acknowledged that the interviewer made clear that unaccounted inconsistencies hampered their credibility, and this might have resulted in the suspects believing that they failed to provide a credible impression. As a result, they might have given up trying to convince the interviewer of their innocence, and therefore clung to their withholding strategies. Based on the outcome we argued that whether or not a suspect believes that he or she can restore his or her undermined credibility may play an important role in the process. Differently put, and from the perspective of the interviewer, in order to win the game (i.e., to elicit admissions), it is necessary to keep the suspect in the game (i.e., to motivate the suspect to strive to restore his or her credibility).

Encouraged by the outcome of the two first studies, we conducted yet another lab-based study examining the SoS approach. For this study we aimed to gain further insights on how suspects' motivation to "stay in the game" moderates their willingness to reveal self-incriminating information (May, Granhag, & Tekin, 2017). We introduced a new interview condition, for which (1) the interview was introduced in a non—guilt-presumptive manner, (2) the elicited statement-evidence inconsistencies were presented in a manner that allowed the suspects to comment on them, and (3) when they did comment, the interviewer met their explanations in a non—guilt-presumptive manner. We named this new condition SUE-Introduce-Present-Respond (SUE-IPR). The SUE-IPR condition was compared with the same conditions as before; the early disclosure condition and the SUE-C condition. We predicted (1) that the SUE conditions would elicit comparatively more new information (admissions) about the phase for which the interviewer lacked information, and (2) that the SUE-IPR condition would result in more new information (admissions) compared with the SUE-C condition and the early disclosure condition. The rationale for this was that we expected the nonjudgmental approach used for the SUE-IPR condition to contribute to an increase in the suspects' motivation to explain potentially emerging inconsistencies (i.e., to stay in the game) and that this, in turn, would result in comparatively more admissions during the critical phase.

Participants (university students, $N = 88$) individually performed a mock crime consisting of several actions (i.e., received a code from an accomplice, used the code to open a locker containing a mock chemical bomb and a detonation device, placed the mock bomb at a strategic place).

After having performed this mock crime, they were arrested and interviewed as suspects. As expected, both SUE conditions generated more statement-evidence inconsistencies compared with the early disclosure condition. Furthermore, and in line with our hypothesis, the SUE-IPR condition resulted in comparatively more new critical information (admissions) about the phase of the crime for which the interviewer lacked information. A likely explanation for this was that the interviewers for this condition used the elicited inconsistencies both (1) to make the suspects overestimate their knowledge about the critical phase of the crime and (2) to create a positive interview atmosphere. In essence, this study lends further support to our reasoning that in order to win the game (i.e., to obtain admissions), the interviewer needs to keep the suspect in the game (i.e., by not being too confrontational and judgmental).

This pattern of results—that suspects often shift their strategies throughout the interview as a reaction to their changing perception of the evidence held by the interviewer—appears to generalize to experienced criminals. In a sample of experienced criminals in Sweden ($N = 61$), we compared the effectiveness of early disclosure, SUE-C, and a modified version of SUE-C, and found results consistent with those of the studies reviewed earlier (Luke, Hartwig, & Granhag, 2017). In this modification of SUE-C, the interviewer incorporated aspects of the Evidence Framing Matrix (SUE-C-EFM) (Granhag, Strömwall, Willén, & Hartwig, 2013): If the suspect made a statement that was inconsistent with the evidence, the interviewer immediately presented the evidence he or she possessed, at a level of specificity that matched the inconsistency. If the suspect continued to deny (i.e., did not change his or her statement to account for the evidence), the interviewer would disclose the evidence at incrementally increasing levels of specificity. For example, the first activity in the paradigm involved the suspect collecting materials from a plastic container, and the interviewer knew that the suspect's fingerprints were on the container. If the suspect denied having been in the area where the container was located, the interviewer would disclose that he or she had information that the suspect was indeed in that location. If the suspect denied having touched the container, the interviewer would disclose that he or she had the suspect's fingerprints on the container.

The theoretical reasoning underpinning the SUE-C-EFM derives from the notion that suspects may be more prone to change their counterinterview strategies if they are provided with immediate and repeated feedback indicates that their current strategy is maladaptive. This idea is consistent with basic principles of self-regulation (see, e.g., Carver & Scheier, 2012), which suggest that humans can and do respond to information about the effectiveness of the strategies they enact to pursue their goals. If feedback indicates that a strategy is ineffective, people will often change their strategy. Thus, to the extent that an interviewer can provide a suspect with information that their withholding counterstrategy is ineffective, the interviewer can prompt the suspect to change strategies and to become more forthcoming.

In our study with experienced criminals, we found that suspects interviewed with SUE-C or SUE-C-EFM tended to be more inconsistent with the evidence in the first phase of the interview, compared to the early disclosure condition Luke, Hartwig, et al., 2017; Luke, Crozier, & Strange, 2017). However, suspects in all three interview conditions became much more consistent with the evidence in the second phase of the interview, likely in response to the evidence disclosed in the first phase, which led them to believe the interviewer was relatively knowledgeable. In the third phase, for which the interviewer lacked evidence, suspects in the SUE-C-EFM condition provided more detail about their activities compared to the suspects in the other two conditions. This pattern of results was consistent across different levels of criminal experience (i.e., the number of times the participant had been questioned by the police in real life). Indeed, if anything, it seemed that experience being interviewed tended to predict increased disclosures of critical information in the SUE-C-EFM condition. Thus, it appears that SUE-C and the SUE-C-EFM can be effectively combined to create an approach that prompts suspects to change their strategies.

Summing up the empirical outcome of our studies on obtaining shifts in counterinterview strategies during the actual interview, we highlight five findings. First, it is clear that suspects' perceptions of the interviewers' knowledge is open to influence. Second, one way to exert such influence is to interview strategically (for themes other than the critical), with the aim of eliciting statement-evidence inconsistencies. Third, presenting these inconsistencies will make the suspects revise their initial hypothesis on the interviewers' knowledge and a portion of the suspects will decide that they are better off shifting counterinterview strategy (from withholding to more forthcoming). Fourth, more forthcoming strategies result in more admissions. In brief, the combined evidence supports our theoretical reasoning. Fifth, we have also gained some knowledge suggesting that *how* the elicited inconsistencies are handled by the interviewer seems to be a critical piece of the puzzle. More precisely, it is important to keep the suspects motivated to care about their own credibility. Examples of ways to increase the suspects' motivation—to make them stay in the game—is to offer opportunities to explain the inconsistencies presented to them (Tekin et al., 2016), and to meet the explanations offered in a nonjudgmental manner (May et al., 2017).

We may ask if our SoS approach is already common knowledge among professionals. In a recent study (Tekin, Granhag, Strömwall, & Vrij, 2017) we presented police officers from three different countries with a scenario that was supposed to mimic a situation that occurs rather frequently in investigations: to have some background information about a suspect's whereabouts, but to have less (or very little) information about the suspect's whereabouts during the most critical phase of the crime. The police officers' objective, which was made very clear to them, was to try to gather information on the phase of the crime for which they lacked information. They were given information about certain aspects of the crime, and the suspect's whereabouts before and after the crime. The officers were asked to report how they would plan for and conduct the interview with the suspect. Here we would like to highlight two results. First, the officers reported that they would use the available evidence in a strategic manner. For this situation it meant that they planned to gather further information about the phases for which they already held information, and/or to interview in ways that would reveal whether the suspect was lying or telling the truth. Second, from the officers' reports we could not infer that they intended to use the available evidence to try to gather information about the phase for which they lacked information. Differently put, the officers did not report that they would try to shift the suspect's counterinterview strategy from less to more forthcoming. Based on the outcome of our survey it would not be correct to say that the SoS approach is a commonly known and commonly used approach among police officers.

A Note on Countermeasures

In the real world, interviews are sometimes conducted with suspects/ sources that are themselves knowledgeable about interviewing techniques. This knowledge can be accrued through training or briefings, but it is also possible for anyone with access to the Internet or to a bookstore to obtain material on interviewing and interview techniques. Indeed, the scientific literature on the SUE technique and many other intelligence interviewing techniques is completely unclassified and not protected by institutional secrecy. As such, it is reasonable to ask whether it is possible that people with knowledge of the SUE technique could develop effective countermeasures.

To date, there has been one study that has explored this possibility. Luke, Hartwig, Shamash, and Granhag (2016) manipulated whether suspects were provided with information about the SUE technique. Specifically, some suspects were instructed that the interviewer likely possessed some evidence and would withhold it from the suspect in order to assess whether the suspect would make statements contrary to the evidence. That is, they were provided with information that the interviewer was concerned with statement-evidence inconsistencies. Guilty suspects who were provided with this information disclosed slightly more information about their activities, compared to guilty suspects who were not informed about the SUE technique. But this shift in forthcomingness was not nearly enough to make these guilty suspects appear as if they were innocent suspects: There was still a large and statistically significant difference between SUE-informed guilty suspects and innocent suspects with regard to statement-evidence inconsistencies and the disclosure of information. As such, although information about the SUE technique seemed to influence guilty suspects' counterinterview strategies, they were unable to spontaneously generate effective countermeasures to the technique.

This is not to say that it is impossible to develop countermeasures to the SUE technique, however. It remains an open empirical question whether trained individuals would be able to behave in a manner that would permit them to elude detection by the SUE technique, and there has never been a study, to the best of our knowledge, that has examined whether it is possible for suspects to develop countermeasures such that they are less likely to disclose critical information in response to techniques such as a SUE-C version.

ETHICAL CONSIDERATIONS

Somewhat separate from questions about the effectiveness of the SUE technique, it is reasonable to inquire about the ethics of the technique, especially considering that many interview methods, such as the Reid Technique (Inbau, Reid, Buckley, & Jayne, 2013), have been seriously criticized for being unethical (e.g., Gallini, 2010). Hartwig, Luke, and Skerker (2016) provided an analysis of the ethics of contemporary interviewing and interview techniques, including the SUE technique.

Of particular ethical importance is the extent to which an interview technique involves deception of a suspect. Some philosophers object to nearly all forms of deception (e.g., Bok, 1978). In line with Skerker (2012) and other philosophers who believe that deception is, at least under some circumstances, defensible, Hartwig et al. (2016) argued for a less hard-line position: specifically, that we should evaluate the ethics of interview techniques by asking whether rational persons—those who are well-informed and acting in a manner that serves their interests—would consent to their use by the police, even if they involve deception. For obvious reasons, people cannot actively consent to being deceived (after all, if they knew they were being deceived, they would not, by definition, be deceived). However, it is reasonable to ask whether a person would consent to being deceived if they were, hypothetically, given the opportunity to evaluate the deceptive act. That is, if it were possible to know you were going to be deceived in a specific way or in a specific context, would you consent to that deception?

It is of particular ethical importance to consider (1) whether the SUE technique is deceptive and (2) the extent to which the SUE technique is deceptive, whether that deceptiveness is such that a rational person would consent to it. Hartwig et al. (2016) argue that the SUE technique is morally defensible, largely because it does not tend to put innocent persons in danger of wrongful conviction and because the level of psychological manipulation it entails does not tend to unjustly deprive people of their moral (and legal) rights. Although the SUE technique certainly involves concealing and strategically using the evidence in an investigation, members of the public—let alone suspects—usually do not have a moral right to know all the evidence in an active investigation. Moreover, the SUE technique never advocates for the use of false evidence ploys (in which interrogators lie about having evidence that does not exist), evidence bluffs (in which interrogators claim they will soon analyze evidence that does not in fact exist), or bait questions (in which interrogators ask a suspect to respond to hypothetical evidence), all of which involve lying or actively misleading a suspect about what kind of evidence exists. These tactics are known to result in false confessions (Perillo & Kassin, 2011) and memory distortions (Luke, Crozier, et al., 2017). In contrast, the SUE technique relies on authentic evidence to evaluate a suspect's credibility and to induce changes in their behavior. Practitioners trained in the SUE technique have demonstrated an increase in deception detection accuracy, with little to no change in judgment bias (Hartwig et al., 2006; Luke et al., 2016). That is, the SUE technique does not appear to put innocent people at increased risk of being incorrectly judged as guilty. Thus, the risks involved with the use of the SUE technique are likely sufficiently low that rational people would consent to its use.

CONCLUSIONS AND A LOOK FORWARD

On its face, the SoS approach outlined in this chapter may seem similar to other interview techniques and approaches for eliciting information from suspects/sources, and for detecting deceit (e.g., the Model-Statement technique, Vrij, Fisher, et al., 2017; Vrij, Leal, et al, 2017). We therefore want to make clear in what ways the SoS approach is similar to and different from other approaches. First, our SoS approach is similar to other approaches in that the aim is to elicit information from suspects (e.g., the ORBIT approach, Alison, Alison, Noone, Elntib, & Christiansen, 2013). However, the SoS approach is different as we elicit admissions by explicitly utilizing suspects' counterinterview strategies. Second, the SoS approach is similar to some other approaches in that the interview aims to elicit cues to deceit (in our case, statement-evidence inconsistencies). However, the SoS approach is different as the cues elicited are not the end goal, but means to an end. For the SoS approach the elicited cues are a means to get admissions. Third, the SoS approach is not about making truth-telling suspects provide more or different information than lying suspects (e.g., the Verifiability approach, Nahari, Vrij, & Fisher, 2014; the Model-Statement approach, Vrij, Fisher, et al., 2017; Vrij, Leal, et al., 2017). Instead, the SoS approach is about making guilty suspects provide more self-incriminating information than guilty suspects interviewed by conventional approaches. Fourth, the SoS approach is structurally similar to the Scharff technique (Granhag et al., 2016); that is, also with the Scharff technique the interviewer plays on the sources' counterinterview strategies. However, the Scharff technique is not about eliciting inconsistencies, or using these to obtain counterinterview strategy shifts. Furthermore, the SoS approach is geared toward traditional law enforcement interviews, whereas the Scharff technique is aimed for intelligence settings.

Summing up we believe it is fair to say that our empirical work lends support to the theoretical account presented in the opening of the chapter: (1) suspects tend to form a hypothesis about the interviewer's knowledge about the case, (2) this hypothesis affects the suspect's counter-interview strategy, which, in turn, (3) affects the suspect's verbal statement.

Importantly, the suspect's hypothesis is open to influence, and if proper influence is exerted it will affect the causal process driving our approach (i.e., the suspect's perception of the interviewer's knowledge → suspect's choice of counterinterview strategy → suspect's verbal response). For our research program the influence came in the form of strategic interviewing, which resulted in statement-evidence inconsistencies. Confronted with these inconsistencies, the suspects realized that their withholding strategies had not served them well and that it was time for shift of strategy (from less to more forthcoming). That is, the suspects were discouraged from continuing to withhold information, and encouraged to be more forthcoming. In brief, the suspects' use of a more forthcoming counterinterview strategy resulted in more admissions. The outcome of our studies also put the searchlight on the importance of keeping suspects motivated to care about their credibility. Examples of ways to keep suspects motivated are to offer opportunities to explain the inconsistencies presented to them, and to meet these explanations in a nonjudgmental manner. In essence, for the interviewer to win the game, he or she must keep the suspect in the game.

At the surface the SoS approach might seem to be about interviewing strategically to move a suspect from resistant to cooperative. However, this is not correct. The reason for why the suspect—with the SoS-approach—eventually reveals self-incriminating information is not contingent on whether he or she decides it is time to cooperate. The SoS approach works although the suspect is trying to outsmart the interviewer by providing information that he or she believes the interviewer already has. In fact, the SoS approach works *because* the suspect is trying to outsmart the interviewer. The suspect's level of resistance has not changed—what has changed is the suspect's counterinterview strategy. Furthermore, the SoS approach might be described as interviewing strategically to elicit admissions, but such a description does not capture the core of the approach. The key that will make the suspect reveal (instead of conceal) information is to utilize insights about how to obtain counterinterview strategy shifts. We argue, if the aim is to develop effective interview techniques for eliciting new critical information and for detecting deceit, it would be counterproductive to ignore suspects' counterinterview strategies.

There are many roads forward for this research program. One way is to more closely examine the link between (1) the interview objective and (2) ways of handling inconsistencies. In short, we need to learn more about how to handle inconsistencies in order to increase the likelihood of meeting certain interview requirements. For example, if the objective is to deter against further deceptive attempts, the interviewer might want to come down on each and every elicited inconsistency. In contrast, if the objective is to obtain a major statement-evidence inconsistency for a particular theme, the interviewer might profit from not acknowledging each and every inconsistency, but instead strengthen the suspect's withholding strategies. Differently put, to make the suspect think, "This is going quite well."

Finally, we return to the case that opened the chapter: the Nancy Tawsan case. The interview tactics used rested on advanced perspective-taking. In essence, the investigators were clear on that the suspect would bring aversive strategies to the interview room; that he would conceal and deny. They therefore interviewed strategically with respect to the information they had (on his whereabouts before and after the crime). This resulted in a number of inconsistencies—what the suspect said did not match what the investigators knew. The interviewer had to strike a balance between (1) reminding the suspect that these inconsistencies undermined his credibility and (2) keeping him motivated to repair his credibility. The interviewer did not want the suspect to stop engaging. Eventually the suspect learned how the interviewer operated ("he always pretends to have less information than he actually has"), and the suspect therefore decided to shift counterinterview strategy ("I will be better off telling him what he already knows"). Predicting this shift, the interviewer introduced the theme for which he lacked information: the potential links between the suspect (Hussein) and the crime scene/victim. The suspect's shift of strategy resulted in him offering self-incriminating information that he thought (and probably still thinks) was already known to the investigators. Hussein's assumption was wrong; the information he provided was in fact new. In brief, he linked himself both to the crime scene and to the victim (without confessing). Based on his own admissions and circumstantial evidence Hussein was found guilty of having murdered Nancy Tawsan.

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CHAPTER 13

Verbal Lie Detection Tools From an Applied Perspective

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BACKGROUND

Throughout history people have tried to detect lies through speech analysis. C.900 BC, a papyrus of the Vedas mentioned that a liar "does not answer questions, or gives evasive answers; he speaks nonsense" (Trovillo, 1939, p. 849). The French forensic expert Tardieu reported in the 1850s that "quantity of detail," and the American forensic medical doctor Walker noted in 1886 that "the way in which children tell their stories in their own words and the expressions they use," are among the best indicators to distinguish truth from deception in alleged sexual abuse cases (see Lamers-Winkelman, 1999).

The systematic search for verbal cues to deceit has accelerated since the 1950s (DePaulo et al., 2003; Hauch, Blandón-Gitlin, Masip, & Sporer, 2015; Masip, Sporer, Garrido, & Herrero, 2005; Vrij, 2008a). Sometimes verbal cues are measured in isolation (Hauch et al., 2015), but they are often examined as part of a verbal veracity assessment tool. This chapter focuses on such verbal lie detection tools, and the seven tools most frequently used by scholars and/or practitioners (listed in Table 13.1) will be discussed. All of them are described in detail elsewhere[1] so there is no need to describe

[1] For more detailed information about Statement Validity Assessment see Amado et al. (2015), Gumpert and Lindblad's (1999), Köhnken (2004), Oberlader et al. (2016), Raskin and Esplin (1991), Steller and Boychuk (1992), Vrij (2005, 2008a, 2015b), and Vrij and Nahari (2017); for more detailed information about Reality Monitoring see Masip et al. (2005), Oberlader et al. (2016), Sporer (2004), Vrij (2008a, 2015b), and Vrij and Nahari (2017); for more detailed information about Scientific Content Analysis see Armistead (2011), Driscoll (1994), Nahari et al. (2012), Smith (2001), Vrij (2008a,b, 2015b), and Vrij and Nahari (2017); for more information about cognitive lie detection see Vrij (2014, 2015a), Vrij, Fisher, and Blank (2015), Vrij et al. (2016), and Vrij, Leal, Mann, Vernham, & Brankaert (2015); for more information about the Strategic Use of Evidence see Granhag and Hartwig (2015) and Hartwig et al. (2014); for more information about the Verifiability Approach see Nahari's book chapter in this book and Vrij and Nahari (2017); and for more information about Assessment Criteria Indicative of Deception, see Colwell et al. (2013).

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Table 13.1 Overview of the lie detection tools and their usefulness in investigative interviews

	(1) Statement validity assessment (SVA) which includes criteria-based content analysis (CBCA)	(2) Reality Monitoring	(3) Scientific content analysis (SCAN)	(4) Cognitive credibility assessment			(5) Strategic use of evidence (SUE)	(6) Verifiability approach (VA)	(7) Assessment criteria indicative of deception (ACID)
				Imposing cognitive load	Asking unexpected questions	Encouraging interviewees to say more			
1. Is the scientific hypothesis testable?	Yes	Yes	Yes	Yes			Yes	Yes	Yes
2. Has the proposition been tested?	Yes	Yes	Yes	Yes			Yes	Yes	Yes
3. Has the technique been subjected to peer review and publication?	>40	>20	<5	5–10	5–10	10–20	10–20	10–20	5–10
4. Is there a known error rate?	Around 30%[1]	Around 30%[1]	Unknown	Around 30%[2]	Around 30%[2]	Around 30%[2]	Unknown	Around 30%[3]	Around 25%[4]
5. Which verbal cues to deceit do emerge?	[5]Quantity of details; Unstructured production; Logical structure; Reproduction of conversations; Unusual details	[6]Temporal details; Spatial details; Sound details	Unknown	[7]Quantity of details; Plausibility Consistency			[8]Statement-evidence inconsistency; Within-statement inconsistency	[9]Verifiable details; Unverifiable details	[4]Response length; Quantity of details; Coherence; Type-token ratio
6. How many independent groups of researchers examine the technique?	Many	Many	A few	A few, but Vrij and Granhag are dominating			One group (Granhag/ Hartwig)	One group (Nahar Vrij)	One group (Colwell)

7. Is the theory upon which the technique is based generally accepted in the appropriate scientific community?	Yes for CBCA, no for the Validity Checklist	Yes	No	No	Yes	Yes	Yes	Yes	Yes, except the reverse order mnemonic
8. Is the technique an interactive interviewing approach?	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
9. Is the technique easy to incorporate in a typical information-gathering interview?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
10. Will the technique affect the response of a truthful interviewee?	No	No	Yes	Yes	Possibly if carried out incorrectly	No	Possibly	No	No
11. Does the technique have within-subjects measurements?	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
12. Is the technique easy to use?	No	Yes	No	Yes, after practice	Yes, after practice	Yes	Yes, after practice	Yes	Yes, after practice,

Continued

Table 13.1 Overview of the lie detection tools and their usefulness in investigative interviews—cont'd

	(1) Statement validity assessment (SVA) which includes criteria-based content analysis (CBCA)	(2) Reality Monitoring	(3) Scientific content analysis (SCAN)	(4) Cognitive credibility assessment: Imposing cognitive load	(4) Cognitive credibility assessment: Asking unexpected questions	(4) Cognitive credibility assessment: Encouraging interviewees to say more	(5) Strategic use of evidence (SUE)	(6) Verifiability approach (VA)	(7) Assessment criteria indicative of deception (ACID)
13. Does the technique sufficiently protect truth-telling interviewees for appearing suspicious?	Yes	Yes	Maybe	No	Yes	Yes	Yes	Yes	Yes
14. Is the technique sufficiently protected against countermeasures?	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Verdict: Are the findings sufficiently robust, generalizable, and uncontroversial that they can be incorporated in investigative interviews?	**Perhaps, but Reality Monitoring is preferable**	**Yes**	**No**	**No**	**Possibly, but more research is needed**	**Yes**	**Yes**	**Yes**	**Possibly, more research is needed**

[1]Vrij (2008a,b); [2]Vrij, Fisher, and Blank (2017); [3]Vrij and Nahari (2017); [4]Colwell, Hiscock-Anisman, and Fede (2013); [5]Amado, Arce, and Fariña (2015); [6]Vrij (2008a,b); [7]Vrij, Fisher, Blank, Leal, and Mann (2016); [8]Hartwig, Granhag, and Luke (2014), Granhag and Hartwig (2015); [9]Vrij and Nahari (2017).

them in detail here. This chapter will focus on the question to what extent these tools are ready to be used in real life by practitioners. For this purpose 14 criteria will be introduced on which to judge their suitability (most of them derived from Vrij & Fisher, 2016), and this chapter will discuss the extent to which each of these seven tools fits each of these 14 criteria. The difference between this chapter and Vrij and Fisher (2016) is two-fold: More questions are discussed (Questions 5, 6, 8, 11) and some of the techniques discussed here were not discussed in Vrij and Fisher (2016) (SVA, RM, SCAN, ACID). This chapter starts with a brief outline of the seven tools.

THE SEVEN VERBAL LIE DETECTION TOOLS IN A NUTSHELL

Statement Validity Assessment

The key elements of Statement Validity Assessment (SVA) are Criteria-Based Content Analysis (CBCA), a systematic assessment of the transcribed interviews, and the Validity Checklist, an evaluation of the CBCA outcome via a set of questions. CBCA comprises 19 criteria that are thought to be more often present in truthful than in deceptive accounts for cognitive and motivational reasons (Köhnken, 1996, 2004). Several criteria are more likely to occur in truthful statements than in fabricated statements because it is thought to be cognitively too difficult for liars to fabricate them. Examples of these CBCA criteria are: unstructured production (whether the information is not provided in a chronological time sequence); contextual embeddings (references to time and space: "He approached me for the first time in the garden during the summer holidays"), descriptions of interactions (statements that interlink at least two actors with each other: "The moment my mother came into the room, he stopped smiling"), and reproduction of speech (speech in its original form: "And then he asked, Is that your coat?").

Other criteria are more likely to occur in truthful statements than in fabricated statements for motivational reasons. Truthful persons will not be as concerned with making a credible impression on the interviewer as deceivers, because truth-tellers often believe that their honesty will shine through. Therefore, liars will be keener to try to construct a report that they believe will make a credible impression on others, and will leave out information that, in their view, will damage their image of being a sincere person. As a result, a truthful statement is more likely to contain information that is inconsistent with people's stereotypes of truthfulness.

Examples of these criteria are spontaneous corrections (corrections made without prompting from the interviewer: “He wore a black jacket, no sorry, it was blue”) and raising doubts about one’s own testimony (anticipated objections against the veracity of one’s own testimony: “I know this all sounds really odd”).

Since a CBCA score can be affected by factors other than veracity, for example by the standard (poor or high) of the interview, SVA experts attempt to determine the extent to which these external factors have influenced the CBCA score through the Validity Checklist. Factors included on the Validity Checklist are the quality of the interview and consistency with other statements.

Reality Monitoring

The core of Reality Monitoring (RM) is that memories of experienced events differ in quality from memories of imagined events (Johnson & Raye, 1981). Memories of real experiences are obtained through perceptual processes and are therefore likely to contain perceptual information (details of sound, smell, taste, touch, or visual details) and contextual information (spatial details about where the event took place, and details about how objects and people were situated in relation to each other). These memories are usually clear, sharp, and vivid. Accounts of imagined events are derived from an internal source and are therefore likely to contain cognitive operations, such as thoughts and reasoning (“I must have had my coat on, as it was very cold that night”). They are usually vaguer and less concrete. RM is originally not a lie detection tool but is sometimes applied as such, because truth-telling often involves describing experienced events, whereas lying can involve describing imagined events (Masip et al., 2005; Sporer, 2004).

Scientific Content Analysis

In the Scientific Content Analysis (SCAN) procedure, an examinee is asked to write down in detail all of his or her activities during a critical period of time in such a way that a reader without background information can determine what actually happened. The handwritten statement is then analyzed by a SCAN expert based on a list of criteria. It is thought that some SCAN criteria are more likely to occur in truthful statements than in deceptive statements (e.g., the use of pronouns), whereas other criteria are more likely to occur in deceptive statements than in truthful statements (e.g., missing information, Sapir, 1987/2000). However, no theoretical justification is given as to why truth-tellers and liars would differ from each other in the stated ways. SCAN is probably the most frequently used verbal lie detection tool out of the seven tools discussed in this chapter (Nahari, Vrij, & Fisher, 2012; Vrij, 2008a).

Cognitive Credibility Assessment

Cognitive Credibility Assessment (CCA) comprises three elements: (1) imposing cognitive load, (2) encouraging interviewees to say more, and (3) asking unexpected questions. The verbal cues to deceit that are most frequently examined in this approach are lack of detail, implausibility, and inconsistency (Vrij, Fisher, Blank, Leal, & Mann, 2016).

