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Causal Cognition and Culture

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Abstract and Keywords

Causality is a core concept of human cognition, but the extent to which cultural factors constrain, trigger, or shape the way in which humans think about causal relationships has barely been explored. This chapter summarizes empirical findings on the potential for cultural variability in the content of causal cognition, in the way this content is processed, and in the context in which all this occurs. This review reveals cultural variability in causal cognition along each of these dimensions and across physical, biological, and psychological explanations. Specifically, culture helps defining the settings in which causal cognition emerges, the manner in which potential factors are pondered, and the choices for highlighting some causes over others or for expressing them in distinct ways. Future tasks include the need to re-conceptualize 'culture' and to overcome blind spots in research strategies such as those linked to disciplinary boundaries and the 'home-field disadvantages' in cross-cultural comparisons.

Keywords: causal cognition, culture, language, content, processing, context

Why does wood float on water, and why do donkeys remain donkeys even if they are painted to look like zebras? Who or what is responsible for the rising sea levels, and what can be done to slow it down? Why did my friend shout at me? And how do I know if I am in control of my own actions? All these questions share one important feature: they ask for causal explanations. For our attempts to make sense of the physical world and of social interactions, causality is a core concept. Corresponding knowledge is required for a basic understanding of causal mechanisms, for the constitution of ecological and religious worldviews, for the perception of agency and its assignment among different kinds of actors, and for ascribing responsibility to people and circumstances. Besides simply providing us with a sense of understanding in a variety of contexts and domains, causal explanations also shape our attitudes, judgments, emotions, and intentions.

For most of the preceding questions, we (as ordinary people) believe we know the answers, and for most of them we (as scientists) believe we understand how people generate these answers. But when asked for the possible impact that our cultural background, both as people and as scientists, has on these answers and the processes that led to them, we have surprisingly little to offer. In spite of a research tradition on causal cognition that spans centuries, if not millennia, most of this research has revealed only incidental concern for culture as a possibly constitutive factor.

In an attempt to draw attention to culture as fundamental to causal cognition, in this chapter we compile empirical findings from cross-cultural research identifying factors that potentially constrain, trigger, or shape the way in which humans think about causal relationships. In doing so, we also hope to undermine implicit assumptions about methods, research questions, and even ideas about what is relevant and worthy of attention in research on causal cognition. For example, research not only has overinvested in studies with undergraduates (p. 718) at major Western research universities (i.e., the so-called WEIRD people, being from *W*estern, *e*ducated, *i*ndustrialized, *r*ich, and *d*emocratic countries; Henrich, Heine, & Norenzayan, 2010), but also has overinvested in a narrow range of (highly simplified) research paradigms that, at a minimum, beg the question of generalizability. We therefore also broaden the focus of causal cognition by considering not only research on reasoning principles at an abstract level devoid of content, but also studies that target causal concepts and explanations people engage in when reasoning about concrete, everyday phenomena (for similarly integrative approaches, see also Gerstenberg & Tenenbaum, Chapter 27 in this volume).

Our review is organized around three major issues: the potential for cultural variability in the *content* of causal cognition; in the way this content is *processed*; and variability in the *context* in which all this occurs. Specifically, we first document how people differ in their causal perceptions and explanations and the culture-specific concepts on which these are based across the major domains, then focus on potential cultural differences in the processing of causal information, and finally try to identify characteristics of the cultural context that may be responsible for the emergence of these differences. The distinction in content versus processing reflects an old division of labor between anthropology and psychology whereby anthropology studies content and psychology studies processing (D'Andrade, 1981). We reject this division but nonetheless employ it for purposes of illustration before outlining its limitations.

Content and Causal Cognition

The bulk of research on the content of causal cognition has adopted the notion of domain-specific cognition and reasoning processes. Specifically, the claim has been that there is a fundamental difference in reasoning about physical events (naïve physics), biological events (naïve biology), and social or psychological events (naïve psychology). These domains have organized a great deal of research on cognitive development (e.g., Carey, 2009; Goswami, 2002; Hirschfeld & Gelman, 1994; Spelke & Kinzler, 2007; and see Muentener & Bonawitz, Chapter 33 in this volume). The distinction is also intuitively compelling in the sense that notions like agency and intentionality are central to naïve psychology, but presumably are irrelevant to naïve physics. The distinction between naïve biology and naïve psychology may be more debatable, though mind–body dualism appears to be a common understanding, at least in the Western world (Lynch & Medin, 2006).

These ontological domains are motivated by the idea that each has a distinct set of principles that are intuitively available and that allow for understanding and inferences. It has long been proposed that causal explanations—and, as we will see, ideas about their potential susceptibility to cultural influences—depend on the domain to which they refer. That is, each domain is defined by entities having the same kind of causal properties, marked, for example, by the way they move: physical entities are set into motion by external forces, while biological kinds may propel themselves. A further distinction can be made between biological and psychological mechanisms based on the relative importance of agency and intentionality. While agency and intentionality, for instance, seem irrelevant to understanding food digestion or plant growth, they are prominent for organisms endowed with consciousness and deliberative decision-making abilities.

We use this notion of domains to organize our review, but we would not bet a great deal on this distinction having enduring value, as recently researchers have begun to suggest that these domains represent a particular cultural model, and not universal building blocks of human cognition (Medin et al., 2013; Viveiros de Castro, 2004; for a review, see also ojalehto & Medin, 2015). We begin by reporting findings for each domain separately, with an emphasis on those areas for which cultural variation in the content of causal beliefs and explanations has been noted. To this end, we first identify the domain’s core entities, key concepts, and principles, then present empirical findings from cross-cultural research, and finally discuss theoretical conclusions and the possible (in)variance of domain boundaries.