Cognitive Credibility Assessment: Imposing Cognitive Load

In interview settings lying is typically more mentally taxing than truth-telling (see fMRI research, Christ, Essen, Watson, Brubaker, & McDermott, 2009; Vrij & Ganis, 2014). Investigators can exploit truth-tellers' and liars' different mental states by making the interview setting cognitively more difficult, for example by asking interviewees to engage in a concurrent, second, task when discussing the event. Liars, whose mental resources are more depleted, are less able than truth-tellers to cope with additional requests (Debey, Verschuere, & Crombez, 2012), which impairs their storytelling (Vrij et al., 2008).

Cognitive Credibility Assessment: Asking Unexpected Questions

Liars typically prepare themselves for anticipated interviews by considering answers to questions they expect to be asked (Hartwig, Granhag, & Strömwall, 2007). The problem liars face is that they cannot know which questions will be asked. When investigators ask a mixture of anticipated and unanticipated questions, truth-tellers answer these questions with similar ease, but liars find answering the unanticipated questions more difficult than answering the anticipated questions (Lancaster, Vrij, Hope, & Waller, 2012). Questions can be unexpected because of their content but also because of their format. For example, the request to make a sketch of the event while discussing the event can be considered unexpected.

Cognitive Credibility Assessment: Encouraging Interviewees to Say More

In ordinary conversations, people never say initially all they know but typically provide a summary of their activities, highlighting some core issues ("I did some shopping in the morning, and had a BBQ in the evening") (Fisher, 2010; Vrij, Hope, & Fisher, 2014). This is, in part, the result of conversation rules (Fisher, 2010; Fisher, Milne, & Bull, 2011). Through life experience, people learn how much detail is anticipated in conversations. Truth-tellers realize that in interview settings they have to provide much more information than in ordinary conversations but they still do not provide all the information they know (Fisher, 2010; Vrij et al., 2014). One effective way to change truth-tellers' expectations about how much information to provide in an interview is to expose them to a detailed model statement (MS), which is an example of a detailed account/story unrelated to the topic of the interview (Leal, Vrij, Warmelink, Vernham, & Fisher, 2015). An MS changes interviewees' expectations about how much detail is required and results in more information from both truth-tellers and liars (Bogaard, Meijer, & Vrij, 2014; Ewens, Vrij, Leal, et al., 2016; Leal et al., 2015). Differences emerge in the quality of the information they provide. For example, after an MS, truth-tellers' stories sounded more plausible than liars' stories (Leal et al., 2015) and truth-tellers included more complications in their stories than liars (Vrij, Leal et al., 2017).

Strategic Use of Evidence

During interviews truth-tellers are generally forthcoming, whereas liars are inclined to be avoidant (e.g., in a free recall, avoiding mentioning where they were at a specific time) or to use denials (e.g., denying having been at a certain place at a specific time when asked directly; Granhag & Hartwig, 2008). When investigators ask questions related to the evidence without making the interviewee aware that they possess this evidence, these different strategies used by truth-tellers and liars result in truth-tellers' accounts being more consistent with the available evidence than liars' accounts (Hartwig, Granhag, & Luke, 2014). In addition, when liars start to realize during an interview that the interviewer may hold some incriminating evidence against them, they are inclined to change their statement and try to provide an innocent explanation for this evidence. As a result, liars show more within-statements inconsistencies than do truth-tellers (Hartwig et al., 2014).

Verifiability Approach

In principle, liars prefer to provide many details, because detailed accounts are more likely to be believed (Bell & Loftus, 1989; Nahari et al., 2012). Liars also prefer to avoid mentioning too many details out of fear that investigators will check such details, which could subsequently give the lie away (Nahari et al., 2012). A strategy that incorporates both goals is to provide details that cannot be verified. Liars use this strategy and typically report fewer details that can be checked than do truth-tellers (Nahari, Vrij, & Fisher, 2014a). This effect becomes stronger when interviewees are asked to include, where possible, details in their statement that the investigator can check, as truth-tellers, more than liars, add checkable details in their accounts following such a request (Harvey, Vrij, Nahari, & Ludwig, 2016; Nahari, Vrij, & Fisher, 2014b).

Assessment Criteria Indicative of Deception

The Assessment Criteria Indicative of Deception (ACID) interview procedure starts with an initial free recall in which an interviewee is invited to describe, in as much detail as possible, everything that happened during a specific period of time. This is followed by the use of mnemonics, which are interview techniques that facilitate memory recall (Colwell, Hiscock-Anisman, & Fede, 2013; Colwell, Hiscock-Anisman, Memon, Taylor, & Prewett, 2007). Examples are recalling the event from the perspective of another person present during the event (e.g., "What could that person see?"), and reverse order recall, that is, reporting the event from the end to the beginning (e.g., "Report what you did last time by beginning to describe what you did last, followed by what you did just before that?") These mnemonics are derived from the Cognitive Interview (Fisher & Geiselman, 1992), a well-established protocol to elicit more information from cooperative witnesses. It is thought that truth-tellers will benefit from these mnemonics more than liars and provide more additional detail. In addition, and unlike in the cognitive interview, in ACID a series of multiple-choice questions are asked in between the different mnemonics. These should be questions that liars have not anticipated and are therefore not part of their rehearsed answers.

CRITERIA FOR THE USE OF LIE DETECTION TOOLS IN INVESTIGATIVE INTERVIEWS

The 14 criteria I believe are important to determine whether a lie detection tool could be used in investigative interviews are mentioned in Table 13.1. Five of these criteria (1, 2, 3, 4, and 7) are derived from the Daubert guidelines, the guidelines that need to be met for a technique to be accepted as evidence in US criminal courts. Table 13.1 also shows how each of the seven verbal lie detection tools satisfies each of these 14 criteria.

Criterion 1: Is the scientific hypothesis testable? All techniques provide detailed and specific information how truth-tellers' accounts will differ from liars' accounts, which means that the hypothesis underlying each technique is testable.

Criterion 2: Has the proposition been tested? To fulfill this criterion an empirical test of the technique should have appeared in a peer-reviewed journal article. All seven techniques fulfill this criterion.

Criterion 3: Has the technique been subjected to peer review and publication? There are substantial differences in how many times the techniques have been empirically tested in peer-reviewed articles. SVA is the most widely tested technique, with more than 40 empirical studies available. Virtually all of these studies focus on the CBCA component of SVA; empirical tests of the Validity Checklist are rare. In contrast, SCAN has been rarely researched, with less than a handful of empirical studies available. There was empirical support for each verbal lie detection tool in most of the empirical papers, with the exception of SCAN, for which no support is found. Let's say, arbitrarily, that a lie detection technique needs to be supported empirically in at least 10 empirical studies to consider its support robust. It could be concluded that robust support has been obtained for the following techniques: CBCA (part of SVA), RM, encouraging interviewees to say more, SUE, and the VA.

Criterion 4: Is there a known error rate? Error rates, or the opposite, accuracy rates, are examined in deception research in two different ways. In some studies, participant-observers watch or listen to statements by liars and/or truth-tellers and then make decisions about the veracity of these statements. In other studies, veracity classifications are based on objective criteria (e.g., the amount of detail in a statement) and a cut-off criterion or decision rule is often determined by statistical analyses (a discriminant analysis). When a statistical method is used accuracy can become inflated. The problem arises when more than one variable is introduced in the statistical model to make veracity classifications. This results in very complicated discriminant models (different variables received different weightings) that (1) cannot be implemented by human observers and (2) are unlikely to be ever replicated in future research. Only in the ACID studies are discriminant analyses with complicated statistical models used. I do not discuss the results of these ACID studies in this section.

Field studies (in which real-life cases are used) can be problematic to assess accuracy. It is often difficult to determine the actual veracity status (truth-teller or liar) of the suspect. If this so-called ground truth is unknown, nothing meaningful can be said about the accuracy rates reported in the study. Driscolls (1994) field study of SCAN had this problem, and it was unknown who of the examinees were actually truth-tellers and who were actually liars. Although SCAN-users refer to this study as evidence that SCAN works, nothing can be concluded from the results of this study. Field studies in deception research are very rare due to the difficulty in establishing ground truth in real-life cases, and the few available field studies in this area are often of poor quality (Vrij, 2008a). Therefore, the error rates presented in Table 13.1 are based on laboratory research only.

Table 13.1 shows that for two tools, SCAN and SUE, the error rates are unknown, because not enough studies have been published reporting error/accuracy rates. In the two SUE experiments where accuracy rates were reported, these were 85% and 65%, respectively (Hartwig, Granhag, Strömwall, & Kronkvist, 2006; Luke et al., 2016), whereas in the two SCAN experiments where accuracy rates were published, SCAN did not perform better than chance level (Bogaard, Meijer, Vrij, & Merckelbach, 2016; Nahari et al., 2012).

The error rates for the tools where these are known are very similar, with average error rates typically around 30% (around 70% accuracy rates). The average error rate (25%) in ACID seems to be a bit lower but this rate is based on only four studies (Colwell & Colwell, 2011; Colwell et al., 2009; Colwell, James-Kangal, Hiscock-Anisman, & Phelan, 2015; Montalvo et al., 2013), and caused by one positive outlier (Colwell, James-Kangal, Hiscock-Anisman, & Phelan, 11% error rate). Over time with more studies published, the ACID accuracy rates may well fall in line with the accuracy rates of the other verbal lie detection methods.

In some studies different verbal veracity assessment tools are compared with each other, which gives insight into the relative accuracy of each tool. In studies where CBCA and RM were directly compared, both methods worked equally well (Vrij, 2008a). There is one study available in which SCAN and RM were directly compared. Based on RM, truth-tellers and liars could be distinguished from each other well above chance, whereas SCAN performed at chance level (Nahari et al., 2012).

Error rates around 30% are too high to be relied upon as evidence in criminal courts. If convictions will be based on the outcome of a lie detection test, error rates have to be much smaller as they need to fall into the beyond-reasonable-doubt range. However, veracity judgments are also frequently made in investigative interviews and often with important consequences. They are not used as proof of anything, but inform investigators about a range of decisions they make (e.g., whether or not to further invest time in interviewing a suspect, or to take specific action based on what a suspect said in an interview). Lie detection tools with error rates around 30% can be very useful when making such decisions.

Criterion 5: Which verbal cues to deceit do emerge? The 19 criteria that constitute CBCA (part of SVA) are the most frequently researched verbal cues to deceit. A meta-analysis about how each of these criteria discriminates between truth-tellers and liars was recently published (Amado, Arce, & Fariña, 2015). The meta-analysis showed that quantity of detail was the most diagnostic cue (truth-tellers are more detailed than liars). The effect size was $d = 0.71$, which is substantial. Quantity of detail was in terms of diagnostic value followed by (1) unstructured production (truth-tellers report information in a more nonchronological time sequence than liars), (2) logical structure (a truthful statement has a better logical structure than a deceptive statement), (3) reproduction of conversation (truth-tellers include more speech in its original form (quotes) than liars: "And then he asked: Is that your coat?"), and (4) unusual details (truth-tellers report more unusual details than liars). The effect size for unusual details was close to a medium effect size, $d = 0.41$. The total CBCA score (summation of all 19 criteria) was also diagnostic. Truth-tellers typically obtain a higher CBCA score than liars ($d = 0.56$).

RM consists of eight variables (Vrij, 2008a). The most diagnostic three variables are temporal details, spatial details, and sound details; all of them appear more frequently in truthful than in deceptive accounts (Vrij, 2008a,b). Temporal details are details about the time order of the events ("First he switched on the video-recorder and then the TV") and details about the duration of events. Spatial details are details about where the event took place, and details about how objects and people were situated in relation to each other ("Fred stood behind me"). Sound details are details representing what someone said he or she heard during the event (this includes conversations but also other sounds).

There is no standardized list of variables used in SCAN, but 12 criteria are mostly used in workshops about the technique (Driscoll, 1994), in research (Smith, 2001), or by SCAN users in a field observation (Bogaard, Meijer, Vrij, Broers, & Merckelbach, 2014). There is no SCAN research examining the diagnostic value of each of these 12 criteria. However, five CBCA criteria (spontaneous corrections, lack of conviction or memory, accounts of subjective mental state, unstructured production, and superfluous details) also emerge on the SCAN list (Vrij, 2008a). Since these

CBCA variables have been examined empirically, they also provide insight into SCAN. Intriguingly, CBCA and SCAN users predict opposite effects. CBCA users believe that these criteria emerge more in truthful accounts, whereas SCAN users believe they emerge more in deceptive accounts. Without exception, the findings support the CBCA predictions and all five criteria occur more frequently in truthful than in deceptive reports (Vrij, 2008a), with the effect sizes ranging from $d = 0.18$ (superfluous details) to $d = 0.69$ (unstructured production) (Amado et al., 2015; Vrij, 2008a). In other words, neither research that examines accuracy rates nor research that examines the diagnostic value of individual SCAN cues provide any evidence that SCAN actually works.

In CCA three verbal cues in particular appear to discriminate between truth-tellers and liars: quantity of detail, plausibility, and consistency. Quantity of detail (truth-tellers include more details into their accounts than liars) also emerged in CBCA as a diagnostic cue to deceit. Plausibility refers to whether something is likely to have happened as described. Thus, "Yesterday, before going to work, I ran 30 miles" is an implausible statement. Truth tellers' accounts are more plausible than liars' accounts. Consistency refers to the amount of identical information provided in two statements, either within one interviewee or between interviewees. Truth-tellers are more consistent than liars when answers to certain types of question are compared (Vrij et al., 2016).

CCA is a rather new approach and I expect more diagnostic cues to emerge over the years as a result of further research. For example, in a recent experiment, self-handicapping strategies were examined for the first time and emerged as a diagnostic cue (Vrij, Leal et al., 2017). Self-handicapping strategies are justifications people give as to why they cannot provide certain information; for example, "My dad did all the planning," "Nothing unexpected happened, I am a very organized person," and "I can't tell you what happened at the beginning of the barbeque, I arrived later." Liars include more self-handicapping strategies in their statements than truth-tellers. Also, complications appear promising, particularly in response to an encouraging-interviewees-to-say-more prompt. A complication is anything a person says that complicates the statement ("The sailing race was cancelled, there was not enough wind," "Initially we did not see our friend, it appeared that he was waiting at a different entrance"). Truth-tellers include more complications into their accounts than liars (Vrij, Leal et al., 2017). Complications are also part of CBCA and emerged in that research as a diagnostic cue ($d = 0.32$) (Amado et al., 2015).

In SUE research two diagnostic cues emerge: statement-evidence inconsistency and within-statement inconsistency. Statement-evidence inconsistency reflects discrepancies or contradictions between the suspect's account and the critical background information (evidence) held by the interviewer. Liars display more statement-evidence inconsistencies than truth-tellers and a meta-analysis examining this variable revealed a strong effect, $d = 1.06$ (Hartwig et al., 2014). Within-statement inconsistency reflects changes in a suspect's statement to make it fit with the evidence presented to him or her (Granhag & Hartwig, 2015). Liars display more within-statement inconsistencies than truth-tellers.

In the VA two diagnostic cues emerge: verifiable details and unverifiable details. Verifiable details refer to details an investigator can check and include (1) activities with identifiable or named persons who the interviewer can consult, (2) activities that have been witnessed by identifiable or named persons who the interviewer can consult, (3) activities that the interviewee believes may have been captured on CCTV, and (4) activities that may have been recorded through technology other than CCTV, such as using debit cards, mobile phones, or computers (Vrij & Nahari, 2016). Truth-tellers report more verifiable details than liars. The remaining details are called unverifiable details, and liars report more unverifiable details than truth-tellers.

In the ACID tool, four verbal cues are examined: response length, quantity of details, coherence, and type-token ratio. Response length refers to the length of the answers (truth-tellers give longer answers than liars); quantity of detail was discussed earlier (truth-tellers provide more detail than liars); coherence refers to consistency (truth-tellers contradict themselves less than liars); and type-token ratio, the ratio of unique words in a statement in relation to the total number of words in the statement. ("One small step for man, one giant step for mankind" has a type-token ratio of 0.80, because there are eight unique words in this 10-word sentence.) Liars have higher type-token ratios than truth-tellers because liars speak more carefully than truth-tellers and provide fewer words to avoid the possibility of making a mistake (Colwell et al., 2013).

Criterion 6: How many independent groups of researchers examine the technique? We can have more faith in a verbal lie detection tool if researchers who work independently from each other provide evidence that the tool works. CBCA and RM received such wide support over the years. SCAN is investigated by at least three different groups of researchers (e.g., Bogaard, Nahari, Vanderhallen). They all failed to find support for SCAN, which strengthens the conclusion that SCAN does not work as a lie detection tool. CCA research is carried out by several independent groups of researchers although the labs of Granhag and Vrij dominate this field. SUE, VA, and ACID research is driven by specific individuals (SUE, Granhag and Hartwig; VA, Nahari and Vrij; ACID, Colwell). In sum, if support from a wide range of independent researchers is desirable, only CBCA and RM fit this criterion.

Criterion 7: Is the theory upon which the technique is based generally accepted in the appropriate scientific community? Initially the CBCA component of SVA received criticism (Wells & Loftus, 1991), but that had more to do with a particularly poorly conducted field study than with the CBCA list of criteria itself (Vrij, 2008a). The Validity Checklist, which is a list of factors that may have affected CBCA scores and therefore should be taken into account when interpreting the CBCA score, is problematic to use. The criticism focuses on three aspects (Vrij, 2005, 2008a). First, the justification of some issues listed on the Validity Checklist could be questioned, such as displaying inappropriate affect during the interview. It implies that appropriate affect exists, whereas it does not. For example, some sexually abused victims express distress that is clearly visible to outsiders, whereby others appear numbed (Burgess, 1985). These different communication styles represent a personality factor (Littmann & Szewczyk, 1983).

Second, some factors on the Validity Checklist are difficult to measure, such as susceptibility to suggestion. To measure this, it is recommended to ask the witness a few leading questions (Landry & Brigham, 1992). However, interviewers should only ask questions about peripheral information, because asking questions about central information could damage the quality of the statement. Being restricted to asking questions about peripheral information is problematic, as it may say little about the witness's suggestibility regarding central parts. Interviewees show more resistance to suggestibility when discussing central parts than when discussing peripheral parts of an event (Dalton & Daneman, 2006).

Third, determining the exact impact of the Validity Checklist factors is also difficult. For example, the age of an interviewee should be taken into account (SVA is particularly aimed at interviewing children) because older children are more eloquent than younger children and therefore are more likely to obtain higher CBCA scores. However, when in one study, SVA experts were instructed to take into account the age of the child when calculating CBCA scores, several criteria still positively correlated with age (Lamers-Winkelman & Buffing, 1996).

SCAN has not attracted much research to date, but it has been criticized by the researchers who have examined it (Bogaard et al., 2016; Nahari et al., 2012; Vanderhallen, Jaspaert, & Vervaeke, 2015). One problem is that the method is theoretical and it is not easy to explain why it would work. For example, the criterion structure of the statement refers to the balance of the statement. It is thought that in a truthful statement the first 20% is used to describe activities leading up to the event, the next 50% to describe the actual event, and the final 30% to discuss what happened after the event. Thus, a 10-line statement is thought to comprise 2 lines to introduce the event, 5 lines to describe the event, and 3 lines about the aftermath. The more unbalanced a statement, the greater the probability that the statement is deceptive. The question, of course is, why would this be the case? What is the theoretical rationale for this assumption? Another point of criticism is that SCAN is not standardized. In CBCA, a list of 19 criteria is used and a total CBCA score is calculated. This is not the case in SCAN. There is no total SCAN score and there is no fixed list of criteria. The result is that different SCAN users may come to the same conclusion, but based on entirely different grounds. That is, User 1 may judge the statement deceptive due to the presence of criteria A and B, whereas User 2 may judge the same statement deceptive due to the presence of criteria C and D. This lack of standardization is problematic in a lie detection test, because it makes the outcome of a test entirely dependent on the individual user (see also Smith, 2001).

The imposing cognitive load technique, part of the CCA approach, has received criticism (Levine & McCornack, 2014). As I will discuss next, part of the problem is that imposing cognitive load could also be mentally taxing for truth-tellers and, if so, truth-tellers then may respond like liars. This point of criticism also applies to the reverse-order-recall mnemonic of the ACID tool, because this mnemonic is a prime example of imposing cognitive load (Vrij et al., 2008).

The remaining techniques have not received criticism in the scientific literature to date but this could be, in part, because some of them were introduced only recently and have not yet attracted interest from independent researchers. This picture may therefore change over the years. However, this is unlikely to apply to RM. That tool has been around for some time, is well researched, and is researched by various independent researchers without attracting any kind of criticism.

Since none of the techniques meet all five Daubert criteria (questions 1, 2, 3, 4, and 7 refer to the Daubert guidelines), they cannot be used as evidence in US criminal courts. This conclusion may be somewhat restricted. For example, outcomes of a SUE interrogation could sometimes be introduced in court. A successful SUE-based interrogation can reveal that a suspect's statement is inconsistent with the evidence and such a lie could be introduced as evidence in court. In a VA lie detection test a suspect's bluffing can be detected. A suspect who tells the investigator, "I was somewhere else at the time of the crime as CCTV footage at the location will show" is caught bluffing if the suspect cannot be seen on that CCTV footage. The alibi thus falls apart, which could be mentioned in court.

Criterion 8: Is the technique an interactive interviewing approach? Verbal lie detection researchers with different backgrounds and from different disciplines agree on one thing: There is more potential to detect deceit when investigators actively interview examinees through specially designed interview protocols than by a more passive and less interactive approach (Levine, 2014; Vrij & Granhag, 2012a,b). SVA, RM, and SCAN are passive approaches. In SVA and RM examinees are just asked to describe their experiences in as much detail as possible. Follow-up questions based on the answers may be asked but there are no guidelines available about which questions should be asked to enhance verbal differences between truth-tellers and liars. SCAN is the most passive approach as the examinee is asked to write down his or her activities without an interviewer present and without any follow-up questions.

The remaining approaches are interactive approaches. In the CCA approach interviewers actively elicit or enhance verbal differences between truth-tellers and liars through imposing cognitive load, encouraging interviewees to say more, and asking unexpected questions. In the SUE technique, the investigator elicits and enhances differences between truth-tellers and liars by asking questions related to the evidence they hold but without revealing that evidence to the interviewees. In the VA, investigators ask examinees to include, where possible, details that the interviewer can check, which results in truth-tellers providing more additional checkable details than liars provide. In the ACID approach, investigators elicit and enhance differences between truth-tellers and liars through the use of mnemonics (mental reinstatement of context, recall from other perspective, and reverse order recall).

Criterion 9: Is the technique easy to incorporate in a typical information-gathering interview? Successful lie detection is an important aim of an investigation, but not the only aim. Another important aim is to elicit from an interviewee as much relevant information as possible (Brandon, 2011; Loftus, 2011). This important second aim can be achieved by using information-gathering interview protocols (Vrij et al., 2014; Vrij, Meissner, et al., 2017). It is therefore desirable that a veracity assessment tool can be incorporated in a typical information-gathering interview so that the aim to detect lies does not occur at the expense of the aim to gather relevant information. All techniques can be easily incorporated in a standard information-gathering type of interview with the exception of ACID, which is a standardized interview protocol on its own and thus replaces a standard information-gathering type of interview. However, this is not necessarily problematic as the ACID interview protocol is an information-gathering interview protocol.

Criterion 10: Will the technique affect the response of a truthful interviewee? To obtain from a truthful interviewee a complete and accurate account of what he or she knows is difficult to achieve and skillful interview techniques are required to achieve this (Vrij et al., 2014). It is important to consider whether a verbal veracity assessment technique, when incorporated in a typical information-gathering interview, runs the risk of hampering the quantity and quality of detail provided by truthful interviewees. In the SCAN procedure, an interviewee writes down prior to the interview what he or she has experienced. Although this writing task does not interfere with the interview itself, the result is that the interviewer may, based on the SCAN analysis, form an impression of the truthfulness of the interviewee before the start of the interview. This is problematic. The belief that an interviewee is guilty quickly leads to an accusatory interview style (Kassin, Goldstein, & Savitsky, 2003), which is poor in terms of eliciting information and cues to deceit (Meissner et al., 2014; Vrij, Meissner, et al., 2017). A belief at the outset of the interview that an interviewee is innocent is equally problematic because interviewees can easily fool credulous interviewers (Levine & McCornack, 1992).

Some imposing cognitive load requests (e.g., carrying out a secondary task) will hamper eliciting information from truthful interviewees because their cognitive resources are being directed to something other than searching through memory. Such requests also could make truthful interviewees feel uncomfortable, which will subsequently hamper the elicitation of information. The unanticipated questions technique could make a truthful interviewee feel uncomfortable in case the questions are seen as odd. A SUE interview reduces the likelihood that a guilty suspect is truthful from the outset of the interview and will confess immediately as no evidence is presented at the beginning of the interview to encourage and convince a guilty suspect to confess. The remaining techniques are not expected to have a negative influence on the amount and accuracy of information truthful interviewees provide.

Criterion 11: Does the technique have within-subjects measurements? Practitioners often stress the importance of within-subjects lie detection tools (Vrij, 2016). That is, they wish to make a decision about the veracity status of an interviewee by comparing different responses made by the same interviewee during a single interview. This request makes perfect sense. There are large individual differences in people's speech (as well as in their nonverbal behavior and physiological responses) (DePaulo & Friedman, 1998). For example, some people are eloquent, others are not. Therefore, simple decision rules such as "He does not say much, so he must be lying" will not work. In physiological (polygraph) lie detection individual differences are widely acknowledged and the two main polygraph tests, the Comparison Question Test (Raskin & Honts, 2002) and the Concealed Information Test (Verschuere, Ben-Shakhar, & Meijer, 2011) are both within-subjects tests. Within the polygraph world exists a lively debate about which questions to ask to make an adequate within-subjects comparison (Vrij, 2008a), but unfortunately, the within-subjects comparisons discussion plays a far less prominent role in verbal lie detection research.

SVA, RM, and SCAN do not employ within-subject measurements. In SVA an attempt is made to control for individual differences through the Validity Checklist, but that method is not without problems, as outlined earlier. The remaining techniques use within-subjects measures. The reverse-order technique (part of imposing cognitive load) can be used as a within-subjects lie detection tool (Vrij, 2016). Interviewees are first asked in an open-ended question to describe in as much detail as possible what they have experienced and are then invited to report it again, but this time in reverse order. This instruction invites truth-tellers to think about the event again, but from a different perspective, and this often leads to reminiscences (Ewens, Vrij, Mann, & Leal, 2016; Shaw et al., 2014; Vrij, Leal, Mann, & Fisher, 2012). Liars include fewer reminiscences than truth-tellers. One reason for this is that liars are concerned about consistency, more so than truth-tellers (Vrij et al., 2016). They therefore may see the request to report information in reverse order as a test ("Can I report again everything I just reported, but now in reverse order?"). Adding new information in the reverse-order recall makes this recall less consistent with the initial chronological recall, so from a consistency perspective liars are unlikely to add new detail. Second, when liars are satisfied with their initial chronological recall, they will see no reason to add information when reporting the rehearsed story in reverse order, because this additional information may give investigators further leads to check the veracity of the statement.

The encouraging-interviewees-to-say-more technique can also be used as a within-subjects technique. In interview settings, as well as in daily conversations, people rarely provide all the information they know (Vrij, Fisher, & Hope, 2014). One reason for this is that they have inadequate expectations about how much detail is expected from them (Fisher, 2010). Investigators can alter the participants' expectations about how much detail is required by providing a model answer, a detailed statement about an event unrelated to the topic of investigation. This MS works as a social comparison (Festinger, 1954) and leads to more detail (Leal et al., 2015). The MS technique allows investigators to make within-subjects comparisons. Start the interview with inviting the interviewee to report in as much detail as possible what he or she has experienced. After this initial recall, let the interviewee listen to an MS and invite him or her again to report in as much detail as possible what he or she has experienced. Unlike the reverse order technique described earlier, liars will understand that additional information is required from them after listening to the MS. As a result, both truth-tellers and liars will provide additional detail, but the type of detail they add is different. First, the additional detail sounds more plausible in truth-tellers than in liars (Leal et al., 2015): Truth-tellers can search their memories and add more detail to their story, whereas liars have to fabricate additional detail on the spot. The latter is mentally taxing and leads to reminiscences that do not sound as plausible as the truth-tellers' reminiscences. Second, truth-tellers elaborate on the core and peripheral elements of their story, whereas liars mainly elaborate on the peripheral elements of their story. Liars prefer to avoid providing potentially incriminating information (Granhag & Hartwig, 2008) and a possible solution is to talk around the core event and add less relevant information instead.

The earlier mentioned self-handicapping strategies and complications, together with scripted common knowledge details (see also scripts, Sporer, 2016), "We ordered food in the restaurant," can be used as a within-tool in encouraging-interviewees-to-say-more interviews by looking at the proportion of complications (complications/[complications + common knowledge details + self-handicapping strategies]). This proportion is higher for truth-tellers than for liars (Vrij, Leal, et al., 2017).

Asking unexpected questions can also be used as a within-subjects measure. Liars prepare themselves for anticipated interviews by preparing possible answers to questions they expect to be asked (Hartwig et al., 2007). Investigators can exploit this by asking questions that liars do not anticipate. Though liars can refuse to answer unexpected questions by saying "I don't know" or "I can't remember," such responses will create suspicion if these questions are about central aspects of the target event. A liar, therefore, has little option other than to fabricate a plausible answer on the spot, which is cognitively demanding. As a result, for liars, expected questions should be easier to answer than unexpected questions, because they can give their planned and rehearsed answers to the expected questions, but they need to fabricate answers to the unexpected questions. The difference liars experience in cognitive load while answering these two sets of questions becomes evident in their verbal responses (e.g., less detailed and less plausible answers to unexpected questions). In contrast, truth-tellers experience similar levels of cognitive load while answering expected and unexpected questions, and they produce more comparable answers to the expected and unexpected questions than liars (Lancaster et al., 2012; Leins, Fisher, & Vrij, 2012; Roos af Hjelmsäter, Öhman, Granhag, & Vrij, 2014; Vrij et al., 2009).

The SUE technique also allows for within-subjects measurements. Liars and truth-tellers enter interviews with different counterinterrogation strategies (Granhag & Hartwig, 2008). Liars are inclined to use avoidance strategies (e.g., in a free recall avoid mentioning where they were at a certain time) or denial strategies (e.g., denying having been at a certain place at a certain time when asked directly), whereas truth-tellers are generally more forthcoming and tell the truth like it happened (e.g., Hartwig et al., 2007). When investigators possess critical and possibly incriminating background information (evidence), they can exploit these differential truth-tellers' and liars' strategies by introducing the available evidence during the interview in a strategic manner. During a SUE interview, liars may start to become aware that the investigator possesses a piece of evidence they initially did not think the investigator possessed. Liars then tend to adjust their story somewhat in an effort to provide a plausible but innocent explanation for that piece of evidence. These within-statement inconsistencies are a within-subjects measure.

The within-subjects aspect of the VA is to examine the *proportion* of verifiable details (verifiable details/[verifiable + unverifiable details]), which is typically higher for truth-tellers than for liars. The ACID protocol allows for within-subjects measures; for example, by examining the amount of additional detail elicited by the mnemonics.

Applying verbal base-lining in real life is challenging. Base-lining methods would be most effective if truth-tellers and liars display truly different response patterns; for example, if truth-tellers always include more verifiable than unverifiable details and liars always include more unverifiable than verifiable details in their statements (e.g., Nahari & Vrij, 2015). In that case a clear cut-off score can be established, but this pattern of responses does not happen in real life. All that can be concluded is that, to continue with the VA example, truth-tellers typically include a higher proportion of verifiable details in their statements than liars. This still leaves practitioners with the following problem: When is the proportion of verifiable details high enough to decide that the interviewee is telling the truth?

Yet, using within-subject measures is still beneficial compared to between-subjects measures. If just amount of detail is considered, the problem arises that the amount of detail will not only be affected by veracity but also by individual differences in being eloquent or preparedness (well-prepared answers are likely to be longer than spontaneous answers). Those additional factors play a lesser role in within-subjects comparisons. That is, it is no longer relevant how detailed an answer is (which is largely influenced by being eloquent and prepared) but it becomes relevant how many verifiable and unverifiable details are included (more likely to be influenced by veracity).

Criterion 12: Is the technique easy to use? The question whether a lie detection technique is easy to use is an important question. Investigators may be less receptive to techniques that require a lot of skill, training, equipment, or resources. There is considerable training required to learn the CBCA coding method (Vrij, 2008a). In addition, since there are so many criteria to code in CBCA it is a time-consuming activity that can be done reliably only on transcripts of the interview (in contrast to when listening to an interview in real time). RM is considerably easier to learn (Sporer, 2004; Vrij, 2008a) and RM coding can be completed when listening to interviews in real time (Vrij, Evans, Akehurst, & Mann, 2004). Regarding SCAN, the problem is that there is no standardized technique (e.g., there is no fixed list of SCAN criteria), and it is never easy to learn something that is unstructured.

The imposing-cognitive-load, asking-unanticipated-questions, SUE, and ACID techniques need some practice. For imposing cognitive load, skills are required to introduce an additional request that introduces cognitive load to interviewees. Some are easier to introduce than others because a better reason can be given for the request. For example, the request to report a story in reverse chronological order is relatively easy to explain to interviewees as it often results in extra information and thus a more complete recall. This reason cannot be given for asking interviewees to look the investigator in the eyes, another request which is known to impose cognitive load (Doherty-Sneddon & Phelps, 2005; Vrij, Mann, Leal, & Fisher, 2010). For asking unanticipated questions, SUE, and ACID, training is required about which questions to ask during the interview. In addition, for ACID training is required to use the three mnemonics properly. The encouraging-interviewees-to-say-more and VA techniques can be introduced without much training.

Criterion 13: Does the technique sufficiently protect truth-telling interviewees for appearing suspicious? The errors lie detection tools generate are not random; some tools are prone to false positive errors (judging a truth-teller as a liar), whereas other tools are prone to false negative errors (judging a liar as a truth-teller). Which error is most serious depends on the situation, but when an investigator mistakenly believes that an innocent suspect is lying (false-positive error), he or she often is inclined to use aggressive, accusatory interview methods to make the suspect to admit that he or she is lying (Kassin et al., 2003). Accusatory interviews in terms of quality are inferior to information-gathering interviews as the latter lead to more information (both in terms of quantity and accuracy), more true confessions, and fewer false confessions than the former (Meissner et al., 2014; Vrij, Meissner et al., 2017). Truth-tellers can easily struggle when cognitive load is imposed on them, which will make them look like liars. The other techniques probably protect truth-tellers sufficiently well enough against being seen as liars, and there is no empirical evidence that they do not protect truth-tellers. The exception could be SCAN. This technique includes several verbal cues indicative of deceit (rather than of truthfulness) and when people pay attention to cues to deceit, they tend to have a lie bias (Vrij, 2008b).

Criterion 14: Is the technique sufficiently protected against countermeasures? Research has shown that CBCA (Vrij, Akehurst, Soukara, & Bull, 2002, 4) and RM (Caso, Vrij, Mann, & DeLeo, 2006; Vrij, Akehurst, Soukara, & Bull, 2004; Vrij, Kneller, & Mann, 2000) can be successfully counteracted by examinees who know the working of these tests. There is no reason to assume that SCAN cannot be counteracted if CBCA and RM can. The other techniques can be less easily counteracted.

The asking-unanticipated-questions technique is difficult to counteract because of the surprise element of the questions that will be asked; the SUE technique, because the suspect cannot know what evidence the investigator has against him or her; and the VA tool, because liars typically cannot provide verifiable detail. The challenge liars face in counteracting the imposing-cognitive-load, encouraging-interviewees-to-say-more, and ACID techniques is to look like truth-tellers. That is, truth-tellers should find it easier to cope with the additional imposing cognitive load requests; and truth-tellers can typically provide more details than liars when encouraged to do so because liars are restricted by the fact that the more information they volunteer, the more leads they provide to investigators, which can give away that they are lying.

WHICH LIE DETECTION TOOLS ARE READY FOR REAL-WORLD USE IN INVESTIGATIVE INTERVIEWS: FINAL VERDICT

There is substantial difference in the extent to which the seven lie detection techniques met the criteria I think should be met to make them ready for real-world use in investigative interviews (see Table 13.1). SCAN falls short on numerous criteria and is in my opinion unfit for use as a lie detection tool. Ironically, it is probably the most frequently used tool in real life of the tools discussed in this chapter.

Fortunately, there are much better alternatives available to practitioners. SVA is one of them, but it is a complicated method to learn and use and in that respect RM is preferable. The imposing-cognitive-load technique has received criticism and, more importantly, there is a risk that truth-tellers cannot cope well with the imposing-cognitive-load demands either and, consequently, may provide similar responses as liars. I therefore do not recommend it for use in real life as a stand-alone tool. However, it could be used in combination with other techniques; see, for example, ACID, where the imposing-cognitive-load mnemonic reverse-order recall is combined with other mnemonics.

The remaining techniques are either ready for use to date (encouraging-interviewees-to-say-more, SUE, and the VA) or ready for use (asking-unexpected-questions and ACID) if they continue to receive support in empirical research. Ideally this support should come from independent labs, which is particularly relevant regarding ACID, because at present, it relies too much on the work of one single academic (Colwell). A possible disadvantage of ACID is that it is much more a stand-alone tool than the other techniques and therefore cannot as easily be implemented in existing information-gathering interviews as the other tools.

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CHAPTER 14

The Applicability of the Verifiability Approach to the Real World

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In the forensic context, verification of details is a common and routine activity. An integral part of law enforcement work involves examining the truthfulness of information collected in each case. The validity of alibi claims, eyewitness testimonies, and complaints must be carefully checked. For this purpose, law enforcement officers compare testimonies to validate the accuracy and truthfulness of their content, search phone records and closed-circuit television (CCTV) footage to validate reported activities or confirm the presence of a person in a certain location, inspect details reported in documents, examine photos to verify the occurrence of events or claims, and so on.

The Verifiability Approach (VA; Nahari, Vrij, & Fisher, 2014a, 2014b) proposes that the verifiability of information, or the potential ability to verify information (rather than actual verification of information), can be used as an indicator for distinguishing truths from lies. According to this approach, the likelihood that an account is truthful increases in accordance with its level of verifiability. In the last several years, the validity of VA as a content-based lie detection tool has been examined and empirically established in law enforcement (Nahari & Vrij, 2014a; 2015a; Nahari et al., 2014a, 2014b; Vernham et al., 2017) and insurance (Harvey, Vrij, Leal, Lafferty, & Nahari, 2017; Harvey, Vrij, Nahari, & Ludwig, 2016; Nahari, Leal, Vrij, Warmelink, & Vernham, 2014; Vrij, Nahari, Isitt, & Leal, 2016) settings. Initial attempts to examine the applicability of the approach in airport (see Jupe, Leal, Vrij, & Nahari, 2017; Kleinberg, Nahari, & Verschuere, 2016) and occupational (Jupe, Vrij, Leal, Mann, & Nahari, 2016) settings have also been made, and its usefulness in detecting malingering has begun to be addressed (Boskovic, Bogaard, Merckelbach, Vrij, & Hope, 2017).

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However, the lab environments in which the VA has been examined to assess its applicability to different settings do not mimic reality perfectly. Thus, as is the case for other tools developed in academia, the question of the suitability of the VA for use in real-world settings (e.g., actual police interrogations) is not trivial.

The current chapter aims to discuss the applicability of VA to the real world. I begin by describing the VA and its theoretical framework. Subsequently, I discuss its applicability with respect to several factors, including countermeasures, individual-case decisions, embedded lies, and ease of application, while comparing it to other verbal and nonverbal lie detection tools. In this section, I put forward suggestions for improving the applicability of VA and propose directions for future research.

THE VERIFIABILITY APPROACH: RATIONALE, THEORETICAL FRAMING, AND APPLICATION

A primary verbal indicator for deception is richness in perceptual and contextual detail. According to the reality monitoring (RM) theory (Johnson, 2006; Johnson & Raye, 1981), actual experience of an event involves perceptual processes. That is to say, when people experience an event, they perceive it with their senses, and are thus able to report what they saw, heard, smelled, tasted, or felt during the event (i.e., perceptual details). Beyond this, every event occurs in a specific context, such that the individuals who experience it are able to provide details regarding the times, durations, and locations of activities, as well as the locations of objects and individuals in space (i.e., contextual details). On the other hand, according to the RM theory, a person who describes an event that he or she has not actually experienced, but rather imagined or dreamed about, will find it more difficult to provide perceptual and contextual details. This is due to the fact that the event was not experienced through the person's senses, and therefore does not have a context in reality. Instead, when people create an event in their minds, they can be expected to describe that event on a more cognitive level, and to report more inferences, reasoning, and thoughts. As a result, truths (based on actual experiences) are expected to be richer in perceptual and contextual details than are lies (based on imagination) (Sporer, 2004; Vrij, 2008). This expectation is indeed supported by empirical evidence (see DePaulo et al., 2003; Masip, Sporer, Garrido, & Herrero, 2005; Nahari, Vrij, & Fisher, 2012; Vrij, 2005, 2008 for reviews) as richness in detail has been found to be an effective indicator for distinguishing truths from lies (Nahari, 2016 reported accuracy rates in terms of AUCs, ranging from 0.82 to 0.90; see also Nahari & Pazuelo, 2015).

Consider a student who was suspected of stealing a bicycle off the street in his own neighborhood. At the police station, he claimed to have an alibi and provided a statement regarding his activities at the time of the theft. Table 14.1 presents his statement and displays examples of perceptual (marked) and contextual (underlined) details. As shown in the table, the suspect provided perceptual details. He told the police what he saw (e.g., he saw that his instructor was wearing (1) a hat that was (2) red (3) with wide margins); heard (e.g., the student heard three statements of the woman that was behind him in the queue); and tasted (e.g., he had tea); and further detailed his activities (e.g., signing his name, walking, drinking). In addition, the suspect provided contextual details. He mentioned times (the class was at two o'clock); durations (e.g., it took him 10 minutes to reach the area of the clothing stores); order of activities (e.g., he signed his name "at the beginning of the class…"); locations (e.g., he signed an attendance form; he was in Hallelujah café; he sat (1) on a bench (2) that was in front of

Table 14.1 Statement example

That day, I was at the other end of town, at the university… I had Statistics class at two o'clock. At the beginning of the class, I signed my name on the attendance form. Our university has this procedure, where you have to sign your name to show that you attended the class. We learned how to perform various analyses manually. Our instructor showed up wearing a red hat, with such wide margins… it seemed a bit ridiculous, I do not know what she was thinking… Anyway, it really distracted me, her hat, and I could not understand a lot of the material. When the class was over … it was my last class of the day. When it was over, I saw that it was nice outside, so I decided to walk around a bit before returning home. I left the university building and walked toward the city center. It took me about 10 minutes to reach the area of the clothing stores. I walked around there and went so-called "window shopping." Then, I sat down to rest on a bench in front of the Hallelujah café. I looked at the passersby. Everyone was relaxed and happy, enjoying the sun… apart from a child that was with a teenager, who was very angry, for some reason. Then, I fancied a tea, so I went into Hallelujah café and bought one. There was a long line; about seven people were in front of me. Behind me was a blond woman. She began to talk to me. She asked if I was a student, asked what I was studying, and told me that her daughter had just completed a bachelor's degree in Psychology. When I finally got to the cashier, I bought my tea, paid by credit card and left. I started walking toward the bus stop, while drinking my tea. On the way, there was a stall selling concert tickets. I stopped there and had a little look, and then I took the bus home.

(3) Hallelujah café); arrangements of people in space (e.g., seven people were in front of him in the line). Richness in detail is assessed by counting the number of perceptual and contextual details (see Nahari, 2016), while avoiding repetitions (e.g., "I fancied a tea… and bought one" and "I bought my tea" repeated the same information, and thus was counted only once), subjective interpretations (e.g., "everyone was relaxed and happy, enjoying the sun"), and explanations, reasoning, or inferences (e.g., "Our university has this procedure…").

The VA focuses on richness in detail as an indicator for discriminating truths from lies. However, it proposes that beyond the number of details, the motivation of liars to manipulate their accounts should be taken into consideration through an examination of the quality of the perceptual and contextual details provided. In this sense, VA is a strategy-based approach to lie detection. The main argument is that liars do not take the impression of credibility for granted and therefore make an effort to come across as honest (DePaulo et al., 2003; Granhag & Hartwig, 2008; Kassin, Appleby, & Torkildson-Perillo, 2010; Vrij, Mann, Leal, & Granhag, 2010). They control their own behavior and speech, attempting to present behaviors and statements that they believe make an impression of honesty and, on the other hand, avoiding behaviors and statements that they believe raise suspicion (Vrij & Granhag, 2012; Vrij, Granhag, & Porter, 2010; Zuckerman, DePaulo, & Rosenthal, 1981). This behavioral monitoring is a type of self-regulation, a process by which "people control and direct their own actions, emotions and thoughts…[Self-regulation] focuses especially on how people formulate and pursue goals" (Fiske & Taylor, 2013, p. 129) and, in our context, is expressed in the use of self-regulatory strategies in order to be convincing (Hartwig, Granhag, Strömwall, & Doering, 2010). Indeed, high percentages of liars in mock crime studies (e.g., Hartwig, Granhag, & Strömwall, 2007; Hartwig et al., 2010; Nahari et al., 2012; 2014b) reported the use of a strategy in providing their statements. With this in mind, the liars' dilemma notion was coined.

THE LIARS' DILEMMA

Over the course of my extensive experience in studying verbal behavior, I have read hundreds of mock suspects' statements. In the basic mock crime paradigm used in my lab, "guilty" participants are sent to conduct a mock crime and "innocent" participants are sent to attend to their own business for half an hour. When the participants from both groups come back to the lab, they are told that they are suspected of committing a crime, and that they are going to be interviewed about it. In the interview, they are asked (by a blind experimenter who acts as an interviewer) to relate the activities in which they participated during the half hour they were away. The instructions they are given follow the basic structure of this example: "*You are suspected of … [the specific crime is mentioned]. Please tell me what you did during the 30 minutes from the time you left the lab to the time you reentered the lab. When you are ready, please tell me about your activities in as much detail as possible, and do not exclude anything, so I can have an idea of what happened during these 30 minutes. Be sure that you mention all details, activities, people you met, and conversations that took place, etc. Give as much information as you can, including information that seems irrelevant.*"

Many of the statements provided in these mock crime studies include activities that were conducted around the campus. The innocent participants (labeled truth-tellers) describe truthful, innocent activities and the guilty participants (labeled liars) often describe false innocent activities. While reading such statements, I repeatedly noted that irrelevant information is at times provided in great detail. For example, one participant (in the liars condition) described in detail an encounter with a black cat on campus. As I continued my explorative examination of statements, I realized that this behavior was systematic, and tended to appear in liars' statements. My intuitive interpretation was that this behavior, which I initially dubbed "the blah blah strategy," reflected the suspects' attempts to inflate their statements with nonsignificant information. These insights were the basis for the liar's dilemma notion.

According to the liars' dilemma, people perceive richness in detail as an indicator for truthfulness: the richer in detail an account is perceived to be, the more likely it is to be believed (Bell & Loftus, 1989; Johnson, 2006; Johnson, Foley, Suengas, & Raye, 1988). Liars may hold this believe about richness in detail, and be aware that people might analyze their accounts in terms of richness in detail. Thus, to make an impression of honesty, they are motivated to provide many details (Hartwig et al., 2007; Nahari et al., 2012). Yet, while the provision of details helps to generate an impression of honesty, it also puts liars at risk, because investigators can, and often do, check the truthfulness of some of these details. Liars are aware of this danger (see Masip & Herrero, 2013; Nahari et al., 2012) and thus may be inclined to avoid mentioning false details. This puts liars in a dilemma. On the one hand, they are motivated to include many details so that they appear honest, while on the other hand, they are motivated to avoid providing false details, to minimize the chances of being caught. A strategy that serves as a compromise between these two conflicting motivations is to provide details that cannot be verified. For example, it is much more difficult for the police to verify whether someone actually asked a stranger for directions in the street than to verify whether someone actually made a phone call at a specific time. Therefore, when attempting to make an impression of honesty, liars may choose to provide details that are difficult to verify and avoid providing details that are easy to verify.

EXPLOITING THE LIARS' STRATEGY

When liars succeed in their strategies, it blurs the behavioral differences between them and truth-tellers and, consequently, decreases the ability to detect their lies (Nahari & Pazuelo, 2015). Yet, in some cases, the awareness that liars are motivated to control their own behavior can be used to uncover the differences between liars and truth-tellers, and thus be applied to lie detection. For example, people believe that truths, in contrast to lies, are consistent over time (Granhag & Stromwall, 1999) and therefore liars attempt to be consistent over time and in line with the accounts of other interviewees (Granhag & Stromwall, 1999, 2002). However, liars' attempts to be consistent can make them recognizably more consistent than truth-tellers (see Granhag, Stromwall, & Jonsson, 2003). In accordance with this, most studies employing standard face-to-face interviews among adult suspects have found that within-statement consistency (i.e., consistency between details provided by an interviewee within one statement), between-statement consistency (i.e., consistency between two consecutive statements provided by the same interviewee), and within-group consistency (i.e., consistency between statements made by different interviewees) were higher among liars than truth-tellers (Vredeveldt, van Koppen, & Granhag, 2014). Thus, higher levels of consistency usually indicate deception rather than truthfulness, and therefore, liars' strategy to be consistent can be exploited to uncover their lies.

In the case of VA, the exploited strategy involves liars' preference for providing unverifiable over verifiable details. The basic expectation is that lies contain fewer verifiable perceptual and contextual details than truths. Therefore, it is possible to assess veracity by determining the amount of verifiable details appearing in accounts.

VERIFIABLE CONTEXTUAL AND PERCEPTUAL DETAILS: WORKING DEFINITION

Put simply, a verifiable detail includes perceptual or contextual information, the truthfulness of which can potentially be checked. Based on this basic principle, an extended definition is as follows: Verifiable details are perceptual and contextual details that are related to occurrences that were (1) documented, (2) carried out together with (an)other identified person(s), or (3) witnessed by (an)other identified person(s) (Nahari et al., 2014a, 2014b). A detail that cannot be related to an occurrence that was documented, carried out, or witnessed by an(other) person(s) is a non-verifiable detail.

To demonstrate how VA is applied, I will elaborate on each of the three components of the definition.

1. **Details related to occurrences that were documented.**

   Activities are documented when they leave traces that can subsequently be checked. Documentation can occur either manually or via technology. Here are some examples of documented details:

   - Phone calls. Using the history feature on phones or information documented by communication companies, it is possible to verify the truthfulness of (1) the existence of a phone call, (2) the duration of the conversation, (3) the person with whom the conversation was held, and (4) the person who initiated the call.
   - CCTV. Surveillance of the public using CCTV is currently common around the world. Cameras are located in places that may need monitoring for security purpose, such as bars, libraries, banks, schools, hotels, airports, hospitals, restaurants, and stores. Sometimes, CCTVs are also located outdoors, on roads and at public transportation stations. By checking CCTV footage, it is possible to verify the presence and activities of people at certain locations and times.
   - Manual registrations or signatures. Sometimes, even in the current technological environment, the presence of an individual in a certain location at a certain time is manually documented. For example, a manual signature on a petition conducted in a certain location, or a name on a waiting list at a restaurant.
   - Virtual documentation of presence and activities. It is possible to reconstruct or recognize activities such as website visits, specific

keyword searches on Google, email sign-ins, submission of electronic forms, and Internet shopping conducted via electronic devices. Sometimes, it is also possible to know when, for how long, and even where these activities were conducted.

The VA posits that verifiability level can help determine veracity because liars use it as a strategy. In this context, the presence of verifiable details in an account is only significant if the interviewee is aware that these details are verifiable. For this reason, details are identified as verifiable only if it is likely that the common interviewee would be aware of their documentation (i.e., the reasonable person standard). Consider a situation in which an interviewee reports activities that he conducted alone, in a private place. The interviewer, a police officer, knows that a candid camera was set up in that private place. Thus, the interviewer knows that the activities that were allegedly conducted were recorded. However, as the interviewee was not aware of the existence of the camera when he provided the details, he could not have meant to provide verifiable details. Consequently, these details should not be considered verifiable.

In the case of CCTV, however, the reasonable person standard is not applicable. It is difficult to predict whether the common interviewee would be aware that CCTV is present at a particular location, as this awareness would be based on familiarity with the location rather than on common knowledge or assumptions of plausibility. For example, CCTV is frequently found in bars in the United Kingdom. Yet, whether it is actually present in a specific bar in the United Kingdom is a matter of familiarity with that bar (rather than a general understanding regarding the presence of CCTV in bars), which is difficult to predict. Thus, in the case of CCTV, alleged activities that could have been caught by the CCTV will be considered verifiable only when the interviewee explicitly mentions the existence of a CCTV on the premises.

2. **Details related to occurrences that were carried out together with (an) identified person(s).**

Sometimes interviewees describe activities or events that were carried out with others. If the persons mentioned are identifiable and traceable, they can be approached to verify the truthfulness of the details provided by the interviewee. For example, an interviewee might mention that she met a friend at the cafeteria and had a five-minute chat with him about an upcoming exam. It is possible to trace that friend and ask him about the existence of the chat, its timing, duration, and content. However, a political conversation that an interviewee claims to have had with a stranger on the train to Amsterdam is not verifiable, as the stranger with whom he spoke cannot be identified, and consequently cannot be asked to confirm the details provided by the interviewee.

Importantly, mentioning the person's name is not a necessary condition for considering him or her as identifiable. It can be argued that saying "friend" without mentioning his or her name is too vague. However, it is very unlikely that an interviewee who mentions a person who can be traced believes that the police will not ask about the person's specific identity, especially because identified persons serve as witnesses (i.e., prime and significant evidence) who can confirm details in the statement, and sometimes even the entire statement. Consequently, it is reasonable to assume that by mentioning persons who can be traced, even without mentioning their names, the interviewee means, or at least is aware, that he or she is providing verifiable details.

3. **Details related to occurrences that were witnessed by (an) identified person(s).**

   This component of the definition is very similar to the previous one. The only difference is that the other person(s) was (were) not said to have carried out the activities with the interviewee, but only to have witnessed them. For example, if an interviewee claims to have had an argument with a stranger in a bar in front of members of his family, the family members can confirm or refute the details of the argument. As such, the perceptual and contextual details provided as part of the description of the argument (e.g., when and where the argument occurred, what was said, how long it took, etc.) can be considered verifiable details. If, on the contrary, the people who witnessed the argument were all strangers, who cannot be identified, the details of this argument would not be considered verifiable.

Going back to the statement presented in Table 14.1, few of the perceptual and contextual details appearing in the text are verifiable. Those that are verifiable are as follows: (1) "other end of the town, at the university" (one verifiable contextual detail); (2) "statistics class" (one verifiable contextual detail); (3) at two o'clock (one verifiable contextual detail); (4) "at the beginning of the class" (one verifiable contextual detail); (5) "signed my name" (one verifiable perceptual detail); (6) "on the attendance form" (one verifiable contextual detail); (7) "we learned how to perform various analyses manually" (one verifiable perceptual detail); (8) "our instructor showed up wearing a red hat, with such wide margins" (four verifiable perceptual details); (9) "I bought my tea, paid by credit card" (two verifiable perceptual details); and that was in (10) Hallelujah Caf'e (one contextual verifiable detail). Thus, in total, 14 verifiable details were recognized in this text.

THE APPLICABILITY OF THE VERIFIABILITY APPROACH

In this section, several issues related to the applicability of the VA will be discussed, including countermeasures, embedded lies, ease of application, and the ability to make decisions on individual cases. These issues are not exclusive to the applicability of the VA, but to that of other lie detection tools as well. The discussion, therefore, will address the VA from a comparative perspective.

Countermeasures

There is reason to believe that liars try to beat lie detection tests. Attempts of this type were introduced in the literature on psychophysiological lie detection, where they were termed countermeasures. In tests conducted by polygraph, EEG, or fMRI, there is empirical evidence demonstrating the disruptive effects of both physical (e.g., pressing the toe to the floor) and mental (e.g., counting in reverse) countermeasures (Ganis, Rosenfeld, Meixner, Kievit, & Schendan, 2011; Honts, Devitt, Winbush, & Kircher, 1996; Honts & Kircher, 1994; Rosenfeld, Soskins, Bosh, & Ryan, 2004).

Countermeasures have also been observed in verbal lie detection tools. One line of research showed that when participants were informed about criteria-based content analysis (CBCA) indicators (Köhnken, 1996; Kohnken & Steller, 1988), they were able to manage their verbal responses in a manner that led them to be judged as truth-tellers (Vrij, Akehurst, Soukara, & Bull, 2002, 2004; Vrij, Kneller, & Mann, 2000). More relevant to our context, when participants were introduced to RM criteria (Sporer, 2004; Vrij, 2008) and encouraged to provide many perceptual and contextual details, it was not possible to differentiate between truths and lies by measuring richness in detail (Nahari & Pazuelo, 2015).

To apply countermeasures effectively, the examinee must (1) be aware that a lie detection test is being administered, (2) understand which lie detection test is being administered, and (3) understand how that test works.

To successfully beat the test, the examinee also has to know how to disrupt the tool's mechanism without being caught.

It can be argued that it is easy to conceal the administration of verbal tools, mainly because they are administered in the absence of the examinee. As the statement provided by the examinee is coded in accordance with the verbal tool criteria *after* the examinee's part is over (i.e., provision of the statement), the examinee can stay unaware to the administration of the tool. This is different from many psychological tools, where the administration of the tool (e.g., polygraph test) requires the presence of the examinee, and consequently it is impossible for the examinee to be unaware of it. However, information about techniques used by law enforcement agencies can be leaked, such that it is difficult to completely rule out an examinee's awareness of a specific tool's mechanism. The knowledge that a tool is being administered is not, in and of itself, sufficient for beating the tool. As noted earlier, it is also necessary to understand how the tool works and to know how its mechanism can be disrupted. This is somewhat easy to do with verbal tools, as their principles are relatively simple (e.g., adding perceptual details). Thus, countermeasures should be taken into account when developing such techniques.

The sensitivity of the VA to countermeasures has been studied in two settings: police interrogations (Nahari et al., 2014b) and insurance statements (Harvey et al., 2016). Nahari et al. (2014b) sent participants to either commit a mock crime (liars) or conduct innocent activities around their university campus (truth-tellers). When they came back to the lab, they were told that they were suspected of committing a crime, and asked to provide a detailed statement regarding their activities at the time the crime occurred. Half of them were informed, before providing the statement, that the number of verifiable details they provided would be the indicator for judging their veracity. The results showed that informing participants about the mechanism of the VA did not hamper the effectiveness of the method in detecting lies, suggesting that the VA is not sensitive to countermeasures. In fact, the accuracy of the VA in detecting lies was actually higher when participants were informed of its mechanism than when they were not. It appeared that informed liars did not provide more verifiable details than did uninformed liars, presumably because they did not have truthful verifiable details to provide. In contrast, informed truth-tellers, who were made aware of the importance of verifiable details, and were able to provide such details, provided more verifiable details than did uninformed truth-tellers. As a result, the difference in level of verifiability between liars and truth-tellers was greater among informed participants than it was among uninformed participants. This finding led to the inclusion of information regarding the VA's mechanism (henceforth, information protocol) as an integral component of the VA protocol. Harvey et al. (2016) replicated this pattern, and further showed that in the insurance setting, including an information protocol not only facilitated the VA, but was critical to its ability to distinguish between true and false claims. Thus, the VA successfully discriminated between liars and truth-tellers only among informed claimants. This finding is related to the opportunity of liars to provide embedded lies, which are discussed in the next section.

Embedded Lies

Liars usually do not tell outright lies. When possible, they prefer to embed true details into their false accounts (Leins, Fisher, & Ross, 2013; Vrij, 2008; Vrij, Granhag, et al., 2010; Vrij, Mann, et al., 2010), many of which can be largely truthful. Nahari et al. (2014b) demonstrated how liars present their criminal activities as innocent acts. In their experiment, liars stole an exam and went to the library to copy it. Their presence in the library at the time of the crime was legal, as it was during opening times, when students were allowed to be present in the library. Thus, liars were able to provide details about true, innocent, activities that they had conducted, such as people they actually met and conversations they truly had. They could even tell their interviewer about the act of copying at the library (e.g., which machine they used, whether they had to wait in line, paying by credit card, etc.), while concealing only what it was that they were copying (i.e., a stolen exam). This strategy enables liars to provide many truthful perceptual and contextual details. When they provide richer accounts, liars may be wrongly classified as truth-tellers. This is relevant to all verbal tools that examine richness in detail, and especially to RM, in which richness in detail is a core element (Nahari, 2016; Nahari & Ben-Shakhar, 2013). Since some of the truthful details liars include in their embedded lies are verifiable, VA is also affected by this phenomenon.

It is usually possible to predict whether a liar will have the opportunity to provide an embedded lie. In police interrogations, legality of the suspect's presence at the crime scene at the time the crime occurred is a primary factor. In fact, a suspect can provide one of two accounts: an alibi or an alternative explanation. An alibi is a claim that the suspect was in another location (rather than at the crime scene) at the time of the crime and thus could not have committed the crime. In an alternative explanation, the suspect admits to being at the crime scene at the time the crime occurred, but provides another reason (rather than committing the crime) for being there. Sometimes, the presence of the suspect at the crime scene is enough to incriminate him or her. This happens when there was no legal justification for the suspect to be at the crime scene (e.g., a private place). In such cases, it is more likely that the suspect will provide an alibi. When the presence of the suspect at the crime scene is legal, the suspect can choose whether to provide an alibi or an alternative explanation. Nahari and Vrij (2015a) compared two criminal scenarios that differed in terms of the presence legality factor: stealing money either from a café at a time when it was open (presence is legal) or from a bank at a time when it was closed (presence is not legal). The participants imagined that they had been involved in planning and committing the crime in one of these two scenarios, and subsequently provided a statement regarding their (alleged) activities at the time of the crime. Forty percent of the participants in the café scenario positioned themselves in the café at the time of the crime, while only 8% of the participants in the bank scenario positioned themselves in the bank. When they positioned themselves in the café, participants in the café scenario could report truthful activities that they had conducted in the café, to a greater extent than participants in the bank scenario. It is not surprising, therefore, that participants in the café scenario provided 30% more verifiable details than did participants in the bank scenario.

There are more opportunities to provide embedded lies in the insurance setting than in the police interrogation setting (Nahari et al., 2014). Police officers often know where and when a crime under investigation occurred. As such, they ask interviewees to report what they were doing at a certain time. As discussed earlier, liars only have the opportunity to provide embedded lies when their presence at the crime scene is legal. Even when they have this opportunity, most liars do not choose to take it, preferring instead to locate themselves far from the scene (Nahari & Vrij, 2015a). The case is entirely different in the insurance setting, in which liars usually have the opportunity to provide embedded lies. The claimant is the one who tells the police (or the insurer) where and when the incident (loss, theft, or damage) occurred. This allows liars to choose a truthful event and to embed a false insurance incident within this event. For example, a liar can describe a birthday party that he actually attended recently, and tell the police that his phone disappeared during that party. In this case, the liar is able to provide many truthful verifiable details about the party (e.g., who was there, descriptions of guest's clothing, content of conversations, and descriptions of food and drinks), while embedding the false claim that his phone was gone.

Memory is another factor that makes embedded lies more feasible in the insurance setting than in law enforcement settings. In a recent study, Nahari (2017) showed that the number of truthful details provided by liars decreased over time, presumably because some of the details were forgotten. As such, when an interrogation does not take place immediately after the criminal event, as is usually the case in real life, liars have fewer opportunities to provide embedded lies. In the case of insurance statements, memory is not expected to affect the opportunity to provide embedded lies. Liars, who choose the time of the false incident, are free to choose an event that they remember clearly.

This difference between the settings in terms of the opportunity to provide embedded lies most likely explains why the information protocol is recommend for police interrogation settings while crucial in insurance settings (Harvey et al., 2016; Vrij et al., 2016). The information protocol increases the differences between liars and truth-tellers. In the insurance setting, where the integration of embedded lies is frequent, differences between liars and truth-tellers are small, and thus require aid to be detected.

Ease of Application

An important consideration in any methodology is how simple it is to apply. In the context of lie detection, there are two primary questions to consider: (1) To what extent is the application effortful and time-consuming? and (2) Is the tool appropriate for a wide variety of conditions, and how many prerequisites are needed to administer it?

For considering the application ease of VA, two prime content-based lie detection tools can serve as comparison cases: RM and CBCA. Both methods have a similar protocol: The interviewee first provides a statement regarding the event under question, after which the statement's content is coded according to predefined criteria. Research shows that both the CBCA and RM methods discriminate effectively between truths and lies, and with similar average accuracy rates of 70%. The accuracy of the VA matches and sometimes even exceeds this rate (Vrij & Nahari, 2017b). Taking into account that coding is an effortful and time-consuming activity (Nahari, 2016), the number of criteria that must be coded is a central indicator for ease of application of verbal tools. While CBCA and RM comprise 19 and 8 criteria, respectively (see Vrij, 2008), the VA requires identification of perceptual and contextual (spatial and temporal) details alone. As it obtains at least the same accuracy rates as CBCA and RM while requiring less effort in coding, it can be concluded that the VA is relatively easy to apply.

An additional advantage of the VA is that all it requires from investigators is to mention at the beginning of the interview that they will check the verifiability of the details provided. Then, the investigators only need to count the number of details that can *potentially* be checked. They do not need to collect any information (facts and evidence) prior to the interview, nor do they actually verify the details provided by the interviewee after the interview (Nahari et al., 2014a). This makes the tool applicable to interviews that are conducted at very early stages of investigation, when little information is available, and in other cases when it is problematic to check evidence for various reasons. It also makes the tool time-efficient and inexpensive to use (see also Vrij & Nahari, 2017a).

Finally, some tools require special equipment and resources. For example, polygraph tests for lie detection require instruments, as well as computers and expendable materials (e.g., electrodes and sanitizers). It also requires a room and a well-trained professional staff. The VA, like other verbal lie detection tools, does not require such equipment or resources, and using the VA does not require special skills or professional knowledge. Though it does require some training to achieve valid and reliable coding, it is not prolonged. This aspect of application ease may be especially appreciated by practitioners (see Vrij & Fisher, 2016).

Individual Case Decisions

A crucial requirement for any tool to be used in the field is its ability to facilitate decisions in individual cases. In other words, it must be able to determine whether a specific interviewee is lying or telling the truth. Making a decision regarding an individual case requires a clear decision criterion, such as normative data (norms) or a predetermined cut-off point, which makes it possible to interpret a specific score. In the case of CBCA, for example, the higher the score achieved for a specific statement, the higher the likelihood that the interviewee is telling the truth. A CBCA examiner charged with interpreting a specific CBCA score needs a criterion in order to decide whether a score is high enough to conclude that the interviewee is telling the truth, or low enough to conclude that the interviewee is lying. Although it may sound obvious, this issue is widely neglected in the verbal lie detection literature. In research settings, the validity of tools in this field is predominantly examined through assessment of their ability to differ between lies and truths at the group level. As such, it is the differences in scores between lies and truths that indicate the efficacy of a tool in determining veracity. It rarely happens, if at all, that the ability to make a decision regarding the veracity of each statement alone, based on its score, is examined. Thus, verbal lie detection tools that were developed in academia usually do not include the means, or decision criteria, for determining veracity in an individual case (e.g., cut-off point).

One challenge in establishing decision criteria is related to variance among interviewees (Nahari & Vrij, 2015b), which has been reported with respect to physiological responses as well as with respect to verbal and nonverbal behavior (Vrij, 2008). In our context, there is empirical evidence for individual differences in the amount of perceptual and contextual details a person provides when lying or telling the truth. Nahari and Vrij (2014b) showed that the tendency to provide statements that are rich or poor in detail is stable within subjects, which implies that this tendency is not random but related to personal characteristics. Indeed, studies have demonstrated such individual differences in verbal behavior in relation to, for example, public self-consciousness and ability to act (Vrij, Edward, & Bull, 2001) and fantasy proneness (Merckelbach, 2004; Schelleman-Offermans & Merckelbach, 2010). Gender differences have also been found, with females showing a tendency to report more senses (e.g., touch, hold, feel), sound details (e.g., heard, listen, sounds), motion verbs (e.g., walk, go), and emotions than males (Newman, Groom, Handelman, & Pennebaker, 2008). In accordance with these findings, Nahari and Pazuelo (2015) found that the truthful accounts of female participants were richer in detail than those of males. If interviewees differ in the amount of perceptual and contextual details they include in their truthful statements, it is difficult to tell how many details to expect in a truthful statement, and consequently impossible to establish norms or cut-off points. This has a direct effect on the VA, as the number of verifiable details depends on the amount of perceptual and contextual details provided.

A potential solution for dealing with individual differences when using a tool is to utilize a within-examinee measure, which enables assessment of interviewee behavior in a relative manner (Nahari & Vrij, 2015b). Such measures assess the relevant responses provided by each interviewee in relation to his or her other responses, under comparable conditions.

Solutions of this type have already been applied in psychophysiological lie detection protocols, with the psychophysiological responses (e.g., skin conductance, heart rates) of each interviewee to the relevant alternative being compared to his or her responses to neutral alternatives. Namely, the intensity of the response to the relevant alternative is assessed in a *relative* way (i.e., compared to the other responses of the interviewee), rather than in an *absolute* way. As such, individual differences are neutralized. Recently, Vrij (2016) proposed several interesting within-examinee measures of verbal behavior.

To the best of my knowledge, VA is the only verbal tool to date that implements a within-examinee measure, in which the amount of verifiable details is assessed in relation to the total details provided[1] (e.g., Nahari et al., 2014). Specifically, the number of perceptual and contextual details that can be verified is divided by the total number of (verifiable and nonverifiable) perceptual and contextual details. This ratio reflects the proportion of the verifiable details in the text. As such, individual differences in the tendency to provide accounts that are poor or rich in detail are neutralized. However, controlling for individual differences using a within-examinee measure is only the first step toward enabling decisions in individual cases using the VA. An additional, necessary, step is the establishment of a cut-off point for the proportion of verifiable details. Apparently, this can already be accomplished using the receiver operating characteristics procedure (see Macmillan & Creelman, 2005) on the collected data. Yet, individual differences constitute only one of the factors affecting the amount of details in an account (beyond veracity). An additional factor, for example, may be the opportunity to embed truthful details (see earlier). Thus, more research is required before it will be possible to use the VA to make decisions regarding individual cases.

CONCLUSIONS

In the current chapter, I introduced the VA, a new content-based tool for lie detection. The tool is still in the early stages of development, but already shows several significant advantages. It is inexpensive and relatively easy to administer. It offers a within-examinee measure that neutralizes individual

[1] It is also possible to calculate a ratio between the number of verifiable details and the number of nonverifiable details (see Nahari et al., 2014a).

differences among interviewees and appears to be resistant to countermeasures. However, as in other verbal tools, its effectiveness may decrease in the presence of embedded lies. To conclude, there are good reasons to be optimistic regarding the applicability of VA in real life. One main challenge is to identify factors (besides veracity) that might affect the number of details provided, and to develop measures that can neutralize these factors. This will bring us closer to enabling decisions regarding individual cases.

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SECTION 6

Special Issues

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CHAPTER 15

Personality, Demographic, and Psychophysiological Correlates of People's Self-Assessed Lying Abilities

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People lie from time to time (Ariely, 2012). DePaulo and Kashy (1998) asked people to maintain a daily record of all their lies and reported that, on average, people tell one or two lies a day. This indicates that lying is an everyday occurrence for most people. In contrast, Halevi, Shalvi, and Verschuere (2014) found that most people reported not lying in the previous 24 h and only a small minority reported frequent lying. This may indicate existence of substantial individual differences in people's tendency to lie frequently (Bond & DePaulo, 2008).

When people lie, they lie about their feelings, preferences, attitudes, achievements, and failures. As to everyday lies, DePaulo et al. (2003) reported that people did not spend much time either planning them or worrying about them. They expressed no regret and reported that such social interactions were more superficial compared to interactions in which they told the truth. However, the more noticeable lying instances are those in which significant lies were told and in these cases the perceived ability to be persuasive when telling lies may be important to accomplish one's goals.

To be successful in social interactions, people should be able to detect others' lies. For this end, they must develop lie-detecting skills and acquire confidence in using them. The perceived ability to detect deception may assist people in their lie-detection decisions. Nevertheless, past research on

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lie detection suggested that most people's lies go undetected (e.g., Bond & DePaulo, 2008). Furthermore, even professionals who are regularly engaged in detecting deceit, such as customs officials (Kraut & Poe, 1980), and federal law enforcement officers (DePaulo & Pfeifer, 1986), were unable to differentiate truthful from deceptive messages.

To determine peoples' feelings about their ability to persuade others when they are lying, and their feelings about their ability to detect lies, the concept of self-efficacy (Bandura, 1977) is central. Self-efficacy is the belief in one's ability to accomplish goals in given situations. Self-efficacy research confirmed that it determines how people think, behave, and feel, and it is also related to actual success.

Similarly, the perceived lie-telling and lie-detecting abilities may be correlated with what people feel, think, and behave. Nevertheless, the research on various aspects of the perceived lie-related abilities is in its creation. In this chapter, I will describe what has been done and portray directions for future research.

HIGH SELF-ASSESSED ABILITY TO DETECT LIES AND LOW SELF-ASSESSMENT OF THE ABILITY TO TELL LIES

Early accounts suggested that individuals tend to rate their own lie-telling ability relatively lower than other people's ability (Ekman & O'Sullivan, 1991; Elaad, 2003; Vrij, 2008). In contrast, they tend to rate their lie-detecting ability higher than that of other people.

Elaad (2003) reported that participants (police interrogators and police personnel) using a nine-point scale, gave low ratings of their own lie-telling ability (mean = 4.45, SD = 2.05), below the middle point (5) "as good as others." At the same time, participants assessed their own lie-detecting ability as being greater than the same ability of others (mean = 6.1, SD = 1.01).

The following were conditions of studies, summarized in Table 15.1, which compared participants' self-assessed lie-telling and lie-detection abilities. Participants in all these conditions, were asked: "Comparing to other people, how would you assess your own ability to tell lies convincingly?" and "Comparing to other people, how would you assess your own ability to detect lies successfully?" Answers were given on a scale ranging from 0 (*much worse than others*) to 100 (*much better than others*) with 50 (*as good as others*) serving as the middle point.

Table 15.1 Percent means, SDs, and other statistics of self-assessed abilities to tell lies convincingly and detect lies successfully

Lying abilities	**Detect lies**			**Tell lies**						
	Mean	**SD**	**95% CI**	**Mean**	**SD**	**95% CI**	**N**	**t**	d_{RM}	**r**
Elaad (2006)										
Secular students	0.61	0.20	0.551—0.666	0.50	0.23	0.423—0.568	48	2.5[a]	0.36	0.06
Secular Kibbutz	0.59	0.20	0.533—0.647	0.53	0.28	0.449—0.607	50	1.9	0.27	0.59
Religious individuals	0.59	0.18	0.529—0.646	0.38	0.28	0.294—471	40	4.2[b]	0.66	0.13
Religious collective	0.54	0.20	0.485—0.596	0.33	0.24	0.265—0.400	52	5.1[b]	0.70	0.11
Elaad (2009)										
Laypersons	0.68	0.21	0.600—0.760	0.48	0.27	0.374—0.576	30	3.9[b]	0.71	0.32
Prisoners	0.65	0.25	0.556—0.744	0.44	0.22	0.354—0.519	30	3.8[b]	0.70	0.17
Interrogators	0.74	0.13	0.691—0.788	0.63	0.19	0.556—0.702	28	3.8[b]	0.73	0.59
Elaad et al.(2012)										
Adolescents	0.63	0.21	0.594—0.669	0.49	0.28	0.443—0.543	121	5.4[b]	0.47	0.35
Elaad (2015a)										
Students	0.67	0.28	0.603—0.727	0.37	0.30	0.297—0.433	80	6.9[b]	0.78	0.12
Elaad(2015b)										
Prosecutors	0.75	0.18	0.686—0.818	0.42	0.25	0.326—0.509	32	6.6[b]	1.16	0.16
Laypeople	0.60	0.22	0.520—0.677	0.45	0.25	0.355—0.535	32	2.7[a]	0.48	0.08

Continued

Table 15.1 Percent means, SDs, and other statistics of self-assessed abilities to tell lies convincingly and detect lies successfully—cont'd

Lying abilities	Detect lies			Tell lies						
	Mean	SD	95% CI	Mean	SD	95% CI	N	t	d_{RM}	r
Elaad and Reizer (2015)										
Students	0.59	0.20	0.556–0.618	0.46	0.27	0.418–0.499	174	6.2[b]	0.47	0.33
Elaad and Sommerfeld (2016)										
Students	0.64	0.20	0.598–0.677	0.48	0.20	0.435–515	100	7.0[b]	0.69	0.33
Yaacov (2017)										
Community	0.54	0.22	0.512–0.574	0.38	0.25	0.346–0.416	192	8.4[b]	0.60	0.34
Elaad (2017)										
Secular	0.77	0.16	0.738–0.809	0.67	0.21	0.624–0.716	80	4.5[b]	0.50	0.38
Religious	0.56	0.19	0.517–0.602	0.39	0.17	0.385–0.400	80	7.2[b]	0.80	0.32
Overall Weighted *Means*	0.62			0.46		0.343–0.582	73.1		0.60	0.30

CI, Confidence Interval; d_{RM} = repeated measure effect size; *N*, number of participants; *r*, correlation coefficient between lie telling and lie detection; *t*, paired sample t-test.
As Table 15.1 represents a repeated-measures design that focuses on differences within a person, a repeated-measure effect size (d_{RM}) was used (see, Morris & DeShon, 2002), which is defined in terms of the mean difference in SD difference (*SD d*) units, as follows:

$$d_{RM} = \frac{Md - Mt}{SD\ d}$$

in which *M*d is the mean lie-detection assessment and *M*t is the mean lie-telling assessment.
Ninety-five percent confidence intervals were defined in standard error units. The 95% confidence intervals for the weighted means were computed only for the lie-telling assessments because, for the lie-detecting assessments, all the variance can be expected from sampling error and the correct variance equals zero. See Hunter and Schmidt (1990).
[a] $P < .05$.
[b] $P < .01$, two tailed.

To summarize the differences between lie-detecting and lie-telling ability assessments, a mini metaanalysis was performed. Such a procedure has been used before in psychological research (e.g., Lamarche & Murray, 2014; Williams & DeSteno, 2008) and has been recently endorsed (e.g., Goh, Hall, & Rosenthal, 2016; Maner, 2014). Goh et al. (2016) asserted that such a metaanalytic procedure allows us to succinctly summarize the results across studies and illuminate the picture, even with only two available studies. The advantage of such a procedure is in redirecting attention toward effect sizes and away from individual studies' *P*-values, which have very limited comparative value. Another advantage of conducting a mini metaanalysis is in providing greater transparency as researchers can include their "null" findings and still provide justification for their overall result. Finally, a mini metaanalysis provides the opportunity to find small and sometime counterintuitive effects that are only detectable in a cumulative design but not in a single study.

For each assessed ability within each condition, 95% confidence intervals (CIs) were computed. CIs provide useful information about differences between the self-assessed ability and the middle point: "as good as others." To secure that the mean ability rating is not just a sampling error, the CI was based on standard error units. Thus, if the lower bound of the CI is larger than the middle point (0.50), confirmation for the overestimation of self-assessed ability is provided. Similarly, if the upper bound of the CI is smaller than the middle point, it may be assumed that the self-assessed ability is underestimated. To estimate if the bias is systematic across all conditions, a correction for sampling error was applied (Hunter & Schmidt, 1990), and the remaining variance, after the correction, was used to compute the 95% CI for the weighted-mean statistic. The means of the two ability assessments, along with other statistics, are presented in Table 15.1.

Table 15.1 indicates that people tend to self-assess their ability to detect lies higher than their ability to tell lies convincingly. In support of this conclusion, 15 out of 16 comparisons are significantly different and present an effect size (d_{RM}) of at least 0.36.

Inspection of Table 15.1 further suggests that the lie-detection ability is overestimated. The lower bounds of 15 out of 16 CIs are clearly above the middle point and, after applying the correction for sampling error, the weighted mean across conditions, which can be assumed to be the correct value, is well above 0.50. The results for the lie-telling ability assessments are not consistent and the upper bound of the CI computed for the weighted mean is above 0.50. This leads to the conclusion that the lie-telling ability assessment is not biased. However, very different populations were used in the different conditions (e.g., religious people, secular, students, prisoners, prosecutors), which justifies a search for moderators.

Because most lies go undetected, it is reasonable to assume that people would rate their lie-telling ability higher than their lie-detecting ability. There are several explanations why the opposite was found. Specifically, why the lie-telling ability is not rated higher than the lie-detecting ability (or at least similarly, high).

First, lie-telling is believed to be a difficult task. It is difficult because the liar must construct a new and never-experienced tale, whereas telling the truth is a simple matter of "telling it like it is" (Buller & Burgoon, 1996; Miller & Stiff, 1993). Nevertheless, some lies are easily formulated when they are based on scripts of familiar stories. Still, examples of difficult lies are more available than easily formulated lies. In addition, the desire to sustain a positive self-image may also explain the results. Thus, if I am not an able lie-teller, I am entitled to believe that I am an honest person.

As to the overestimated lie-detection ability in daily life, people are more often confronted with truthful statements than with deceptive ones. By believing the statements they feel they are correct most of the time. As to deceptive messages, most of the sender's lies remain undetected and the perceivers get no feedback about their lie-detection failures. In the absence of corrective feedback, perceivers feel that they are able lie detectors.

Another explanation for the lie-detection ability bias is the tendency of people to think of themselves in a positive way. Norms dictate that people should not allow themselves to be easily deceived. In support of this attitude people would like to believe that their ability to succeed in detecting lies is above average.

DEMOGRAPHIC FACTORS

Table 15.1 highlights some possible mediators that may account for demographic differences in the lie-detecting and lie-telling ability assessments. We will focus on religiosity, gender, age, and in-service lying experience.

RELIGIOSITY

Elaad (2006) studied the relation between religiosity and lie-related (tell and detect) abilities. The study was published in Hebrew and is, therefore, described in detail here. The effects of religiosity and collectivism on self-assessment of the lie-related abilities were examined on four Israeli groups of participants. It was hypothesized that secular people are more cognitively flexible than religious people. Cognitive flexibility is the ability to restructure knowledge in multiple ways depending on changing situational demands (Spiro, Feltovich, Jacobson & Coulson, 1995). Ariely (2012) used the term cognitive flexibility to describe how people live with two conflicting motivations, to benefit from cheating and at the same time believing to be honest. Therefore, cognitively flexible people tend to "fudge" more than less flexible people. When secular participants were asked to assess their lie-telling ability, they tended to overrate this ability without weakening their sense of honesty. Religious rules compromise the cognitive flexibility of (Jewish) religious people. These rules condemn lying and therefore religious participants underrate their lie-telling ability to preserve their honesty.

Collectivism emphasizes values that promote the welfare of the in-group over values that promote individual goals (Sagy, Orr, & Bar-On, 1999). Members of a segregated Jewish religious community were considered high in collectivism and represented the collective face of religiousness. A sample of individual Jewish religious people from the wide community volunteered to participate in the study and represented the less collective side of religiousness. Similarly, members of an operating Israeli Kibbutz (in contrast to other Kibbutz forms that ceased operating at the time of the study), which emphasizes sharing and community life, represented secular collectivism. Israeli secular students who were individually approached and were asked to participate in the study were considered the less collective secular group. Results indicated that, although all groups rated their lie-detection ability above average and there were no religiosity effects on lie-detection assessments, the religious groups tended to rate their lie-telling ability (Mean = 35.4, SD = 25.8) significantly lower than the secular groups (Mean 51.4, SD = 25.7), $t_{(188)} = -4.29$, $P < 0.001$, d = 0.62.

A more recent study (Elaad, 2017) provided the opportunity to reexamine religiosity effects. Eighty religious and 80 secular people from the community served as participants. Table 15.1 indicates that secular participants rated their lie-telling ability significantly higher than religious participants, $t_{(158)} = 9.30$, $P < 0.001$, d = 1.47. Similarly, secular participants rated their lie-detection ability significantly higher than their religious counterparts, $t_{(158)} = 7.73$, $P < 0.001$, d = 1.23.

Combining the three religious groups (religious individuals, religious collective group, and the religious group in the Elaad (2017) study), the weighted-mean lie-telling ability assessment was 0.37. All the variance is expected from sampling error. Therefore, the computed mean can be assumed to be the correct value. The three matched secular groups yielded a weighted mean lie-telling ability assessment of 0.58 and a 95% CI of 0.466–0.703. It may be concluded that religious participants underestimated their lie-telling ability, whereas secular participants did not. As to the lie-detection ability, the three religious groups yielded a weighted mean of 0.56 (assumed to be the correct value). The three corresponding secular groups exhibited a weighted mean of 0.68 and a respective 95% CI of 0.526–0.829.

To conclude, it is evident that religiosity reduces both lie-telling and lie-detecting ability assessments. Religious people underestimated their lie-telling ability assessments and allocated it below the middle point "as good as others." Both religious and secular participants overestimated their lie-detection ability.

GENDER

Gender differences may also be dominant in assessing lie-related communication abilities. A metaanalysis of scales from widely used personality inventories from 1940 to 1992 showed that females scored slightly but consistently higher on scales of trust (Feingold, 1994). It may be suggested that females believe in other people's honesty and in their positive intentions. Males reported more frequent lying than females and scored higher on the Social Adroitness scale, which was designed to pinpoint ambitious persons skilled at persuading others in a subtle diplomatic way (Kashy & DePaulo, 1996). It is suggested that females, who are more sensitive than males to honesty, may evaluate their lie-telling ability lower than males. The more ambitious males would rate their lie-telling ability higher than females because the lie-telling skill is necessary to accomplish their ambitious goals. Sweeney and Ceci (2014) reported no gender differences in ability to detect lies. No hypothesis regarding gender differences with respect to lie-detecting ability was made.

Elaad (2015a) examined gender differences in self-assessments of lie-telling and lie-detecting abilities. Forty males and 40 female students participated in this study. Male assessments were: Mean = 0.67 (SD = 0.28), and Mean = 0.41 (SD = 0.31) for the respective lie-detection and lie-telling abilities. Using a matched sample t-test, The difference is significant ($t_{(39)} = 4.11$, $P < 0.001$). Female assessments were: lie-detecting, Mean = 0.66 (SD = 0.22) and lie-telling, Mean = 0.32 (SD = 0.29). Again, the difference is significant ($t_{(39)} = 5.76$, $P < 0.001$). A t-test on the lie-telling ability assessments revealed no significant difference between males and females ($t_{(78)} = 1.40$, ns).

Two other recent studies (Elaad, 2017; Elaad & Reizer, 2015) provided the opportunity to reexamine gender differences in lie related ability assessments. Elaad and Reizer compared the lie-telling assessment of 84 male students (mean 50.0, SD = 27.97) with that of 88 female students (mean 40.9, SD = 25.15). Although the difference is significant ($t_{(170)} = 2.37$, $P = 0.019$, d = 0.34). The rather low effect size dictates caution. No gender differences were obtained for the lie-detection ability assessments (Mean = 59.7, SD = 18.3, and Mean = 58.5, SD = 20.7, for males and females, respectively).

Elaad (2017) compared the lie-telling ability assessments of 79 male community members (mean 57.2, SD = 26.0) and 81 female members (mean 48.9, SD = 20.4). Although a significant difference was obtained ($t_{(158)} = 2.25$, $P = 0.025$, d = 0.36) Cohen's d (effect size) is rather small. No significant gender differences were found for the lie-detection assessments (Mean = 66.1, SD = 21.0, and Mean = 67.2, SD = 20.2, for males and females, respectively).

The weighted means and the corresponding 95% CIs of the lie-related ability assessments were computed for the two gender groups across the three studies. Females underestimated their lie-telling ability (weighted mean = 0.42, 95% CI = 0.373–0.472) and overestimated their lie-detecting ability (weighted mean = 0.63, all the variance was expected from sampling error and no CI was, therefore, computed). Males overestimated their lie-detection ability (weighted mean = 0.63, 95% CI = 0.565–0.709) but not their lie-telling ability (weighted mean = 0.51, 95% CI = 0.459–0.562). It may be concluded that both males and females are biased toward enhanced lie-detection ability. Females alone underestimate their lie-telling ability.

When difference in assessing the two abilities are considered, female participants showed a somewhat lower perceived lie-telling ability than males. Nevertheless, the difference is either insignificant or presents a small effect size. Furthermore, studies comprising a male participant majority (e.g., Elaad, 2009) display similar lie-telling assessments as studies that used a female participant majority (e.g., Elaad & Sommerfeld, 2016). In summary, the effect of gender on the self-assessed lie-telling ability is not yet resolved and requires additional research. No gender difference in the self-assessed lie-detecting ability exist.

AGE

Another interesting question is how the self-assessed lie-related skills change over time. A prevailing belief is that older adults, who become more dependent on others, may lose confidence in their ability to lie convincingly. Ruffman, Murray, Halberstadt, and Vater (2012) examined lie-telling skills in older adults. Their adult people (60−89 years old) were more transparent as liars than young adults (17−26 years old). As to the lie-detection ability, Shaw and Lyons (2016) found that deception-detection accuracy increased with age. They explained that as people get older they are more aware that overt expressions do not always resemble internal feelings. However, Shaw and Lyons' sample consisted of a large proportion of students and only few participants were over 50 years of age. Bond, Thompson, and Malloy (2005) compared old adults (ages 62−84) with young adults (ages 18−35) drawn from two different populations (prison and nonprison). They found that older adults were better able to discriminate lies from truths than younger adults. They explained that older participants' experience and knowledge base are advantageous when engaging in social interactions. Sweeney and Ceci (2014) found the opposite. They noted that college students were better at detecting deception than older adults (ages 60−93), and explained that the older participants have worse emotion recognition and may have experienced neurological changes that make them more trusting of others than is warranted by circumstances. Sweeney and Ceci further reported that the older the participants were the worse they were at detecting deception. It follows that old age (above 60) is associated with lower ability to detect lies and this should lower the self-assessment of the lie-detecting ability.

A pioneer study conducted on 39 old people (ages 66−94), all residents of two Israeli nursing homes, showed low self-assessments of the lie-telling ability, Mean = 21.8, (SD = 25.9), and somewhat lower than average lie-detecting ability, Mean = 52.8 (SD = 34.0). It seems that residents of nursing homes, who are in constant need for assistance, feel unequipped to convince other people to believe them when they lie. It should be noted that using age to explain the results may be misleading because results from more independent old people are missing. It may be hypothesized that independent old people would be more confident in their lie-telling skills than the present sample of nursing home residents. The examination of the hypothesis is left for future research.

Elaad et al. (2012) examined the lie-related ability assessments in adolescents (ages 14–18). Adolescents tend to lie to their peers to gain greater autonomy (Arnett-Jensen, Jensen-Arnett, Feldman, & Cauffman, 2004). At the same time, they develop lie-detection skills when protecting themselves from lies directed to them. By doing so they gain experience in lying and lie-detection, thus increasing their confidence in their lie-telling and lie-detection abilities. Nevertheless, Table 15.1 shows that lie-telling and lie-detection ability ratings of adolescents were not different in comparison of those of students and other age groups. Additional research on adolescents' self-assessed lying abilities is necessary.

GAINING ON-THE-JOB LIE-TELLING AND LIE-DETECTING EXPERIENCE

On-the-job experience in occupations that require lying and/or lie-detection skills, such as interrogators, spies, attorneys, salespersons, actors, and others, may enhance the perception of the ability to lie successfully and detect lies efficiently.

Police interrogators and prosecutors are endorsed to exhibit such abilities. Table 15.1 shows that interrogators perceive their lie-telling ability higher than other groups. Specifically, Elaad (2009) reported that police interrogators assessed their lie-telling ability higher than both lay people ($t_{(56)} = 2.49$, $P = 0.016$, $d = 0.65$) and prisoners ($t_{(56)} = 3.55$, $P = 0.001$, $d = 0.93$). Table 15.1 shows that interrogators and prosecutors exhibited the highest assessment of the lie-detection ability. Lie-detection assessments of prosecutors in Elaad (2015b) study were significantly higher than the corresponding assessments of students ($t_{(62)} = 3.05$, $P = 0.003$, $d = 0.76$).

In summary, on-the-job experience may contribute to higher assessments of lie-telling and lie-detection abilities. Alternatively, accepting a job that requires above-average lie-telling and/or lie-detection abilities, may generate self-selection of high perceivers of the lie-telling and lie-detecting abilities. In any case, there are individual differences in the self-assessed lie-related abilities and additional effort to look for these differences is necessary.

OTHER POTENTIAL MEDIATORS

Perceived Importance

The different assessments of the lie-related abilities may be linked to the importance people attribute to these abilities. Strong relations were found between the self-assessed abilities and their perceived importance (Elaad, 2015a). Specifically, the lie-telling ability assessments were positively correlated with the importance participants attributed to that ability ($r = 0.31$, $P = 0.016$). Similarly, lie-detecting ability assessments were positively correlated with the importance people assigned to the ability ($r = 0.31$, $P = 0.017$). When the importance ratings were compared, lie-telling received much lower importance ratings (Mean = 48.17, SD = 29.26) than lie-detecting (Mean = 78.67, SD = 21.51). Using a paired sample t-test, the difference is significant, $t_{(59)} = 7.01$, $P < 0.001$. People feel that it is more important to detect the lies of other people than to be a good liar. The importance ratings can be considered in two opposite ways: "it is important to possess a specific trait therefore I believe I possess it", or "I believe I possess the ability, therefore it is important to have it".

Test—Retest Reliability

Elaad and Sommerfeld (2016) provided some insight into the reliability of the lie-related abilities. In this study, 100 students were asked to self-assess their abilities twice, in two sessions separated by 1—14 days. Test—retest correlations were computed for the lie-telling ability ($r_{(100)} = 0.67$, $P < 0.001$) and for the lie-detecting ability ($r_{(100)} = 0.72$, $P < 0.001$). The reliability results may indicate that both lie-telling and lie-detecting ability assessments are lasting attributes.

SELF-ASSESSED LIE-TELLING AND LIE-DETECTION ABILITIES AND PERSONALITY DIMENSIONS

There are people who associate the ability to lie successfully with dishonesty (negative quality). Such people are expected to rate their ability to persuade others when lying below average. Other people may apply a double standard and consider their own lies as an unavoidable necessity and therefore less innocuous than lies of other people (Bond & DePaulo, 2006). Yet other people may think that lying is a positive quality that serves them well in social interactions (Kashy & DePaulo, 1996). Such people are expected to rate their ability to lie successfully above average. In summary, people do not share similar notions about what is positive and what is negative concerning the lie-telling ability.

Considering the perceived lie-detection ability, most people evaluate their lie-detection ability higher than others. However, a metaanalysis indicate that people are no better than chance when judging deception (Bond & DePaulo, 2008). It seems that the high lie-detection ability evaluation is not justified. Furthermore, lie-detection ability assessments vary among individuals.

Elaad and Reizer (2015) examined the contribution of personality dimensions to self-assessed lie-telling and lie-detecting abilities using the "Big Five" model of personality trait structure (McCrae & Costa, 1997). The Big Five presents five orthogonal dimensions that capture the full range of personality traits: Neuroticism, Extraversion, Openness to experience, Agreeableness, and Conscientiousness.

Using hierarchical regression models for predicting lie-telling and lie-detecting ability assessments, Elaad and Reizer found that higher levels of Extraversion and Openness to experience, and lower levels of Agreeableness, contributed significantly to higher assessments of the lie-telling ability. Similarly, higher levels of Extraversion and Openness to experience and lower levels of Agreeableness contributed significantly to lie-detection assessments. Conscientiousness and Neuroticism did not contribute to the lie-related ability assessments (Table 15.2).

A recent unpublished study (Elaad, 2017) conducted on 160 Israeli participants from the community (81 females) provided an opportunity to reexamine the contribution of the Big Five personality dimensions to high and low self-assessments of the lie-related abilities. Using hierarchical regression models, lower levels of Agreeableness contributed significantly to higher assessment of the lie-telling ability. All other dimensions failed to show any contribution to the perceived ability to tell credible lies. Similar results were obtained for the lie-detecting assessments (Table 15.2).

A yet unpublished M.A. thesis (Yaacov, 2017) performed on 192 participants from the community (108 females) reexamined the association between the self-assessed abilities to tell and detect lies and the Big Five personality dimensions using hierarchical regression analyses. One participant failed to complete the Big Five inventory and was excluded from the personality analysis. It emerged that lower levels of Agreeableness and higher levels of Openness to experience contributed significantly to higher assessments of the lie-telling ability. Higher ratings of Extraversion and

Table 15.2 Data on correlations between lie-telling ability assessments and Big Five dimensions

	Agreeable	Conscientious	Extraversion	Openness	Neuroticism
Elaad and Reizer (2015) N = 174	−0.307[c]	−0.112	0.199[b]	0.218[b]	−0.107
Yaacov (2017) N = 191	−0.217[b]	−0.105	0.111	0.143[a]	−0.101
Elaad (2017) N = 160	−0.348[b]	−0.095	0.022	−0.100	−0.026
M r_z	−0.296	−0.104	0.117	0.156	−0.080
M r	−0.288	−0.104	0.117	0.155	−0.080
Combined Z	−6.52[c]	−1.65	2.06[a]	2.05[a]	−1.14

M r, weighted mean correlation (converted from r_z to r); *M* r_z, weighted mean correlation (Fisher's Z transformation for normalization).
The combined Z value summarizes the Z (standard normal deviate) that corresponds to each study's *P*-value and attaches the appropriate sign. Calculations were performed according the following formula (Goh et al., 2016):

$$Z_{\text{combined}} = \frac{\sum Z}{\sqrt{k}}$$

in which *k* refers to the number of independent Zs being combined.
[a] $P < .05$.
[b] $P < .01$.
[c] $P < .001$.

Conscientiousness and lower ratings of Agreeableness and Neuroticism predicted higher assessments of the lie-detecting ability.

The regression analyses indicate that the association between self-assessments of the lie-telling and lie-detecting abilities and Big Five traits is robust. To reach concise and more convincing conclusions, a mini metaanalysis (Goh et al., 2016), based on three own studies, indicated in Table 15.3, was conducted. The advantage of a mini metaanalysis over the individual regression analyses is the estimation of the overall effect size that places more weight on the reliability and the replicability of the findings than on individual effects that may or may not meet the level of significance (Braver, Thoemmes, & Rosenthal, 2014). For the mini metaanalysis, Pearson correlations between lie-telling ability assessment and the Big Five dimensions in each study were calculated. The correlations are displayed in Table 15.2. Similar correlations computed for the lie-detection ability assessments appear in Table 15.3.

A separate mini metaanalysis was performed for each Big Five dimension across the three studies. Fixed effects were used in which mean effect

Table 15.3 Data on correlations between lie-detecting ability assessments and Big Five dimensions

	Agreeable	Conscientious	Extraversion	Openness	Neuroticism
Elaad and Reizer (2015) N = 174	−0.204[b]	0.093	0.367[c]	0.379[c]	−0.027
Yaacov (2017) N = 191	−0.171[a]	0.197[a]	0.177[a]	0.117	−0.204[b]
Elaad (2017) N = 160	−0.272[b]	−0.010	−0.038	−0.024	0.087
M r_z	−0.216	0.100	0.182	0.168	−0.006
M r	−0.213	0.100	0.180	0.166	−0.006
Combined Z	−4.42[c]	1.89	4.45[c]	3.89[c]	−1.15

M r, weighted-mean correlation (converted from r_z to r); *M* r_z, weighted-mean correlation (Fisher's Z transformation for normalization).
Combined *Z*, Summarized Zs that correspond to each study's *P*-value.
[a] $P < .05$.
[b] $P < .01$.
[c] $P < .001$, (all two tailed).

size (i.e., mean correlation) was weighted by sample size. All correlations were Fisher's z transformations for analyses that were converted back to Pearson correlations for presentation. Across the three studies, lie-telling assessments were positively associated with Extraversion and Openness to experience and negatively associated with Agreeableness. Although consistent negative association emerged between Conscientiousness and Neuroticism and lie-telling ability assessments, the combined Z score is insignificant. Similar results were obtained for lie-detection assessments. Specifically, the assessments related positively with Extraversion and Openness to experience, and negatively with Agreeableness.

The outcomes deserve further explanation. It seems that extroverts who are sociable, energetic, talkative, with positive emotions and tend to seek stimulations with others (McCrae & Costa, 1997), who are drawn to social life and have more opportunities to communicate with others, are more inclined to tell lies than introverts who have fewer social opportunities (Kashy & DePaulo, 1996). Extroverts learn to be persuasive when lying. This is in line with the notion that extroverts perceive themselves as good persuaders (Barrick & Mount, 1991). Frequent social interactions also contribute to the perceived ability of extroverts to notice and detect when other people are lying to them.

Openness to experience also contributed to the perceived abilities to tell lies persuasively and to be able to detect others' lies. Openness to experience reflects the degree of intellectual curiosity, independent thinking, creativity, and preference for novelty and variety (McCrae & Costa, 1997). Such people are motivated to engage in intellectual pursuit (Moutafi, Furnham, & Crump, 2006) and are positively associated with emotional intelligence (McIntyre, 2010). Such people are curious about other people and spend time and effort in collecting information from others. Confidence in their lie-related abilities helps them in this matter. Furthermore, open-minded people who prefer variety of experiences over a strict routine (Barrick & Mount, 1991) will try deception more often than others and will learn how to become a better liar. In summary, gaining experience with lying may be associated with higher self-assessed lie-telling ability.

Agreeable people consider themselves as nice, friendly, and trustworthy (McCrae & Costa, 1997). Agreeableness is associated with the tendency to be genuine in one's relationships (Gillath, Sesko, Shaver, & Chun, 2010) and is associated with low self-assessments of the abilities to lie persuasively and detect lies successfully.

LYING PREFERENCE AND LIE-TELLING ABILITY ASSESSMENTS

Yaacov (2017), linked the self-assessed lie-related abilities to preferences for a deceptive option over a truthful one. Specifically, participants drawn from the local community were presented with four implausible scenarios of misconduct. They were then asked to simulate the role of the innocent respondent and defend themselves by convincing that they are indeed innocent. There were three alternative options: (1) tell a completely true but implausible story; (2) tell a story that was basically true story although many implausible aspects of the event were removed from the description; (3) tell a complete lie that makes sense.

Yaacov found that participants who rated high their lie-telling ability tended to choose deceptive alternatives more often than low lie-telling ability raters ($r_{(189)} = 0.19$, $P = 0.009$). Specifically, participants who gave a high score to their lie-telling ability preferred a deceptive alternative over the truthful option, whereas participants who were less confident in their lie-telling ability preferred to tell the less-plausible truth. No association between the self-assessed lie-detection ability and preference for a deceptive option was found.

SELF-ASSESSED LIE-TELLING AND LIE-DETECTING ABILITIES AND PERFORMANCE IN THE CONCEALED INFORMATION TEST

The final part of the present review offers evidence of associations between participants' self-assessed lie-related abilities and their responses to critical items in the Concealed Information Test (CIT). The CIT consists of a series of multiple-choice questions, each containing one critical item (e.g., an item of information related to the crime under investigation) and several neutral (control) alternative items, which cannot be distinguished by innocent suspects who have no crime-related knowledge (Lykken, 1998). Typically, if a suspect's physiological responses to the critical items are consistently greater than to the controls, it is possible to infer that the examinee has knowledge about the crime in question. Usually, three physiological measures are being used to detect concealed knowledge—electrodermal responses, cardiovascular activity, and respiration changes.

A recent attempt to link between self-assessed lie-telling and lie-detecting abilities and the performance on a version of the CIT (the Guilty Answer Test [GAT]) was made by Elaad and Sommerfeld (2016). The experiment used a mock-theft procedure in which 100 participants were randomly assigned to four experimental conditions in a 2 × 2 factorial design. There were two guilt conditions (guilty and informed innocents) and two human interrogation-feedback conditions. In one condition, participants received a feedback of belief from an "interrogator," whereas in the other condition they were not believed. The polygraph test was administered several days after the mock crime and the human interrogation. Self-assessments of the ability to tell lies convincingly and to detect lies successfully were gathered twice, in the mock-crime session and after the polygraph session.

In this study, skin conductance responses (SCR) were computed as the maximal increase in skin conductance, from 1 to 5 s after stimulus onset (Ben-Shakhar, Gronau, & Elaad, 1999). Other measures used in this study include finger pulse waveform length (FPWL) responses, the measured line length of the pattern that depicts the activity of the peripheral blood vessel within 15 s from stimulus onset, and respiration line length (RLL) responses, the total respiration line length during the 15 s interval following stimulus onset. For both FPWL and RLL, shorter lines represent stronger responses (see Elaad & Ben-Shakhar, 2006; Elaad, Ginton, & Jungman, 1992; for details).

It was observed that in the 2-min rest period before the test, guilty participants who have high assessments of their lie-telling ability elicited higher tonic skin conductance levels (SCL) than lower lie-telling ability raters. Larger SCL responses may reflect arousal; therefore, it is suggested that guilty (but not-informed innocent) participants who have high assessments of their lie-telling ability were more aroused before the test compared with their low-rated counterparts. It was suggested that low lie-telling ability raters acknowledge the fact that the polygraph will detect their concealed knowledge and make no effort to change this outcome. The smaller group of high lie-telling ability raters may have felt that they have to prove something and were motivated to influence the polygraph outcome. Such motivation may have increased tonic SCL before the test and enhance responsivity to critical items during the test. As to standardized responses to critical items along the test, high self-assessed ability to tell lies convincingly contributed to the relative magnitude of SCRs. Lie-telling ability assessments were not associated with RLL or FPWL responses. Lie-detection ability assessments did not predict physiological responses. As the SCRs are most sensitive to orienting responses (Klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2016), future research should explore the relation between orientation and the lie-telling ability assessment.

DISCUSSION

The present chapter clearly shows that many people feel that they have difficulties to persuade others to believe their lies and rate low their lie-telling ability. Demographic differences such as gender, age, religiosity, and on-the-job experience may mediate these assessments. However, these differences await further experimental clarifications. Current research on the association between self-assessed lie-related abilities and additional demographic differences, such as education, social-economic status, and profession, calls for future research.

It was found that high lie-telling ability raters were more responsive in the CIT than lower lie-telling ability raters. The effect was observed only for the SCR measure which is sensitive to orientation. It was speculated that high lie-telling ability raters may be more susceptible to orienting responses than lower lie-telling ability raters. This should be further examined in future research. A related question is: would high lie-telling ability raters, undergoing a CIT polygraph test, use more countermeasures than other examinees? The rational is that people who believe they have the ability to lie persuasively may be motivated to try and prove their assertion in the polygraph test when they are lying. A clear answer may be relevant and important for the polygraph industry.

Generally, people feel confident about their ability to detect deception. This lie-detection ability is important in situations that involve personal relations including law enforcement situations. High self-assessed lie-detection ability serves well police interrogators' tendency to be suspicious (Elaad, 2003; Meissner & Kassin, 2002) and that of prosecutors' who are committed to prove their case in court. No wonder that interrogators and prosecutors exhibited the highest lie-detection ability assessments (see Table 15.1).

Personality attributes may play a role in lie-related ability assessments. Using the Big Five personality inventory, results indicated that lie-telling and lie-detection assessments were positively related with Extraversion and Openness to experience and negatively related to Agreeableness. Specifically, people who perceive high their ability to lie successfully and their ability to detect lies accurately can be characterized by extraversion dimensions such as sociability and positive emotions, a tendency to seek contact with other people, and being talkative. It was further found that high lie-related ability raters assessed high features of the Open to experience dimension. Attributes such as curiosity and independent thinking, emotional intelligence, seeking novelty and variety, as well as spending time and effort in collecting information from other people may characterize this group of people. In contrast, low Agreeableness ratings were associated with high lie-telling and high lie-detecting ability assessments. Agreeable people trust others and tend to perceive themselves as nice and friendly. In contrast, people with low ratings of Agreeableness assume that others are generally untrustworthy and act accordingly until their trustworthiness is demonstrated over time.

It may be suggested that people who assess high their lie-telling ability are inclined to tell lies more often than low lie-telling ability raters who are more introverted and have fewer social opportunities. The rational is that high raters are open to a variety of experiences and gain more lying skills than low lie-telling raters.

In this framework, the Self-efficacy theory (Bandura, 1986) is relevant. Self-efficacy is commonly defined as the belief in one's capabilities to achieve a goal or an outcome. Higher self-efficacy levels in a specific area are related to better performance in that area. For example, students with a strong sense of self-efficacy are more likely to challenge themselves with difficult tasks and are ultimately likely to achieve better academic performance (e.g., Margolis & McCabe, 2006).

It follows that higher self-assessment of one's ability to tell lies may be associated with better and more successful lying. Some evidence to support this notion was offered by Yaacov (2017), who reported association between high lie-telling ability assessments and lying preferences. Schneider and Goffin (2012) developed the Perceived Ability to Deceive (PATD) scale and found an association between the scale scores and self-reported counterproductive workplace behaviors. Grieve and Hayes (2013) investigated the relationship between PATD scores and actual ability to deceive successfully within the context of simulated vocational faking. They found that PATD scores did not predict successful faking. Nevertheless, the relation between high confidence in one's lie-telling ability and actual lying behavior deserves further attention. Other related questions that warrant further investigation include: Do above-average lie-telling ability raters lie more frequently than others? In what situations do above-average lie-telling ability raters tend to use or refrain from using their alleged lying skills?

It was indicated that people tend to self-assess their ability to detect lies higher than their ability to persuade others when they lie. Further, the lie-detection ability assessment is generally overrated, whereas the lie-telling ability is not. Several possible explanations were provided for the lower lie-telling ability assessment. For example, the desire to sustain a positive self-image. By rating low the ability to lie successfully, people support their self-image of being honest. Similarly, an explanation for the overrated lie-detection ability refers to the tendency of people to think of themselves in a positive way. Norms dictate that people should not allow themselves to be easily deceived. In support of this attitude people would like to believe that their ability to succeed in detecting lies is above average.

The question that follows is: Do respondents lie intentionally when they self-assess their lie-related abilities? Specifically, are people motivated to present themselves as honest people who lack the ability to lie convincingly when they do not truly believe they lack lie-telling skills? Do people truly believe that they are above-average lie detectors or do they rate themselves as such simply because they are motivated to deny being gullible or being easily deceived by others?

Social desirability, or the tendency of respondents to answer questions in a manner that is viewed favorably by others, is relevant here. However, social desirability predicts negative correlation between the self-assessed lie-telling ability (low) and the self-assessed lie-detection ability (high). In contrast, Table 15.1 presents positive correlations between the two assessed abilities for all 16 examined conditions, with nine substantial correlations (above $r = 0.30$). It may be suggested that alternative explanations, such as confidence (or lack of confidence) in the lie-related abilities, play the major role in biased assessments rather than social desirability. Williams and Gilovich (2008) provided further support to this notion showing that people truly believe in their self-enhanced ratings and take their estimates seriously enough to guide their actions.

LIMITATIONS

The set of studies reviewed in the present mini metaanalysis were conducted in Israel by a single research group. Specifically, all samples comprised Israeli (mostly Jewish) individuals. This is a primary limitation of the reported results, which impairs their external validity. To assess the role of self-assessed abilities in more general terms, it would be beneficial to conduct similar studies in different countries and societies, using a variety of individuals. The robust findings described in this review are replicable and should encourage further research in investigating the role of self-assessed lie-related abilities in countries other than Israel. Such replications are expected to support the present outcomes.

Another limitation is the evaluation procedure. All the described studies used a single question to define lie-telling and lie-detecting ability assessments. Such a procedure may preclude separate reliability tests for each study. It is advised to develop a questionnaire containing several items that represent the multiple aspects of each ability to continue this line of research. An earlier attempt in this direction was the PATD scale (Schneider & Goffin, 2012), a multiquestion questionnaire, that was developed to examine individual faking differences in preemployment testing. The PATD results offer some external support to the present outcomes. For example, PATD scores are negatively related to Agreeableness and unrelated to Conscientiousness.

CONCLUSIONS

The present review of studies is in line with the tendency to examine how biases influence social and interpersonal attitudes, thoughts, feelings, and behavior. Lie-telling and lie-detecting ability assessments influence a variety of features. However, caution is recommended when one tries to determine the direction of influence. For example, the link between personality dimensions and lie-telling assessments can be interpreted in both directions. Personality attributes influence the way people learn about their abilities to lie convincingly and at the same time accumulated feedback on lying experiences shape an individuals' personality. The task of future research is to help us resolve the direction of the link. It is vital to learn more about the influence of high lie-telling ability ratings on specific behaviors. For example, more attention should be given to guilty high lie-telling ability raters who seem more responsive than low raters to critical items in the CIT. In summary, research on self-assessed lie-telling and lie-detecting abilities is in its creation and additional research is necessary. I hope that the current review made its contribution in encouraging further research.

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CHAPTER 16

Detecting Concealed Information on a Large Scale: Possibilities and Problems

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In 2014, one of the main nuclear power stations in Belgium, "Doel 4," was sabotaged (DeClercq, 2014). Investigators quickly realized that the perpetrator must have opened a valve that caused overheating in one of the turbines. The search for the perpetrator was, therefore, narrowed down to those engineers, technicians, and workers that were present at the time of the incident. Forty employees who had been in the machine chamber at the time of the sabotage were suspected, denied access to the nuclear plant for months, and were asked to take a polygraph test. This request raised such indignation that the vast majority of the employees refused to take the polygraph test. To date, no arrests have been made nor has the case been solved. This is an example of a setting in which a larger number of examinees need to be assessed, and in which some of the standard methods of deception detection are limited.

With a few exceptions (e.g., Meijer, Bente, Ben-Shakhar, & Schumacher, 2013), deception research has largely targeted the detection of deception in individual cases. From an applied perspective, however, there is an increasing need to detect concealed information at a larger scale, be it security clearance of staff working with sensitive information, border security (Honts & Hartwig, 2014), insurance claims (e.g., Harvey, Vrij, Nahari, & Ludwig, 2017), terrorism prevention screening (see Kleinberg, Arntz, & Verschuere, 2017), or employee theft. In this chapter, we review the dominant methods of detecting concealed information as to their potential of being suitable for large-scale purposes. For the remainder of this chapter, we do not restrict concealed-information detection to a specific test (i.e., the guilty knowledge test or Concealed Information Test [CIT];

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Lykken, 1959; Verschuere, Ben-Shakhar, & Meijer, 2011) nor specific instances of concealed information.

The aim of this chapter is to outline and discuss the methods that facilitate large-scale deception detection. First, we provide an overview of those methods from a broad spectrum of deception detection that could be applied on a large scale. Each method will be outlined, evaluated, and discussed. We also propose a framework that might help to establish the potential of a deception detection method when applied to large groups. Specifically, we focus on (1) the theoretical foundations of the methods, (2) the possibility of using the method in quick procedures, and (3) the flexibility of the method for various contexts. For all criteria, we provide a brief evaluation of the feasibility within 5 years to avoid speculation about long-term technological developments. We conclude this chapter with an outlook on the future of large-scale deception detection.

METHODS FOR THE DETECTION OF CONCEALED INFORMATION

This section provides an outline of various methods that could be used to detect concealed information and discriminate between truthful and deceptive people. We start with an overview of methods that are already applied in large-scale settings, such as behavioral observation, and the analysis of paraverbal speech properties. Next, we describe approaches that are currently not yet implemented but could be applied in large-scale screening procedures within the next 5 years: thermal imaging, reaction time tests, and verbal methods. It should be noted that we have made a selection for this chapter and that several other methods to detecting deception exist but are not part of this chapter, for instance, because they are not suitable for large-scale applications. Among these methods are brain imaging (e.g., Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003; Ganis, Morris, & Kosslyn, 2009; Ganis, Rosenfeld, Meixner, Kievit, & Schendan, 2011), and electroencephalography (EEG) (e.g., Rosenfeld, Hu, Labkovsky, Meixner, & Winograd, 2013; Rosenfeld, Soskins, Bosh, & Ryan, 2004).

Screening Passengers by Observation Techniques

Outline

As a response to the 2001 terrorist attacks, the US Transportation Security Administration (TSA) started with the development of the "screening passengers by observation techniques" (SPOT) program. The outline presented here uses SPOT as one example from a family of related methods that use suspicious behavior as an indicator for deception. Although we focus on SPOT, the general assumptions and shortcomings apply to a range of suspicious-behavior detection methods.

SPOT is intended to identify passengers who may pose a threat to aviation security (Government Accountability Office, 2013) and was developed based on Paul Ekman's work on facial expressions and deception (Transportation Security Administration, 2009). SPOT assumes that someone displaying suspicious behavior is potentially hiding their real purpose at the airport (e.g., by posing as a passenger) or is flying for an illegal purpose (e.g., to carry out an attack at their destination airport). The development of that TSA program culminated in its United States-wide implementation in 2007, and the program was expanded over the following years (albeit under a different name, *Behavior Detection and Analysis Program*; Government Accountability Office, 2016). One of the core assumptions of SPOT is that security-threatening passengers will behave differently compared to ordinary travelers and display suspicious behavior. That behavior is claimed to result from experiencing emotional states such as stress or fear (see also Honts & Hartwig, 2014). Central to SPOT are so-called Behavior Detection Officers (BDOs): employees trained in identifying passengers that show behaviors allegedly indicative of deception (Government Accountability Office, 2015). BDOs initially observe people waiting in line at the airport to establish a general baseline and then assess the passengers' behavioral cues and appearance. They also engage in "walking the line," a process during which they initiate brief conversations with the waiting passengers to assess them for any suspicious behaviors (Department of Homeland Security, 2013).

In case a passenger does display suspicious behavior and exceeds a certain threshold indicated by SPOT, that person is referred for further screening.

This additional screening process includes a search of the passenger and his/her personal luggage, as well as an examination of identification and travel documents (Department of Homeland Security, 2013). For long, it remained unclear exactly which behaviors the SPOT method regarded as suspicious. Recently, however, a 2009-version of a SPOT Referral Report was published online by the news site *The Intercept* (Winter & Currier, 2015). That document revealed the behavioral cues enlisted by the program, including being pale, sweating, excessive eye blinking, trembling, and whistling during the screening process.[1]

Evaluation

Although the program is widely implemented—with over 3000 BDOs working in the aviation sector in 2013 (Department of Homeland Security, 2013)— there are significant concerns about the effectiveness and efficacy of SPOT. For instance, although BDOs referred over 200,000 passengers for a secondary screening between 2006 and 2009, less than 1% of these referrals led to an actual arrest, of which the majority was for reasons unrelated to terrorism (Weinberger, 2010). This points to a high number of false positives (here: larger than 99%). SPOT advocates would argue that false-positive test outcomes in an airport setting are less severe than those in criminal investigations because the adverse consequences are much smaller (i.e., referral for further questioning rather than a criminal conviction). Moreover, SPOT is used primarily as a screening method so that other deception detection methods such as information-gathering interviewing could be combined with it and applied at a later stage. However, the costs of false positives are high both from the individual passenger's perspective (e.g., missing a flight, being treated like a criminal) as well as from the airport's perspective (e.g., spending time and money for extensive security procedures on ordinary passengers). One could argue that a high false-positive rate (i.e., low specificity; identifying those who are regular passengers) would be outweighed by an exceptionally high sensitivity (i.e., identifying those who are in fact planning a malicious act). There are currently no reports of SPOT identifying terrorists. To the contrary, there are several known cases of terrorists traveling undetected through airports

[1] The TSA stated in 2015 that the protocol was about to be improved, which could mean that the published report is outdated (Transportation Security Administration, 2015). Nevertheless, the TSA also mentions that it continues to use behavioral cues to identify suspicious passengers. The cues outlined in the Intercept document (Winter & Currier, 2015) might therefore still provide the only publicly accessible insight into SPOT.

where the SPOT program was implemented (Government Accountability Office, 2010; Perry & Gilbey, 2011).

Although there are no peer-reviewed reports on the empirical evaluation of behavioral detection methods or its working mechanisms (for a published example of random classification accuracy of a suspicious-signs method, see Wijn, van der Kleij, Kallen, Stekkinger, & de Vries, 2017), the program has been rolled out across multiple countries. SPOT uses behavioral cues to detect deception, yet many of the cues have not been empirically evaluated, and others have typically shown no or weak associations with deception (e.g., Bond & DePaulo, 2006; Vrij, 2008). Behaviors such as avoiding eye contact, fidgeting, or fast eye blinking are all listed as being used as indices of deception, whereas metaanalytical research has shown these behaviors bear no relationship to deception (DePaulo et al., 2003). Another behavioral cue that is being regarded as a suspicious is nervousness. Although there are indeed indications that being nervous is related to deception (DePaulo et al., 2003), the relationship is weak at best, and it could be argued that, in an airport setting, displaying nervousness is rather common. Passengers may experience fear of flying, they may feel uncomfortable with the screening procedures, or they might rush to catch their flight. In other words, the already-weak relationship between nervousness and deception can be expected to be weakened further in airport settings leading mainly to false-positive outcomes.

Finally, there is the question of actual implementation. It is uncertain whether human evaluators can be expected to assess large numbers of passengers on a vast list of cues in a short time (i.e., while casually talking to them in the waiting queue), and to effectively integrate that information to reach a decision. To date, no studies have investigated whether and how BDOs use the cues put forward by the SPOT method. Although BDOs are expected to draw objective conclusions based on behavioral indicators, former security agents have asserted that many of their colleagues used subjective judgments and that the program was vulnerable to racial profiling (Schmidt & Lichtblau, 2012). In May 2016, both academics and government officials pointed out that the TSA has not been able to show convincing proof of the SPOT program and suggested that funding should be reduced. In a reaction, the TSA announced that it would take action to optimize the program by conducting operational tests starting September 2016 (Government Accountability Office, 2016). After obtaining documents from the TSA under the Freedom of Information Act, the American Civil Liberties Union concluded that the foundations of SPOT are "unscientific and unreliable" and that its validity is overstated in official government documents (American Civil Liberties Union, 2017).

Speech Analysis

Several tools try to detect deception by analyzing people's speech signal (e.g., the pitch and intensity). Within the field of forensic speech analysis, there are two dominant approaches: Computerized Voice Stress Analysis (CVSA) and Layered Voice Analysis (LVA). They share the underlying assumption that differences in voice signals of truthful-versus-deceptive statements are due to the different mental states of the truth tellers and liars who uttered them (Gamer, Rill, Vossel, & Gödert, 2006). Because the assumptions are the same and differences between the two versions marginal, this section will focus on Computerized Voice Stress Analysis.

Outline

The first generation of speech-analysis devices was developed in the 1970s under the name Computerized Voice Stress Analyzers (CVSAs, sometimes referred to as VSAs), or Psychological Stress Evaluators (PSEs). The companies that manufacture these tools state that, because of stress, people who are lying produce a different profile of tiny vibrations than truth tellers. Those vibrations, so-called microtremors, are produced by muscles in the throat or larynx (Horvath, 1982) and are inaudible to the human ear but would be detectable through specialist software. To be able to discriminate between truth tellers and liars, CVSA uses interviewing techniques that are based on a set of roughly 12 questions. Some of these questions function as a baseline measure for the level of stress experienced by an individual. They are in turn compared to responses to relevant questions that are related to the subject of interest, such as a crime (see Truth and Deception Technologies, 2009). In general, people are expected to answer each question with "yes" or "no."

Evaluation

Peer-reviewed studies systematically showed that CVSA lacks validity and does not exceed chance level in differentiating deceptive from truthful statements (e.g., Damphousse, Pointon, Upchurch, & Moore, 2007; Gamer et al., 2006; Hollien & Harnsberger, 2006). However, despite the lack of support, CVSA tools are widely used by several law enforcement agencies (see the website cited in Damphousse et al., 2007). The closest evidence to any effects of microtremors stems from a metaanalysis (DePaulo et al., 2003) that found that liars often sound tenser and have a higher pitch than truth-tellers. The reported effects were, however, small and not a direct test of the microtremors postulated by CVSA. Moreover, there is no theoretical justification for the specific assumption that microtremors differ in truthful and deceptive statements. Olaf Lippold, a British physiologist, who is said to have discovered microtremors in human muscles in the 1970s, is often mentioned in CVSA manuals. It is noteworthy, however, that Lippold and colleagues never investigated the effect of psychological stress on microtremors, nor is there any proof that the arm-muscle microtremors studied by Lippold can also be found in throat or larynx muscles (Eriksson & Lacerda, 2008; Shipp & Izdebski, 1981). Speech analysis seems not fit for larger applications.

Thermal Imaging

Outline

Thermal-imaging technology aims to detect deception by measuring facial temperature with thermal cameras (Pavlidis & Levine, 2002). Deceptive individuals will experience more stress and anxiety compared to innocent people. These emotional differences would, in turn, result in measurable physiological differences (in facial-heating pattern; see following section) that discriminate between truth tellers and liars (Pavlidis, Levine, & Baukol, 2000).

Deceptive individuals afraid of being caught would show an increased sympathetic nervous system activity, related to a "fight or flight" response. That increased activity results in a redistribution of blood in the human body (Pavlidis & Levine, 2002) visible especially in the periorbital regions of the face. To facilitate rapid eye movement, blood flow to this region will increase, in turn causing a rise in the temperature around the eyes (Pavlidis, Eberhardt, & Levine, 2002b). Other research has suggested that the activation of the sympathetic nervous system due to deception also increases nose temperature (Panasiti et al., 2016). With advanced thermal cameras, it is possible to detect these alterations in blood flow, providing possible cues for deception.

It has been suggested that thermal imaging could serve as a tool in security screening processes in public settings such as airports (e.g., originally in Pavlidis, Eberhardt, & Levine, 2002a; Pavlidis et al., 2002b), although these initial claims were later relativized in an erratum (Pavlidis et al., 2002a).

It is proposed that thermal-imaging cameras could be installed at strategic checkpoints in the airport. Checkpoint agents, who already engage in asking travel-related questions to passengers, could then also measure whether passengers show an increase in temperature in the relevant facial areas (combined possibly with remote heart-rate measures) after being asked about their trip. This information could be used as additional data for deciding whether a passenger should be considered suspicious or not (Pavlidis & Levine, 2002).

Evaluation

A small set of studies have reported thermal imaging to successfully distinguish truthful from deceptive subjects (e.g., Panasiti et al., 2016; Park, Suk, Hwang, & Lee, 2013; Pavlidis et al., 2002b; Rajoub & Zwiggelaar, 2014; Warmelink et al., 2011). It should be noted, however, that thermal imaging did not always outperform human interviewers and that it is, therefore, not clear what the added value of that method is (Warmelink et al., 2011). In one study participants were asked to either conduct a mock crime (stealing a wallet from a lab) or an innocent act (sending an email from a lab; Park et al., 2013). After carrying out their activity, participants were interviewed about whether they had committed the crime, using a Concealed Information Test protocol in which expected knowledge concerning the mock crime was tested. While answering the questions, the participants' faces were analyzed with thermal cameras. The authors report an overall accuracy rate of over 90%.

There are, however, certain aspects of thermal imaging that merit attention. Most importantly, the assumption that an alteration in blood flow is the result of deception is controversial. For example, it is possible that innocent airport passengers will also show an increase in blood flow when being interviewed by security officers because of heightened arousal unrelated to deception (see SPOT). People could be worried about missing their flight, might feel anxious about the upcoming flight, or might find the conversation with a security officer stressful (Warmelink et al., 2011). Furthermore, the accuracy rates might have been influenced by the use of validated interviewing approaches (i.e., the Concealed Information Test, Park et al., 2013) and by increasing the cognitive load in participants (Rajoub & Zwiggelaar, 2014). The apparent successful truth—lie discrimination might, therefore, not be attributable to the ability to pick up stress during deception through thermal imaging. Rather, the results might be due to the use of methods that tap into cognitive differences between lying and truth telling. Moreover, physiological variables like skin-surface temperature are affected by individual characteristics other than deception, such as illness, body metabolism, and facial expressions (Khan, Ingleby, & Ward, 2006; Rajoub & Zwiggelaar, 2014). Environmental factors like the temperature and humidity level of a room also affect thermal measurements (Park et al., 2013). These noise factors might deteriorate the measurements in settings like an airport where passengers might experience stress in a rather unique environment. Most thermal-imaging studies indeed took place in highly controlled lab settings (e.g., Park et al., 2013; Pavlidis et al., 2000; Rajoub & Zwiggelaar, 2014; Warmelink et al., 2011), and it remains an open question whether the effects are stable in less controlled (e.g., the airport) settings.

Reaction Times

Outline

Since the early 2000s, there has been an increased interest in reaction time (RT)-based deception detection (for reviews see Verschuere, Suchotzki, & Debey, 2014; Suchotzki, Verschuere, Van Bockstaele, Ben-Shakhar, & Crombez, 2017). There are several RT-based deception paradigms (e.g., CIT, autobiographical Implicit Association Test [aIAT], Sheffield Lie Test), which have in common that RTs can shed light on the differences in information processing involved in lying versus truth-telling. These paradigms assume that (1) the truth is the dominant, automatic response and increases the speed of responding to stimuli; and/or that (2) lying puts greater demands on cognitive abilities than truth telling which consequently delays the speed of responding. We focus our discussion on the two paradigms that may be readily applied for deception detection at the individual level: the aIAT and the RT-based CIT.

The aIAT assesses which of two conflicting statements is true, by evaluating their association with true and false propositions. Imagine that a refugee asked about activities in his country of origin, Syria, tells the interviewer that he assisted a volunteer organization called White Helmets. The investigator, however, has reason to doubt that statement and suspects that the refugee was, in fact, selling oil to support ISIS. In that situation, an aIAT could be used to contrast "I assisted the White Helmets" with "I sold oil for ISIS." In an aIAT, the participant pairs statements that are autobiographical (e.g., "I sold oil for ISIS") with objectively true and false statements (e.g., "I am in front of a computer," "I am hiking in the mountains"). Each statement appears one by one on a computer screen and the participant determines its label by pushing one of two buttons on a keyboard. The general assumption of the aIAT is that the examinee will be faster in associating the true statement with the label *true*, and the false statement with the label *false*. For example, faster associations (i.e., shorter response latencies) for "I assisted the White Helmets" with true (and "I sold oil for ISIS" with false) than "I sold oil for ISIS" with true (and "I assisted the White Helmets" with false) would corroborate the refugee's story (see also Chapters 10 and 11). If the refugee was faster in associating "I sold oil for ISIS" with true and "I assisted the White Helmets" with false, this would contradict the subject's original account and might be incriminating.

The RT-CIT (here simply: CIT), in contrast to the aIAT, assesses recognition of critical pieces of information and can be used as a deception-detection method if knowledge of the critical information is unique to the criminal who committed a crime. Think back to the sabotage at the Belgian nuclear plant. Many employees have knowledge of the site, but to the extent that investigators kept the information private, only the culprit would know the specifics of the sabotage (e.g., the exact series of actions that led to the overheating). Those actions could be the critical informational items for a CIT. Similarly, whereas investigators will typically ask the refugee about intimate knowledge of the White Helmets that real volunteers are likely to have (Veldhuizen, Horselenberg, Landström, Granhag, & Koppen, 2017), a CIT would ask about intimate knowledge an ISIS oil seller would have (e.g., who are the buyers of the oil; the current oil price). In a CIT, one embeds critical information within a series of plausible (yet noncritical) alternatives. For instance, "You told me you do not know what price ISIS has been selling oil in the last 3 months of your stay in Syria. I will ask you whether it was 15, 20, 30, 35, or 40 USD a barrel." Denying any knowledge, the refugee is expected to answer NO to all answer options. A slower response on the correct answer as compared to the alternative answers is taken as an indication of recognition. The CIT is built on the premise that only the examinee with intimate knowledge will recognize the correct answer. Although the underlying cognitive processes leading to the RT slowing remain to be fully explored, a likely candidate explanation is response inhibition (see Suchotzki, Verschuere, Peth, Crombez, & Gamer, 2015; Verschuere & De Houwer, 2011). Specifically, it is assumed that, only in those with intimate knowledge, the response tendency elicited by the correct answer (YES) conflicts with the response denying involvement (NO).

Evaluation

A recently published metaanalysis (Suchotzki et al., 2017) suggests that RTs may be a useful means to assess deception. Across contexts and paradigms, RT-based deception-detection tests had a large standardized-effect size (Cohen's $d = 1.05$), although a subsequent, smaller meta-analysis in the same paper showed that both the CIT and the aIAT seemed susceptible to countermeasures.

The aIAT has further been reviewed by its developers who conclude that classification accuracies (i.e., truth tellers and liars identified as such) range above 90% (Agosta & Sartori, 2013), making it a tool suitable for the detection of deception at the individual level (see also (Hu & Rosenfeld, 2012). Some of the results of the aIAT have been independently replicated, although typically with more modest accuracy (e.g., 81% accuracy; Verschuere & Kleinberg, 2017, 67%−86% in guilty and 61% in innocent participants, Verschuere, Prati, & Houwer, 2009; see also Hu, Rosenfeld, & Bodenhausen, 2012).

The CIT has since its inception (Seymour, Seifert, Shafto, & Mosmann, 2000; for a review, see Verschuere et al., 2011) been applied in different contexts and the response latency difference between critical and noncritical stimuli has been found in numerous studies (Seymour et al., 2000; Suchotzki et al., 2017). Using an espionage scenario, Seymour et al. (2000) found support for the use of reaction times as cue for the detection of concealed information. Noordraven and Verschuere (2013) found the CIT capable of identifying the planning of a mock crime with an area under the curve (AUC) of 0.87. The AUC expresses the diagnostic efficiency of a criterion (e.g., the RT difference) and ranges from 0.5 (random classification) to 1.00 (perfect classification). In contrast to accuracy rates, the AUC is an indication of the diagnostic power of a criterion across all observed cutoff points (i.e., it also becomes larger if very high, or very low values are observed for participants belonging to the respective class, e.g., truthful and deceptive). AUCs offer a more comparable metric across methods and approaches (National Research Council, 2003).

The reaction time-based CIT paradigm has also been applied to fake identity settings and applied as such in online environments. For example, participants in Verschuere and Kleinberg (2016) concealed salient details of their identity (e.g., their first name). Using known moderators of the CIT effect (i.e., using multiple highly salient pieces of information increases accuracy), a state-of-the-art CIT showed an AUC of 0.98 with an accuracy of 86%.

Notwithstanding the promising rationale and findings, RT-based deception detection is facing specific challenges. For the CIT, potential leakage of critical information is a major limitation. If the critical information is accessible to more people than just the true perpetrator, the recognition indicated by the test is not unique to the perpetrator, and hence the conclusions become invalid. Further, both the CIT and the aIAT have been shown susceptible to countermeasures (i.e., faking the test, see Suchotzki et al., 2017; Verschuere et al., 2009). Finally, the associations captured by the aIAT might come about through processes other than deception: the association of false sentence with an ISIS-related proposition might be due to the shared negative connotation of both propositions (i.e., they are both perceived as highly negative and therefore rapidly paired; see Rothermund & Wentura, 2004; Verschuere et al., 2014).

Verbal Content

Outline

The verbal approach to deception is based on the assumption that the content of a truthful statement differs from that of a deceptive statement (e.g., Johnson & Raye, 1981; Köhnken, 2004). Reality Monitoring, for instance, suggests that truthful stories are told differently because they have been stored in the memory through perceptual processes (e.g., smelling, seeing, hearing). Deceptive stories, on the other hand, have never been truly experienced, and are obtained through internal, fabricated cognitive processes (Johnson & Raye, 1981). A meta-analysis supports the usefulness of Reality Monitoring for deception detection (e.g., truthful stories contained more visual, auditory, and temporal detail compared to deceptive ones; Masip, Sporer, Garrido, & Herrero, 2005).

As with most deception cues, the association of verbal content differences and deception is weak (DePaulo et al., 2003). Therefore, it has been recommended to focus on techniques that increase these verbal differences (Vrij, Granhag, & Porter, 2010; for further developments like the Verifiability Approach, see Nahari, Vrij, & Fisher, 2014). A series of methods to enhance truth—lie differences have been proposed (e.g., telling a story in reverse order, maintaining eye contact during the interview, drawings; see Vrij, Fisher, & Blank, 2015). The model statement (i.e., providing a detailed example answer) and the unexpected question technique (i.e., asking questions that the suspects do not anticipate, e.g., about the physical layout of a restaurant) seem most readily applicable. Statements from truth tellers are richer in detail, but they do not always know how much information they need to include in their stories. In the model statement technique, people are, therefore, asked to read a detailed example statement, so that they know how much information they need to mention (Vrij et al., 2015). This is particularly beneficial to truth tellers because their detailed statements could prove that they are telling the truth. For deceptive persons, however, including more information could lead to cues that reveal their lies. Another technique that is widely used in the verbal approach is asking unanticipated questions. Liars often prepare their story, which makes it easier for them to appear truthful. If, however, an interviewer asks unexpected questions, liars have to fabricate a plausible answer on the spot, thereby enlarging the opportunity of being caught (Vrij, Granhag, Mann, & Leal, 2011).

Contemporary verbal approaches emphasize the need to ask questions that actively elicit verbal differences between truth tellers and liars. Interviewers are encouraged to use an information-gathering interviewing style, rather than using accusatorial questioning techniques (Vrij et al., 2010). By applying cognitive interviewing techniques such as asking open-ended questions and building rapport, it is likely that both truth tellers and liars will provide more information when being interviewed. Truth-tellers' providing extra information could lead to cues that prove that their story is genuine (e.g., the person they claim to have an appointment with can be verified). Liars, on the other hand, could risk mentioning information that suggests that they are deceptive (e.g., contradicting information, Vrij et al., 2015).

Evaluation

There are indications that the verbal approach to deception detection could be useful in security settings. Research from the past few years suggested that the verbal approach is also promising when discriminating between genuine and deceptive intentions. For instance, deceptive accounts of false intentions were found to contain fewer details compared to stories of true intentions when unexpected questions are asked (e.g., Sooniste, Granhag, Knieps, & Vrij, 2013; Warmelink, Vrij, Mann, & Granhag, 2013; but see Fenn, McGuire, Langben, & Blandón-Gitlin, 2015). Liars also appeared less plausible and more contradictory in their statement compared to truth tellers (e.g., Vrij et al., 2011). Despite the promising theoretical rationale behind the verbal approach to detection, it must be noted that the effect sizes are small and that the reported high-accuracy rates are often found in discriminant analysis and are not cross-validated.

The verbal approach to deception detection is promising due to its simplicity and reliance on rather easily gathered data (i.e., spoken or written statements). Nevertheless, it is yet an unsettled issue how this method can address so-called embedded lies (i.e., in which the lie is just a small part of a largely truthful account), practiced lies (i.e., in which the liar is used to telling a detailed and plausible, false account), and complicated truths (i.e., in which the truth is more complex, vaguer, or less plausible than the lie).

POSSIBILITIES FOR LARGE-SCALE APPLICATIONS

Criteria for Large-Scale Applicability

The previous section outlined various deception-detection methods and evaluated their theoretical background, whereas this part focuses on the large-scale potential. To examine how fit various deception detection methods are for the application at scale, we assess those methods that were evaluated as theoretically sound, valid, or at least promising in their application (thermal imaging, reaction times, and verbal content (Table 16.1)) on two requirements. The large-scale fitness and suitability are defined through (1) the possibility of using the method in quick procedures (quick data collection), and (2) the flexibility of applying the method in various contexts and scenarios (flexibility).

Quick data collection is essential for any method applied to larger numbers of people because of the sheer fact that much more than single individuals are subjected to a test poses logistical challenges. For example, a method that requires extended interaction with participants or relies heavily on large apparatuses is less suitable than a simple online method. The flexibility criterion pertains to the ability of a method to be used in different contexts (e.g., airport passenger screening, criminal investigations) and scenarios (e.g., false identity allegations, burglaries, threat assessment). Although one could argue that every application inherently defines a specific context for a deception detection method (e.g., a threat assessment method at the airport), the aim of this section is to evaluate the different methods independent of a specific, well-defined application context.

Thermal Imaging

One potential advantage of using thermal-imaging techniques is that it is noninvasive and—privacy and ethical issues aside—that it does not require cooperation from passengers (Rajoub & Zwiggelaar, 2014). For instance,

Table 16.1 Summary of large-scale criteria per deception-detection method

	Quick data collection	Flexibility	Theoretical foundation
Thermal imaging	Promising if combined with proper interviewing techniques; challenge lies in the equipment needed and an automated analytical pipeline.	Difficult in stress-inducing contexts (e.g., airports); equipment needed is static (e.g., Infrared [IR] sensors installed at specific locations).	Largely determined by the interviewing paradigm.
Reaction times	Promising but still relies on a large number of trials.	Poor. Needs fine-tuned stimulus selection and careful consideration on a case-by-case basis.	Rooted in cognitive psychology.
Verbal content	Currently not fit for large-scale purposes; still relies on face-to-face interviews and/ or long texts.	Promising; needs little baselining or calibration.	Theoretically embedded in theories such as Reality Monitoring.

conducting thermal-imaging measurements does not require any interaction (e.g., attaching sensors) with passengers (Arora et al., 2008). Because the thermal cameras largely resemble normal cameras used in an airport, it is possible to scrutinize passengers without their awareness, which might also offer a strategy to prevent passengers' countermeasures (Park et al., 2013). Furthermore, data collection and analysis could be fully automated, an important aspect of the implementation of screening tools in large-scale settings, although developing these automated systems would still prove a challenge.

Although the measurement of thermal changes in the facial regions can in principle be done unobtrusively, it is important to realize that current thermal-imaging deception detection requires participants to hold still (to assess the temperature in certain facial regions) and it relies on interviewing techniques to assess changes in facial temperature while answering questions. Accompanied by the thermal measurements are questions aimed at identifying deceptive passengers before the thermal method would be of any use. The results from the abovementioned study of Park et al. (2013) suggest that CIT techniques (questioning people about critical information specific to the crime scenario under investigation) could be helpful in discriminating between truth tellers and liars. However, security agents at border settings do not possess the necessary critical crime information. Interviewing techniques based on verbal and cognitive principles (e.g., asking questions in reverse order) might be useful as a supplement to thermal imaging techniques. Regarding the first criterion of quick data collection, thermal-imaging techniques seem promising once interviewing techniques and the analytical process are automated.

The second criterion of flexibility proves trickier for thermal imaging. As already mentioned in the evaluation of the method, it could be argued that areas such as airports are not a proper location for the use of thermal imaging. People at the airport can become easily aroused because of innocent stress regarding their flight, and environmental factors could influence the measurements. It remains questionable whether this technique will apply to large-scale security settings.

Reaction Times

The minimal requirements needed to administer RT-based tests makes them attractive for large-scale purposes. The first adaptations of the aIAT (e.g., Greenwald, McGhee, & Schwartz, 1998) and RT-CIT (e.g., Seymour et al., 2000) were conducted with specialist laboratory software for the accurate timing of stimuli presentations and the precise recording of response latencies. However, recent developments showed that RT tests can be administered reliably and validly online (e.g., Kleinberg & Verschuere, 2015, 2016; Lukács, Kleinberg, & Verschuere, 2017; Verschuere & Kleinberg, 2016, 2017). For example, results of lab studies were replicated with considerably larger sample sizes in a fraction of the time of lab studies, whereas participants merely needed a computer with an Internet connection and a standard web browser (e.g., Kleinberg & Verschuere, 2015). The online replications do depend on the context of deception and seem particularly promising for autobiographical settings (e.g., lying about one's identity), so future investigations will need to show that other settings (e.g., mock crimes) can be replicated online as well. Nevertheless, with rapid technology improvement of web browsers, the difference between lab software and online tool will likely begin to vanish (for a discussion, see van Steenbergen & Bocanegra's, 2016, response to Plant, 2016).

Limitations concerning the applicability of the aIAT and CIT stem from a methodological and an implementation point of view. On a methodological level, the RT-based tests require a minimum duration to derive at participant-level predictions. That is, the length of the tests cannot be shortened drastically because one must instruct the participant, provide some practice with the task, and provide sufficient trials to account for errors, missed trials, and different blocks (aIAT) and stimuli presentation proportions (CIT). Likewise, findings from online studies suggest that populations not used to such fast-paced reaction-time tasks require a detailed introduction procedure to the test. Such a time frame can be considered realistic for some applications (e.g., criminal investigations) but may be too long for others (e.g., large-scale screening at airports). Even a short test will probably take about 10 min. From an implementation perspective, the RT-based tests—even if the length problem could be solved—are likely to be perceived as rather unnatural, for example, by passengers on an airport, and cannot be administered unobtrusively. An additional challenge for possible remote testing settings (e.g., testing participants online) is the verification of the test taker's identity[2]—although this limitation is not unique to RT tests but an impediment for all remote testing settings.

[2] It might be feasible to address the identity verification with a CIT itself (Verschuere & Kleinberg, 2016).

The quick data collection criterion discussed earlier is connected to the flexibility criterion. A key prerequisite for the both the CIT and aIAT is a fine-tuned stimulus selection. For the CIT, it takes information about the criminal context (i.e., which are the critical items) as well as a selection of plausible yet unrelated alternatives (i.e., what are the noncritical, matched items). Similarly, it is essential for the aIAT that the associations indicated by the RT differences are a result of deception and not an irrelevant cognitive process such as preference or similarity. For example, "I am in prison" (=the true/false category) and "I have stolen the money" (=the autobiographical category) both share a negative connotation and are not necessarily only associated by truthfulness or deception. If the stimulus selection problem were solved, both tests would be quicker (because the preparation time before the actual test is drastically reduced). With quicker administration procedures, the tests become more flexible because the context (and hence the stimulus selection) is adaptable. To date, the formulation of good test items for the CIT and aIAT are the key impediment for large-scale applications. In the future, this problem could be addressed with advanced statistical modeling and item calibration (e.g., empirically determining the truthful response profile of an exhaustive set of stimuli—e.g., months of birth—and testing how much truthful and deceptive participants deviate from that profile).

Although a large-scale implementation of these tests has not yet been done, RT-based deception detection seems a candidate worth trying on a large scale. Contrary to other deception detection methods, the RT-based tests are among the few that fulfill the requirement of being applicable with relatively minimal equipment and are still considerably quicker for participants than physiological and brain-based methods.

Verbal Content

When looking at the first criterion, quick data collection, the verbal content analysis seems challenging at first glance. Many studies on verbal deception detection rely on personal face-to-face interviews that are manually coded afterward (i.e., oral statements are being transcribed, read by one or more independent coders, and finally scored on variables such as plausibility or richness of detail; see Nahari, 2016). Despite promising results, in its current state, the verbal content method excludes the possibility of real-time data collection, an essential criterion for quick data collection.

Can the verbal approach be used for large-scale purposes? For that to be the case, two key requirements should be met. First, the interviewing procedures (i.e., the collection of data) must become quicker—either through shorter interviews or through online procedures (e.g., providing a statement online before arriving at a security checkpoint). Second, the analysis of provided statements (i.e., the data analysis) must transition toward fast and scalable procedures. The latter could be achieved with methods that allow quick real-time interviewer judgments or through computer-automated analyses. A recent study shows there may be a possibility of short interviews and on-the-spot assessments (Ormerod & Dando, 2015). This extensive in vivo randomized-controlled trial on several international airports tested whether participants would pass security with fake identity papers. After a few days of preparation, the mock passengers went to the airport and tried to pass security screening without being exposed as a liar by security agents. The critical test was whether security personnel trained in two different methods would be able to detect the mock passengers. Using cognitive questioning techniques and paying close attention to the verbal accounts of passengers (termed the Controlled Cognitive Engagement [CCE] method), it turned out that security agents were able to correctly identify more mock passengers (66% of all mock passengers) compared to agents using a behavioral, suspicious-signs method (3%). Agents focusing on verbal content also interviewed their passengers more quickly than did the behavior-detection agents, implying that the verbal method might even be more time effective than methods presently used in security screening. Considering the criterion of quick data analysis (circa 3 min), CCE sounds promising. Furthermore, developments in Natural Language Processing approaches to deception detection might be a promising way to substitute or approximate parts of the manual coding by fully automated scoring (Bond & Lee, 2005; Ott, Cardie, & Hancock, 2013; Ott, Choi, Cardie, & Hancock, 2011). Regarding the flexibility criterion, there is little reason to assume that other deception contexts (e.g., mock crime, malicious intent) would impede CCE-like methods. The original study must be replicated and extended to diverse contexts to reach a verdict on the flexibility. It also remains an open question how exactly the CCE-trained security agents derive their subjective judgment and which verbal or behavioral cues they pay attention to.

OUTLOOK ON THE FUTURE: WHAT NEEDS TO BE DONE?

To bridge the gap between existing deception detection methods and large-scale applications we identify two requirements for research in the next few years: cross-disciplinary collaboration and rigorous research transparency. First, a shift toward large-scale methods will imply that individual researchers need to form interdisciplinary teams. It will be imperative to overcome islands of expertise that are focused on either a method (e.g., verbal content analysis) or technique (e.g., automated analysis). For example, although the psycho-legal deception research community is paramount for theoretical frameworks underlying deception-detection methods and the provision of theoretically founded deception cues (e.g., the plausibility of statements), their resources for developing large-scale methods are limited. Computational disciplines (e.g., computational linguistics) can add to the integration of cues (e.g., dozens of content-based cues) and methods (e.g., verbal content and thermal imaging), the automation of cues (e.g., automating the scoring of a statement's plausibility), and the development of predictive models (e.g., through [un] supervised machine-learning tasks). An illustration of multimodal approaches—contrary to isolated, discipline-specific efforts (e.g., Psychology, Computational Linguistics, Neuroscience)— is shown in Box 16.1.

Box 16.1 Illustration of multimodal deception methods

Combining Methods: Multimodal Deception Detection

One key feature of the methods discussed earlier in this chapter is that they are unimodal; that is, they assume a relationship between the mental state of deception and one specific outcome measure (e.g., reaction time differences, verbal content differences). There are indications that deception detection might benefit from combining multiple cues (Hartwig & Bond, 2014).

For example, Pérez-Rosas et al. (2015) used verbal and nonverbal (i.e., facial displays and hand gestures) variables to classify cases as deceptive or truthful. They found that machine-learning classifiers based on a combined set of predictors (verbal + nonverbal, 77.11%) were more accurate than verbal (accuracy: 65.25%) or nonverbal (75.42%) predictors alone. Further evidence of multimodal approaches comes from Hu and Rosenfeld (2012), who combined EEG and reaction-time measurements and achieved an AUC of 0.98 (compared to 0.84 and 0.95 for reaction times and EEG alone, respectively). Furthermore, Abouelenien, Pérez-Rosas, Mihalcea, & Burzo, 2014) examined physiological variables (e.g., heart rate, skin conductance), linguistic variables (unigrams and psycholinguistic variables), and thermal variables. The latter resulted in heat

Box 16.1 Illustration of multimodal deception methods—cont'd

maps of the facial area of participants during their deceptive and truthful statements. The combination of linguistic and thermal predictor variables resulted in significant accuracy increases compared to unimodal classifications.

Although these results hint at the benefits of multimodal classifiers over unimodal ones, it remains an open question how much better the accuracy of the former needs to be to justify additional data collection for a new modality.

The work on multimodal methods is relatively young but has yielded promising results. As Abouelenien et al. (2014) have shown, accuracies above 70% can be obtained without any involvement of human annotators. The key challenge for such methods is the time needed to gather reliable physiological, linguistic, and thermal data. On a large scale, time is a premium (see Honts & Hartwig, 2014; Kleinberg et al., 2017) and a short procedure is one of the key requirements. At the same time, a multimodal approach brings about new challenges, including the handling of false positives that come with each method and the generalizability of machine-learning models to various contexts.

Second, for deception research applications on a large scale, we believe it is necessary that the disciplines involved embrace the open science philosophy of sharing data and methods. Be it from the point of view that future large-scale applications are inevitably intertwined with computational methods (e.g., machine learning), or from the perspective that open data will allow metaanalytical research on raw data, the necessity, relevance, and usefulness of deception research will depend on the sharing of data. With the logistic efforts of data sharing minimized (see the Open Science Framework's data repository, www.osf.io), it will be paramount for the future generations of researchers equipped with ever more sophisticated tools, to be able to rely on, learn from, and make use of existing data. Consider, as an illustration, the example of Ott et al.'s (2013, 2011) studies on fake and genuine hotel reviews. Ott et al. compiled a corpus of 1600 hotel reviews and made it publicly accessible to everyone. Their data set resulted in novel methodologies (Feng & Hirst, 2013) and insights (Fornaciari & Poesio, 2014) into verbal deception detection that would otherwise have been slowed down by individual efforts of collecting identical or similar data. The efforts made by the original researchers as well as the contributions by other research groups should be encouraged and should pave the way for a better, open approach toward deception detection.

CONCLUSION

In this chapter, we discussed a selection of deception detection methods concerning their potential of being applied on a large scale. Although some methods are easily usable on a large scale (e.g., behavioral observation, speech analysis) they lack theoretical underpinnings, empirical validation, or both. Other methods are well founded in theory and validated (e.g., RT-based tests, verbal content tools) but have yet to take final steps to be useful for applications at scale. Although each method has advantages and shortcomings, likely candidates for applications at scale are reaction time-based methods as well as verbal content analysis. The future of deception-detection systems suitable for scenarios in which scores of people are investigated might lie in intelligent methodological integration (e.g., multimodal methods, computational methods with theoretically founded cues) as well as cross-disciplinary collaboration. An important step in that direction can be made through the sharing of data and tools.

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CHAPTER 17

Admissibility and Constitutional Issues of the Concealed Information Test in American Courts: An Update*

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INTRODUCTION

The use of physiological tools to detect intentionally concealed knowledge about crime-related information has been a controversial and well-researched topic among scholars for well over 100 years. While essentially all the research in the first half of the 20th century focused on detecting *lies* about concealed knowledge, a substantial body of research related to the detection of *recognition* of concealed knowledge has also developed, beginning with David Lykken's seminal work in the 1950s (Lykken, 1959). While that body of work began exclusively by measuring autonomic nervous system (ANS) data using the polygraph, it has now been expanded to a variety of other measures, including reaction times and, perhaps most notably, physiology directly linked to brain activity in the form of event-related potentials (ERPs) or the hemodynamic response as measured via functional magnetic resonance imaging (fMRI).

Tests related to detecting intentionally concealed knowledge have a long history with the American legal system as well, though mostly related to lie detection rather than recognition detection. The seminal case outlining the dominant standard for the admissibility of scientific expert testimony for 70 years, *United States v. Frye* (1923), involved a challenge to the admissibility of the systolic blood pressure deception test, an early precursor to the ANS-based comparison question test (CQT). That case also started a

* The views expressed in this chapter are those of the author and do not necessarily represent the positions of the Department of Justice or the United States.

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trend that has endured to the present: skepticism in the legal community as to the use of credibility-assessment tools in court. Indeed, the *Frye* court held that the results of the systolic blood pressure deception test could not be introduced because the test had not yet gained sufficient "standing and scientific recognition among physiological and psychological authorities" (United States v. Frye, 1923, p. 1014). Since then, nearly every major decision to consider a tool potentially falling under the label of deception detection—a label that is dubious in the case of the Concealed Information Test (CIT), as I will discuss next—has rejected that evidence.

In this chapter, I explain the governing legal standards that will determine the potential use of the CIT in court. Those standards come from two distinct sources: (1) the Federal Rules of Evidence (and the cases interpreting those rules), which limit the admissibility of evidence in certain circumstances, and (2) the US Constitution (and the cases interpreting it), which limits the use of evidence obtained in violation of certain individual rights—most notably, for our purposes, the privilege against self-incrimination. I focus primarily on the first category of standards, as the literature is better developed and more accurate predictions can be made as to the current challenges and ways those challenges could be overcome. I briefly discuss the second category, though the way in which courts will conduct that analysis remains largely unknown.

Though these issues may seem esoteric to nonlawyer scholars involved in CIT research, I argue that they should drive the research agenda of every CIT researcher interested in the practical use of their work, at least in the United States. There are serious hurdles that the CIT faces limiting its potential use in American courts, but targeted empirical research can address at least some of the problems.

POTENTIAL ADMISSIBILITY OF THE CONCEALED INFORMATION TEST

Credibility Assessment Tests and the American Legal System

As a general matter, testimony in the American legal system is separated into two categories: lay witness testimony and expert witness testimony. Lay witnesses are those individuals who have firsthand, personal knowledge about matters relevant to the case. For example, a person who witnessed events related to the commission of a crime would be a lay witness who could testify about what her or she saw or heard. As a general matter, lay witnesses are limited in the extent to which they can testify in the form of an opinion; they must testify only to what they actually saw or heard, and may provide opinions only based on those firsthand perceptions, and not based on any specialized knowledge or expertise they may have (Federal Rule of Evidence 701, 2000).

In contrast, expert witnesses who are sufficiently qualified by specialized knowledge, training, or other expertise are permitted to testify in the form of an opinion, provided that certain circumstances are met. Did the car's poorly maintained breaks give out at the time of the accident, contributing to the collision? Did the DNA sample found at the scene of the crime match the defendant's DNA? Expert witnesses are permitted to opine on such questions based on their specialized knowledge. As you can imagine, such testimony is often at the heart of critical issues in the case, and can be very powerful in influencing the judge or jury tasked with weighing the evidence. Accordingly, the American legal system has long had checks in place to help ensure that only sufficiently valid and reliable opinions are presented.

For most of the 20th century, the dominant test for assessing whether proposed expert testimony is sufficiently valid and reliable was derived from *Frye v. United States* (1923). In that case, the defendant—on trial for second-degree murder—had sought to offer an expert to testify about the results of a systolic blood pressure deception test that he had administered to the defendant and that had presumably indicated that the defendant was being truthful in denying his involvement in the crime. That particular test appears to have been a precursor to the modern CQT. As the court described the systolic blood pressure test,

> *it is asserted that blood pressure is influenced by change in the emotions of the witness, and that the systolic blood pressure rises are brought about by nervous impulses sent to the sympathetic branch of the autonomic nervous system. Scientific experiments, it is claimed, have demonstrated that fear, rage, and pain always produce a rise of systolic blood pressure, and that conscious deception or falsehood, concealment of facts, or guilt of crime, accompanied by fear of detection when the person is under examination, raises the systolic blood pressure in a curve, which corresponds exactly to the struggle going on in the subject's mind, between fear and attempted control of that fear, as the examination touches the vital points in respect of which he is attempting to deceive the examiner (p. 1013).*

The trial court rejected the expert, and the defendant was convicted. The court of appeals agreed with the trial court's decision to reject the evidence. It explained that it is the court's role to determine whether the scientific principle at issue had "crosse[d] the line between the experimental and demonstrable stages." In order to make this determination, the *Frye* court instructed that courts must decide whether the scientific method or principle at issue is "sufficiently established to have gained general acceptance in the particular field in which it belongs." Applying that standard to the systolic blood pressure deception test, the court found that the test "ha [d] not yet gained such standing and scientific recognition among physiological and psychological authorities," and accordingly determined that the trial court had made the correct decision in rejecting it.

Following *Frye*, nearly all courts adopted some form of what has come to be known as the general acceptance test, determining whether a proposed expert's method is "sufficiently established to have gained general acceptance in the particular field in which it belongs." That standard persisted until at least 1975, when the Federal Rules of Evidence were adopted. The Federal Rules of Evidence sought to codify evidentiary rules that had long been established through cases, and provide a uniform and easy-to-understand set of rules for use in federal courts. Federal Rule of Evidence 702 (which currently governs the admissibility of expert testimony in all federal and most state courts) provided at the time a very broad standard, stating that, where helpful to the body weighing the evidence, a witness qualified as an expert by sufficient skill or expertise is permitted to testify in the form of an opinion (Federal Rule of Evidence 702, 1975). The rule made no mention of the *Frye* general acceptance test, and for some time there was a question as to whether Federal Rule 702 had replaced the *Frye* test, and, if so, how the new test was to be applied.

That question was answered in 1993, when the US Supreme Court decided *Daubert v. Merrell Dow Pharmaceuticals, Inc.* That case involved a claim that the ingestion of a particular antinausea drug marketed by the defendant had caused birth defects in the children of mothers who had taken the drug during their pregnancies. Both sides offered experts supporting their claims as to whether the drug could have caused such defects, but the trial court rejected the plaintiffs' experts on the basis that their studies were based on methods that had not been generally accepted in the relevant scientific field.

On appeal, the Supreme Court explained that Federal Rule 702 made no mention of any general acceptance test, nor were the rules designed to embrace any such standard, and accordingly, the rules displaced the *Frye* test entirely. The Court then went on to explain that Rule 702's discussion of scientific evidence meant that it included a requirement that the method at issue meet a certain standard of evidentiary reliability, a somewhat murky term that the court noted is akin to trustworthiness, or what scientists would typically call validity (Daubert v. Merrell Dow Pharmaceuticals, 1993). How is a court to determine whether such evidentiary reliability is present in a method? The court largely left this question to the discretion of trial judges, though it outlined four now-famous factors for courts to apply:

- "[W]hether [the theory or technique] can be (and has been) tested,"
- "[W]hether the theory or technique has been subjected to peer review and publication,"
- "[T]he known or potential rate of error" and "the existence and maintenance of standards controlling the technique's operation,"
- The "general acceptance" of the technique, as outlined in *Frye*.[1]

Though the Court was careful to note that these factors are nonexclusive and that other factors may bear on the inquiry, the vast majority of admissibility inquiries under the *Daubert* standard[2] focus on these four[3] factors. With this basic history in mind, I now turn to a discussion of the potential admissibility of the concealed information test under the now-dominant *Daubert* standard.

Prior Accounts of the Concealed Information Test's Admissibility

Daubert was a monumental decision. Expert testimony is common in American trials, and *Daubert* completely upended the method by which judges are to evaluate such testimony's admissibility. Unsurprisingly, *Daubert* immediately engendered substantial scholarly discussion. Scholars have disagreed both as to the merits of the standard (e.g., Bernstein, 1994; Capra, 1998; Faigman, Kaye, Saks, & Sanders, 2000; Fenner, 1996; Heinzerling, 2006; Jonakait, 1994) and whether it has actually had any real impact on admissibility outcomes (Black, Ayala, & Saffran-Brinks, 1994; Chen & Yoon, 2005).

[1] Federal Rule of Evidence 702 was subsequently amended in 2000 in response to *Daubert*.

[2] Although the *Daubert* standard has been adopted by the majority of states, states are not obliged to follow the Federal Rules of Evidence, and some states have continued to apply the *Frye* standard, or have applied some other standard (see Daubert v. Frye).

[3] There is some dispute as to whether the test contains five separate factors (with maintenance of standards as a separate factor) or whether the error rate and maintenance of standards factors combine to form one single factor, yielding a total of four. For discussion, see Meixner and Diamond (2014, p. 1068).

Pertinent to this volume, a number of authors have previously discussed the potential admissibility under *Daubert* of both the CIT and the CQT and its analogues, particularly those tests as conducted using neuroscience-based methods such as ERPs and fMRI. Those authors have largely been critical of the potential admissibility of neuroscience-based CQT-like tests that purport to determine whether a participant is telling the truth or lying, largely for the same reasons that many scholars have been critical of the ANS-based variant of the CQT: the lack of a coherent theoretical underpinning for the tests, the potential for a high number of false positives, and the lack of clearly controlled laboratory studies demonstrating a promising rate of error (Alexander, 2007; Ellenberg, 2009; Kittay, 2007; Meixner, 2012; Moreno, 2009; Moriarty, 2009; Shapiro, 2016; Spence, 2008; Woodruff, 2014). Others have called for regulation limiting the use of fMRI-based lie detection, independent of its admissibility under *Daubert* and the Federal Rules of Evidence (Greely & Illes, 2007).[4] And at least three courts have rejected fMRI-based lie detection evidence, one rejecting it on the basis that it fails to satisfy the *Daubert* standard (United States v. Semrau, 2010, 2012), one on the basis that it fails to meet the *Frye* standard (Smith v. Maryland, 2011), and a third because the lie-detection evidence would impede on the role of the jury as a credibility assessor (Wilson v. Corestaff Services, LLP, 2010).[5]

Perhaps because of those cases and because of the rise of fMRI as a popular imaging tool, discussion of the admissibility of neuroscience-based credibility assessment tools has focused largely on lie detection paradigms, like the ones at issue in the *Semrau*, *Smith*, and *Wilson* cases. Further, numerous commentaries have failed to make any distinction whatsoever between lie detection paradigms and recognition detection paradigms like the CIT, whether using neuroscience-based tools or autonomic-based tools. This is important and dismaying, because, as many of the chapters in this volume outline in detail, there are critically important differences

[4] Some authors, however, have expressed a more positive view of the potential use of neuroscience-based tests using CQT-like methods (Langleben, 2008; Schauer, 2010; Langleben & Moriarty, 2013).

[5] Aside from methodological problems, there is another potentially fatal hurdle facing true lie detection paradigms: the notion that "the *jury* is the lie detector," one of the principles the Supreme Court has referenced in rejecting attempts of parties to admit the results of polygraph exams (United States v. Scheffer, 1998). Empirical data cast at least some doubt on the utility of that principle, but it nonetheless is a well-established legal doctrine that may limit the use of lie detection evidence even if methodological problems are solved. For a more complete treatment of this issue, see Meixner (2012).

between the two, both as a matter of theoretical validity and as a matter of practical accuracy in lab testing. As I and others have written in the past, those differences should radically affect the *Daubert* analysis conducted by a judge willing to examine the science at a deep level (Erickson, 2007; Meixner, 2012; Rosenfeld, Hu, Labkovsky, Meixner, & Winograd, 2013), though the fact that the scholarly literature has been inconsistent in doing this will make judges' jobs more difficult.

In the past, I have argued that the P300-based CIT—a variant of the CIT using the P300 ERP component as the primary measure of recognition—is reasonably close to admissibility, and I think the arguments I outline here also apply to the autonomic-based CIT conducted using the polygraph.[6] The CIT has been subjected to rigorous peer review for more than half a century, and, especially in the past 3 decades with the introduction of the P300-based CIT, the number of peer-reviewed publications of the CIT has skyrocketed, likely satisfying *Daubert*'s aim that methodological flaws be identified by other scientists so they can be remedied. Likewise, these tests are well-regarded in their scientific fields, and survey data have already been collected demonstrating the general acceptance of the CIT among psychologically oriented scientists (Iacono & Lykken, 1997). Further, most of the laboratories regularly conducting CIT research use specific standards and methods in their testing, leading to the consistency and reproducibility that the *Daubert* standard seeks.

The most difficult factors of the *Daubert* analysis for the CIT to overcome, I think, are the "known or potential rate of error" factor and the testability factor. This may seem counterintuitive at first, since the CIT has undergone extensive controlled laboratory testing across a variety of conditions, and has generally been reported to have a reasonably low false-negative error rate and a very low false-positive error rate. The issue, as I and others have argued, is that the vast majority of these studies have been conducted in conditions that do not sufficiently approximate those of the real world. For example, it is common in the P300-based CIT literature to use what is termed "self-referring information"—items like birth date, address, or telephone number—as an analogue for the critical crime-related information that an individual associated with the crime would recognize in a real-world CIT (e.g., Rosenfeld, Soskins, Bosh, & Ryan, 2004; Rosenfeld et al., 2008). Most other studies use some form of a mock-crime paradigm,

[6] Indeed, the ANS-based CIT has undergone at least some level of field testing, and that would be to its benefit in a *Daubert* analysis.

in which participants are given instructions to steal a particular item or carry out a particular task under controlled conditions (e.g., Ben-Shakhar & Dolev, 1996; Carmel, Dayan, Naveh, Raveh, & Ben-Shakhar, 2003; Lui & Rosenfeld, 2008; Lykken, 1959; Meixner & Rosenfeld, 2011; Mertens & Allen, 2008; Rosenfeld et al., 1988; Winograd & Rosenfeld, 2011).

Both of these designs are problematic when we seek to extrapolate the error rates yielded by the laboratory study to the error rates we might expect when using the test in the field. Self-referring information is rehearsed repeatedly and is particularly meaningful to individuals, likely driving up sensitivity of the test. And mock crimes—while approximating real crimes—suffer from several external validity problems. First, they involve a singular focus on the assigned crime and do not provide the rich array of distracting details that exist in the real world, which may decrease detection sensitivity because of reduced salience at the time of encoding. Second, the items involved are often notable, stand out, or are easily remembered by participants (e.g., the critical item in a test might be the only potentially valuable item encountered during the task, such as a ring or a computer disk). Third, participants in a mock crime CIT study know that they are participating in an experiment, and may be more likely to strongly encode and clearly remember relevant items due to the salience of the experiment itself. And fourth, actions committed by the subject in the lab are generally not voluntary, while actions involved in real crimes typically are.

There have been a few true field tests of the CIT, all using the ANS-based CIT variant. A pair of studies conducted in Israel found excellent accuracy rates in classifying nonknowledgeable/innocent individuals (between 95% and 98% specificity), but significantly lower accuracy rates among knowledgeable/guilty individuals (around 75% total sensitivity, and as low as 50% when using only a single ANS measure) (Elaad, 1990; Elaad, Ginton, & Jungman, 1992). Other articles have attempted to analyze data from field use of the CIT in Japan, where police have regularly used the test in criminal investigations for more than half a century. Kobayashi, Yoshimoto, and Fujihara (2009) reported results of 25%—50% sensitivity for individual autonomic measures in response to single questions, but did not report any specificity results, nor combined sensitivity results that would be indicative of detection rates. At least one other paper has reported some Japanese data with similar results and approximately 95% specificity, but the methods and data are difficult to interpret (Hira & Furumitsu, 2002; for reviews of Japanese methods, see Matsuda, Nittono, & Allen, 2012; Osugi, 2011). And one additional concern is that it may be difficult in many crimes to cull appropriate details on which to test (Krapohl, 2011); a critique that was borne out in one examination of FBI records (Podlesny, 1993).

These issues would likely influence a judge's *Daubert* analysis of the CIT, whether ANS-based or P300-based, though the ANS-based CIT would have a stronger argument for having known error rates and having been tested. In assessing an fMRI-based CQT variant, the *Semrau* trial court noted that "there are no known error rates for fMRI-based lie detection outside the laboratory setting, i.e., in the 'real-world' or 'real-life' setting" (United States v. Semrau, 2010, p. 11). If a judge cannot trust laboratory studies to provide a realistic approximation of the error rate of the test in the real world, there is no relevant error rate to assess, and the factor would clearly cut against admissibility. These issues may come into play under the testability *Daubert* factor as well: while there has been significant testing of the CIT's general methodology in the lab, an argument can be made that virtually no testing of the CIT has been done in sufficiently realistic settings. Indeed, without a reliable way to determine ground truth in a field test, it may be difficult to truly test the CIT at all.[7]

Because these conclusions are dependent on the literature, they are subject to change, and the most recent substantial commentaries on this issue are now nearly 5 years old, and largely discuss only the P300 literature (Meixner, 2012; Rosenfeld et al., 2013). In the next section, I examine recent CIT studies and assess the extent to which they have contributed to solving the puzzle of the true error rate of the CIT.

How Do More Recent Studies Affect the Analysis?

As an initial matter, I note that a large number of CIT papers published each year are not focused on developing a CIT paradigm that even attempts to mimic real-world conditions. Perhaps the majority of CIT studies in a given year are instead focused on refining a particular technique or aspect of the CIT (such as the ideal timing of items presented or presentation format), tweaking an analysis method (such as the ideal way to score responses, or the statistical measures used to make decision criteria, like bootstrapping), testing the effectiveness of countermeasures against a particular test, or

[7] We might ask whether judges, as nonscientists, will be capable of making these sorts of nuanced assessments of the literature. While the extent to which judges actually assess scientific methods is the subject of a long-running debate since *Daubert* was authored, at least one recent empirical study has demonstrated that judges spend significant space in their opinions assessing the validity of experts' scientific methods and their likely effects on error rates (Meixner & Diamond, 2014).

designing an entirely new CIT protocol (e.g., Deng, Rosenfeld, Ward, & Labkovsky, 2016; Labkovsky & Rosenfeld, 2014; Rosenfeld, Ward, Frigo, Drapekin, & Labkovsky, 2015).

One particularly notable subcategory in this group is studies that have sought to refine the so-called searching CIT (sometimes abbreviated as SCIT). In that test, rather than attempting to determine whether a particular suspect possesses a specific item of concealed information, the investigator knows that the suspect possesses at least *some* concealed information, and is trying to determine specifically what the information is, such as the location of a bomb or the name of a conspirator (e.g., Breska, Ben-Shakhar, & Gronau, 2012; Elaad, 2016; Meijer, Smulders, & Merckelbach, 2010; Meixner & Rosenfeld, 2011). Relatedly, more recent studies have conducted the SCIT on groups, much like individuals in a terrorist cell might be questioned jointly to maximize information (e.g., Elaad, 2016; Meijer, Ben-Shakhar, Verschuere, & Donchin, 2013; Meijer, Bente, Ben-Shakhar, & Schumacher, 2013). While these studies are qualitatively different from other CITs, they are important for our discussion here because they demonstrate the use of the CIT even if admissibility is never achieved—the SCIT is potentially useful to law enforcement in seeking to stop crime before it happens, or in finding new suspects of crimes that have already happened.

However, more pertinent to this chapter are a number of recent studies that have focused specifically on the issue of external validity in the CIT. While none of these studies involve actual field testing of actual crime suspects,[8] they do use unique methods to attempt to make laboratory studies more realistic. I will briefly describe several recent efforts.

First, while many early CIT experiments involved repeated rehearsal of the critical items in order to ensure that they would be recognized during the CIT, which is a method with low ecological validity (e.g., Farwell & Donchin, 1991), more recent studies have sought to measure the effects of such rehearsal (Bradley, Malik, & Cullen, 2011), finding that it does lead to stronger sensitivity. More recent CITs have sought to eliminate such priming of the information to be tested, and in some circumstances, have tested for both central details, which relate directly to the assignment given

[8] It is worth noting here that true field testing on criminal suspects will be extremely difficult to conduct, for a number of reasons, including: law enforcement may be reluctant to work with experimenters on real cases; IRB approval for research on criminal suspects will be very difficult to obtain; and any such research would require the cooperation of criminal suspects, who may not be inclined to participate voluntarily.

to the participant (e.g., the item to be stolen), and peripheral details, which may be noticed but are incidental to the crime (e.g., the color of the wall in the room where the crime was committed). As a general matter, these studies have found that knowledge of peripheral details is not detected with as much sensitivity as central details (e.g., Gamer, Kosiol, & Vossel, 2010; Nahari & Ben-Shakhar, 2011; Peth, Vossel, & Gamer, 2012; for review, see Meijer, Ben-Shakhar, et al., 2013; Meijer, Bente, et al., 2013). How might this information influence a *Daubert* analysis? If peripheral details cannot be detected with the same sensitivity as central details (a question that certainly still warrants further research), the critical question becomes: how often will peripheral details need to be relied upon in order to make detection decisions? The answer to this question remains unknown, though at least one study has come to the conclusion that strongly encoded details will be difficult to find in many case records (Podlesny, 1993). A judge deciding the admissibility of a CIT might then conclude that laboratory studies involving detection of only central details inflate the sensitivity of the CIT as compared to what could reasonably be expected in the field.

This concern might be at least in part alleviated by a recent study that did not employ a mock-crime paradigm, but rather attempted to detect recognition of events experienced during normal daily life (Meixner & Rosenfeld, 2014). In that study, subjects wore a video-recording device for a 4-h period, and then returned to the lab on the following day, when they were presented with CIT blocks containing information related to events that were recorded by the camera that participants wore. At the individual subject level, the investigators were able to correctly classify all 24 participants as either knowledgeable or nonknowledgeable. From a legal perspective, the study might be useful in demonstrating that the CIT is capable of detecting purely incidentally acquired information, and it is also notable in that it is one of the few CIT studies that detects information acquired purely voluntarily by participants, rather than requiring them to memorize information or commit a mock crime. However, given the novelty of this method, replication and extension are still necessary before the results can be given significant weight.

Other recent studies have sought to examine and address different ecological validity limitations common in many CIT experiments. For example, in Peth et al. (2015), investigators had three groups of participants either commit a mock crime, plan (but not commit) the same mock crime, or fulfill a noncriminal task that exposed them to information related to the mock crime. Following a CIT in which both fMRI and skin conductance response data were collected, the authors found virtually no differences between the three groups. While the result is potentially discouraging in that they "indicate[] a high risk for innocents with crime related knowledge to be misclassified as guilty," (p. 170), it is encouraging in that it indicates that CIT studies with poor ecological validity may not necessarily have poor external validity—that is, even though CIT studies do not approximate field-like conditions, the artificial conditions they employ may not actually influence the results.

One other recent result in this vein was published by Zaitsu (2016). That study involved an artificial card test paradigm in which the test sought to determine which of five numbered cards the participant had drawn. What makes the study interesting is the participants: the study compared performance of voluntary participants and actual criminal suspects, finding virtually no differences in performance between the groups. The result, as in Peth et al. (2015), is encouraging in that it indicates that laboratory participant populations may not be so different from field populations.

Another area of poor ecological validity for most CIT studies is motivation: an individual taking a CIT with his potential livelihood on the line would have a strong incentive to avoid detection, while typical student participants in CIT studies do not have the same motivation. This shortcoming could cut in either direction: participants motivated to avoid detection might be more effective in avoiding detection (perhaps though effective performance of countermeasures) but, on the other hand, their motivation could also have a detrimental effect of making the critical information even more salient, and thus make them stand out even more from irrelevant items.

While some studies assessing polygraph CIT data have found mixed results as to the effect of motivation (e.g., Elaad & Ben-Shakhar, 1989; Furedy & Ben-Shakhar, 1991; Zvi, Nachson, & Elaad, 2012), many of those studies are now nearly 20 years old, and nearly all use exclusively polygraph data. One recent study examined the effect of motivation using a reaction time-based CIT, finding that an incentive of up to $5 to avoid detection had no effect on detection rates (Kleinberg & Verschuere, 2016). While it may be questionable whether such a small reward sufficiently motivated participants, manipulation checks in the study indicated that those in the motivation group did seek to avoid detection more than the control group. A new set of studies from the Rosenfeld group, discussed in Chapter 6 of this volume, has similarly found no significant effects of modest ($10) financial motivation to avoid detection in several P300 CIT applications. More work, especially with potentially stronger motivators, would be helpful in this area, along with extension of this line of research to P300-based and fMRI-based CITs.

Other, more traditional, recent CIT studies have also continued to define the contours of the CIT's accuracy and limits in the lab context, and while these studies do not solve the ecological validity problems described earlier, they will still be useful if and when CITs are subjected to a *Daubert* analysis. Recent studies have continued to demonstrate very good sensitivity and specificity of the CIT using a variety of dependent measures (e.g., Lukács et al., 2016). One of the primary topics of interest continues to be countermeasures (e.g., in the memory suppression context, Bergström, Anderson, Buda, Simons, & Richardson-Klavehn, 2013; Hu, Bergström, Bodenhausen, & Rosenfeld, 2015; Rosenfeld, Ward, Drapekin, Labkovsky, & Tullman, 2017; Ward & Rosenfeld, 2017). While the evidence of the effectiveness of countermeasures is mixed and some protocols appear to be more resistant to them than others, they continue to be a serious concern for the overall accuracy of the CIT.

What effect are countermeasures likely to have on a *Daubert* analysis? It is difficult to know for certain, but I expect that the effect will be relatively minimal, largely because of the strong specificity of the CIT. This is somewhat paradoxical, as countermeasures threaten the sensitivity of the test. However, as the false-positive rate approaches zero (as should theoretically occur as the number of categories of questions is increased in a CIT), even if the sensitivity is not close to 100%, the test still provides strong probative value because when a knowledgeable result occurs, the person weighing the evidence can trust that it is almost certainly valid (as a false-positive error is exceedingly rare). Of course, if such strong specificity cannot be guaranteed, countermeasures become a much greater threat; where the judge or jury considering the evidence cannot strongly rely on either a knowledgeable or nonknowledgeable test result, the probative value of the test is substantially reduced and its potential prejudicial effect is greater (see Federal Rule of Evidence 403, 2011, which requires that a court exclude evidence "if its probative value is substantially outweighed by a danger of…unfair prejudice").

This chapter would be remiss not to discuss the controversial studies that have recently been published by Lawrence Farwell and his colleagues. Farwell was a coauthor on one of the very first P300-based CIT studies (Farwell & Donchin, 1991), and eventually sought to market a commercially available variant of the P300-based CIT that he terms

"Brain Fingerprinting." That test was raised in two court cases—the only such US cases to discuss the admissibility of a CIT paradigm. Those cases, *Harrington v. State* (2001) and *Slaughter v. State* (2005), do not, in my view, shed much light on how the *Daubert* analysis would apply to a CIT in future instances. This is for several reasons. First, these cases involved a unique procedural situation. In both cases, criminal defendants had been convicted at trial, and then—years later—took a Brain Fingerprinting test that yielded a null result: they indicated that the defendants lacked knowledge about particular aspects of the crimes (and, in Harrington's case, the results indicated that Harrington did respond to stimuli related to his alibi defense). Both defendants then sought to obtain a new trial, alleging that the Brain Fingerprinting tests, among other things, were newly discovered evidence that they could not have obtained previously and that indicated their innocence. Defendants seeking such relief generally must pass a high hurdle—they must show not only that the newly discovered evidence is admissible, but also that it would have changed the outcome of the trial if it were then known.

Because of this unique procedural situation, a full Daubert analysis was not completed in either case. In *Harrington*, an Iowa court opined that while the P300 component itself is generally accepted among psychophysiologists, the MERMER effect—Brain Fingerprinting's proprietary analysis method—was not generally accepted. It also discussed a number of other methodological issues related to the fact that the conclusion was based on a null result, with subjectively chosen stimuli, years after the actual crime was committed. But it never made a clear determination as to the admissibility of the evidence because it found that the defendant did not demonstrate that the evidence would have changed the result of his trial. On appeal, the Iowa Supreme Court reversed Harrington's conviction on entirely independent grounds, making no statement as to the admissibility of the Brain Fingerprinting evidence (*Harrington v. State*, 2003).

Similarly, in *Slaughter v. State* (2005), an Oklahoma state appellate court found no evidence that Brain Fingerprinting is generally accepted in the psychological community, and could not even complete a *Daubert* analysis because Farwell failed to provide any report to support his affidavit. Ultimately, the court found that the Brain Fingerprinting evidence was not newly available because the test could have been conducted at the time of the defendant's original appeal. It also stated that, in part based on the lack of a complete report regarding the test, the defendant had not demonstrated that the test would survive a *Daubert* analysis.

While Farwell went for a period of time in the early 2000s without publishing any significant work, he and his colleagues have been active more recently, publishing a broad description of Brain Fingerprinting (Farwell, 2012) as well as two sets of purported field studies (Farwell, Richardson, & Richardson, 2013; Farwell, Richardson, Richardson, & Furedy, 2014).

In Farwell et al. (2013), the authors report results from four studies, two of which used acronyms well known to FBI agents or explosive device dismantlers as the critical information to be detected (studies 3 and 4, pp. 274–276). A third study (study 1) used information known to CIA operatives about their investigations, and a fourth (study 2) used "information regarding real crimes, in circumstances where the outcome of the test could produce major, life-changing consequences" presented to "suspects in criminal investigations or convicted prisoners who claimed innocence and were appealing their convictions" (p. 272). Among all four groups, the authors report perfect accuracy, with no indeterminate results. Similarly, in Farwell et al. (2014) the authors presented military medical experts with terms "known only to experts in military medicine" among other irrelevant items, along with the same items presented to nonexperts, and again reported perfect discriminability between experts and nonexperts.

These results would be very important to the field and to the issue of admissibility, especially the one true field study in Farwell et al. (2013) (study 2), if not for a number of shortcomings. First, as is a common criticism of Farwell's studies, the methods are not described in sufficient detail that they could be independently replicated. Accordingly, there have not been any independent studies conducted by any groups other than Farwell's that use Farwell's methods. Such independent replication is especially important when the claims are extraordinary, as Farwell's are. Second, the results are so uniformly perfect (as is virtually every result reported by Farwell since Farwell & Donchin, 1991) that they are difficult to believe. As others have noted, the use of highly specific standards could lead to selection bias, influencing the result (Meijer, Ben-Shakhar, et al., 2013). Because of these and other issues, Farwell's studies have been strongly criticized by experts in the field (e.g., Guadet, 2011; Meijer, Ben-Shakhar, et al., 2013; Rosenfeld, 2005).

How would a judge facing an admissibility decision interpret the Farwell line of P300-based CIT studies? While Farwell's work has been examined previously by courts, as just discussed, it has become so broadly criticized in the field that it is hard to imagine how any court could consider it generally accepted, either under *Frye* (in which general acceptance is the only inquiry) or *Daubert* (in which general acceptance is a single, but important, factor). Other shortcomings in the Farwell studies, as discussed in the critiques outlined earlier, would further cut against its admissibility under *Daubert*.

The effect of Farwell's studies on an admissibility determination leads into another, broader, question: to what extent would CIT studies using one dependent measure (e.g., ANS measurements) be considered in determining the admissibility of a CIT conducted using a different dependent measure (e.g., P300)? When discussing the four *Daubert* factors, the *Daubert* Court instructed trial judges to assess them through the lens of the "theory or technique" or the "particular scientific technique" at issue. How broadly to frame the question of what scientific technique was at issue or what constituted the relevant scientific community was long a central argument in Frye determinations of admissibility, and remains an issue under *Daubert*. However, I think the more natural reading of *Daubert* asks the trial judge to make determinations based on the specific method sought to be admitted. The *Semrau* court's analysis largely bears this out—both the trial-level court and the court of appeals assessed research on fMRI-based lie detection, not lie detection research generally.

This does not mean, however, that ANS-based CIT research will necessarily be irrelevant to the admissibility of a P300-based CIT, or vice versa. To the extent that the research demonstrates consistently similar results across modalities, studies focusing on one modality may inform capabilities in another modality. Some recent studies have begun to combine data from multiple modalities into single CIT paradigms (e.g., Langleben et al., 2016; for meta-analysis of various modalities, see Meijer, Selle, Elber, & Ben-Shakhar, 2014), and while those have shown some differences in the capabilities of different modalities, research in this area has promise in better allowing the various subfields of CIT research to benefit each other.

Ultimately, a review of the recent CIT literature leads me to the following recommendations if a goal of the field is to eventually attain admissibility of the CIT in American courts:

- As I and others have written in the past (Meixner, 2012; Rosenfeld et al., 2013), the top priority for CIT researchers should be field testing, especially P300-based CITs, which have not undergone any field testing. Until such testing is done, I think it will be exceedingly difficult to admit a P300-based CIT under the *Daubert* standard. An ANS-based

CIT would have a stronger case, given the field testing that has occurred in Israel and the regular use of the ANS-based CIT in Japan, though the data presented from Japan to date remain limited, and the Elaad field studies from the early 1990s report some concerning issues with sensitivity. More detailed descriptions of error rates in the field in Japan (with specific explanations of the methods used to ascertain ground truth) would be particularly useful.

- To the extent that field testing is not possible, laboratories should seek to maximize external validity in their studies. In mock-crime studies, researchers should focus on making mock crimes as complex and realistic as possible. A major concern of courts assessing the value of mock-crime studies is likely to be the fact that crime-related information in mock-crime CIT studies is readily encoded, whereas in the field that same information is frequently learned during the often-chaotic and unrehearsed commission of a crime. To the extent that we can model our studies after that environment, they will be more useful in a *Daubert* analysis.
- Researchers should seek to empirically assess the opinions of the psychological community regarding CIT methods and other tests in the same domain, such as the CQT. Iacono and Lykken (1997) conducted a survey examining this, but that was before the broad proliferation the P300-based CIT and the variety of new methods that are now being explored. The CIT sits in an odd position: it appears to be widely accepted among the scientific community as a valid method and a superior tool for detection of crime-related knowledge as compared to lie-detection methods such as a CQT, and yet it is not well known to anyone outside of that community. Because judges assessing admissibility fall outside of that community, the more concrete evidence can be gathered to demonstrate the scientific community's view of the validity of the CIT, the better.
- Researchers should seek to make extremely clear in their papers the distinctions between memory detection and lie detection. A judge applying *Daubert* is likely to have very little familiarity with the credibility assessment field, and the term "polygraph" is so intertwined with lie detection that judges are likely to confuse the two classes of tests (Meixner, 2012; Ogawa, Matsuda, & Tsuneoka, 2015). This may lead to judges projecting many of the CQT's validity problems onto the CIT. Critically, true lie detection methods may never be admissible because their role overlaps with the traditional credibility-assessment

role of the jury. Memory detection should not suffer from the same pitfall, but without making the distinction between the tests clear in the literature, it will be more difficult for nonexperts to properly treat the tests separately.

- Researchers should seek collaboration with law enforcement whenever possible. Law enforcement personnel are in the ideal position to explain likely problems that the CIT would encounter in practice, such as the difficulty of finding appropriate probe items. Some scholars associated with law enforcement have already written on this topic (e.g., Krapohl, 2011), but there remains a dearth of information.
- Researchers should seek to conduct experiments using multiple dependent measures (such as ANS, ERP, and fMRI measures). Such experiments would have multiple benefits. To the extent that various dependent measures yield results that are independent of each other, combining those measures could increase the sensitivity and specificity of the test. And to the extent that the dependent measures yield results that overlap, those results can be used to argue that results of one measure can be extrapolated to other measures. This may impact the *Daubert* analysis—if a party seeks to admit a P300-based CIT, for example, being able to argue that ANS-based field tests are relevant to the admissibility analysis would be a major benefit.

In sum, the *Daubert* analysis of the CIT has not, in my view, changed in any major way over the past few years, but there has been an incremental step made toward admissibility. While we still lack field studies that are likely critical to admissibility, experimental studies have become more numerous and more externally valid, and the general acceptance, methodological consistency and sophistication, and rigor of the results have continued to strengthen.

OTHER CONSTITUTIONAL ISSUES WITH CONCEALED INFORMATION TEST USE

The previous discussion addressed the complex issue of what would be necessary for the CIT to pass muster under American evidentiary principles, but those are not the only requirements that the CIT would have to satisfy before it could be used in criminal trials. Constitutional protections also limit the extent to which evidence can be involuntarily seized from individuals and then later used against them at trial. There are two Amendments to the US Constitution that are most relevant: the Fourth Amendment, which protects an individual from "unreasonable" government searches and seizures, and the Fifth Amendment, which protects an individual from being "compelled in any criminal case to be a witness against himself." How a court would consider a compelled CIT under these principals is an entirely novel question, but scholars have begun to consider these questions, and I will briefly summarize some of the positions taken.

The Fourth Amendment guarantees "[t]he right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures." In determining whether a search is reasonable, courts first determine whether there was a search at all. The US Supreme Court has developed a two-part test in which there is a search when an individual exhibits an actual, subjective expectation of privacy in the thing searched and, most importantly, that expectation, "viewed objectively, is justifiable under the circumstances" (Smith v. Maryland, 1979). Where there is an objectively justifiable expectation of privacy held by the individual subject to the search, government agents must generally obtain a warrant prior to conducting the search, or the evidence found in the search will be suppressed.

Though no court has addressed whether conducting a CIT on an individual would be considered a search under the Fourth Amendment, scholars have generally agreed that compelled mental tests are likely to be considered searches. The Supreme Court has found that compulsion of a physical substance from an individual, such as obtaining a sample of blood or urine, is a search under the Fourth Amendment (Schmerber v. California, 1966; Skinner v. Railway Labor Executives' Association, 1989; for discussion, see Pardo, 2006). And retrieval of information that is emitted outside of a location, such as heat waves from a house (or, by analogy, brain activity measured outside the skull), can still be considered a search where there is a reasonable expectation of privacy in the information searched (Kyllo v. United States, 2001).

However, even if a compelled CIT would be considered a search, scholars appear to agree that government actors would be able to obtain a warrant for that search. In order to obtain a warrant, the government must show that "there is a fair probability that contraband or evidence of a crime will be found in a particular place" (Illinois v. Gates, 1983). And it would likely not be difficult to demonstrate that the evidence of the crime—in a CIT, the presence of crime-related knowledge held by a suspect—would probably be found if a CIT were conducted (e.g., Pardo, 2006; Shen, 2013).

The Fifth Amendment issue is far more complex. That amendment protects an individual from being "compelled in any criminal case to be a witness against himself." However, what type of evidence is considered compelled, and whether compelled evidence is protected by the privilege, is the subject of substantial legal doctrine. For our purposes, the most important distinction is between physical materials, such as a blood or fingerprint sample (which can be compelled without violating the Fifth Amendment) and communicative acts or statements (which are protected under the privilege).

As a number of scholars have observed, CIT evidence, whether obtained through ANS-based methods or neuroscience-based methods, does not neatly fit into this dichotomy. As Dov Fox succinctly put it, "[b]rain imaging is difficult to classify because it promises distinctly testimonial-like information about the content of a person's mind that is packaged in demonstrably physical-like form, either as blood flows in the case of fMRI, or as brainwaves in the case of EEG" (Fox, 2009, p. 791). And the CIT, in many cases, does not even require a voluntary response on the part of the participant—in many ways, it is similar to a blood sample, but instead, it is a sample of neural activity under certain conditions. And yet, the Supreme Court has opined that "[t]o compel a person to submit to testing in which an effort will be made to determine his guilt or innocence on the basis of physiological responses, whether willed or not, is to evoke the spirit and history of the Fifth Amendment" (Schmerber v. California, 1966, p.764).

Some have argued that CIT-like evidence should be considered testimonial because it is *evoked* by a question or stimulus, unlike a blood sample or other physical evidence that was already present prior to any questioning or the presentation of any stimuli (Farahany, 2012; Pustilnik, 2013; for related arguments see Barillare, 2006; Murphy & Greely, 2011). Others have argued that the evidence is not testimonial because it does not put the suspect in the "cruel trilemma" (of either perjuring himself, putting himself in contempt of court by refusing to testify, or incriminating himself) that the Fifth Amendment was designed to protect against (Hurd, 2012) or because the test does not compel any action or behavior on the part of the suspect (Holley, 2009).

Given the Court's long history of mistrust of polygraph evidence and the compulsion of thoughts, I think it is likely that, when confronted with the issue, courts are likely to either fit CIT-like evidence within the current testimonial framework or modify the test so that such evidence is protected from compulsion under the Fifth Amendment. But that does not mean that the test will not be useful in criminal investigations. For example, in Japan, consent from the suspect is required before a CIT is given, and yet hundreds of CITs are still conducted annually (Osugi, 2011). The test may also be useful outside the court as well; as Danaher (2015) suggests, the CIT may serve as a signaling tool to help parties better evaluate an appropriate plea bargain.

On the whole, these issues are still extremely new, and we lack direction from courts as to how the analysis will likely proceed. As technology continues to develop, it will become more and more likely that courts will be confronted with these and similar issues, and they will help to shape Fourth and Fifth Amendment jurisprudence going forward.

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Detecting Concealed Information and Deception

Recent Developments

Edited by

J. Peter Rosenfeld

Detecting Concealed Information and Deception brings together the world's leading experts on all aspects of concealed information detection. The book examines an array of different methods—behavioral, verbal interview, and physiological—and chapters address how to make use of detected information for present and future legal purposes. With a theoretical and empirical foundation, *Detecting Concealed Information and Deception* also covers burgeoning new human interviewing techniques, including the highly influential Implicit Association Test, among others.

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- Explores the legal implications and admissibility of the CIT
- Covers electroencephalography, event-related brain potentials, and autonomic detection measures
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- Identifies how to perceive malicious intentions
- Explores personality dimensions associated with deception including religion, age, and gender

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