The Physical Domain: Objects, Forces, and Effects

The physical domain consists of inanimate objects that behave in accordance with physical laws (animate entities are, of course, also subject to laws of physics such as gravity). Children appear to possess intuitive knowledge of at least the following mechanistic principles: objects have continuity and solidity, their movements are caused by external forces through contact, and they are affected by gravity and inertia (e.g., Carey, 1985, 2009; Spelke & Kinzler, 2007). Specifically, some mechanistic events such as *launching* (in which an object hits another object, setting it in motion) and states such as *floating* (when an object floats on a liquid) have (p. 719) long been assumed to trigger universal and immediate impressions of causality (Leslie, 1982; Lewin, 1935; Michotte, 1963; for an overview of causal perception, see White, Chapter 14 in this volume).

Early Understanding of Force and Motion, Animacy, and Weight

The assumption that knowledge about physical principles is universal has rarely been tested across cultures. One exception is Bödeker's (2006) pioneering study on the development of intuitive physical knowledge pertaining to force and motion, animacy, and weight among children of different ages from Germany and Trobriand, an island group off the coast of New Guinea. Participants were asked, *inter alia*, to predict and explain the trajectories of moving entities, or to indicate whether and, if so, why specific entities are animate or float on water. Cultural differences did not arise with respect to the concepts of motion and force (or floating for that matter), but partly with respect to weight conservation and especially with respect to animacy. Substantially more Trobriand than German participants described clouds, fire, and waves as animate. This difference in the perception of animacy is important, because it raises the possibility that Trobrianders might see the behavior of clouds, fire, and waves—by virtue of not being simple inanimate entities—as subject to different principles linked to agency. Bödeker's findings suggest an influence of formal education on the development of basic concepts for causal cognition, but also hint at cultural framework theories regarding the living world that seem to play an important role for what and when children learn about causal principles. Whether the conceptual link between animacy and movement is additionally (or perhaps exclusively) paved by semantics remains an open question though, as the local term for "animate" (-*mwawoma* in Kilivila) is also used to characterize specific types of movement (Bödeker, 2006, p. 362f.).

Causal Attributions for Launching and Floating

Research into adults' understanding of why objects behave in specific ways has yielded a wealth of empirical evidence and theoretical elaboration, particularly for causal learning and reasoning, as attested to in the numerous chapters of this volume (e.g., Johnson & Ahn, Chapter 8; Lombrozo & Vasilyeva, Chapter 22; Oaksford & Chater, Chapter 19; Over, Chapter 18). However, most of this research appears to be predicated on the implicit assumption that the perception of physical causality is relatively direct and unmediated by culture or education, thus justifying the use of highly restricted samples in Europe and the United States.

In one of the first attempts to investigate whether causal reasoning in the physical domain is susceptible to cultural influences, Morris and Peng (1994, Study 1) presented animated displays to participants having either a US or Chinese background. *Physical* displays depicted interactions of geometrical shapes; those categorized as *social* depicted interactions of fish. In the launching scenario, for instance, one entity moved immediately upon impact of another entity. When rating the extent to which the movements seem influenced by internal factors (such as air pressure inside a ball or, for fish, the intention to move) or external factors (a person kicking the object or, for fish, being guided to move by other fish), US participants gave higher ratings than the Chinese to internal causes in the social domain, but not the physical domain, where both groups focused equally on external factors (Morris, Nisbett, & Peng, 1995). These findings were taken as evidence for the assumption that, while attribution of causality in the social domain may be susceptible to cultural influences, in the physical domain it is not.

This conclusion was qualified by Peng and Knowles (2003, Study 1), who presented US and Chinese participants with animated displays of eight physical interactions (including launching and floating). For three of the eight scenarios, including the launching scenario, the Chinese participants indicated more external causes for the movement of the focal object than the US participants. In a second study, they also investigated the effect of formal physics education, which seemed to supplant individuals' folk theories in the physical domain and thereby to eliminate the cultural differences. Still, the study by Peng and Knowles reopened the idea of cultural differences in the perception of physical causality.

Not discussed by the authors was the result of the floating scenario, for which both the US and the Chinese participants alike preferred external causes. This result is puzzling insofar as Bödeker (2006) had obtained explanations (across cultures) focusing almost exclusively on properties of the floater, an internal cause (see also Lewin, 1935). Scrutinizing this further was the goal of a set of studies conducted in Germany, the Kingdom of Tonga, and China. In the first of these studies (Beller, Bender, & Song, 2009b), participants were asked to indicate (p. 720) which entity they regarded as causally most relevant for statements such as "The fact that wood floats on water is basically due to… ." Overall, the ratings depended on cultural background, exhibiting a preference for the floater (here: the wood, an internal cause) among German participants, a reversed preference for an external cause in the form of the carrier (water) among Tongan participants, and no clear preference among Chinese participants. However, the specific entities involved in the task also affected participants' assessments, and did so distinctly for each cultural group. For instance, the German and Chinese participants, but not the Tongan participants, considered a carrier's capability for buoyancy only when the floater was a solid object such as wood, but not for a fluid like oil (Beller, Bender, & Song, 2009b). The general pattern was largely replicated in a second study with German and Tongan participants that included a broader range of physical relations, contents, and linguistic variations. Again, assessments of causal relevance were affected by cultural background, and the most pronounced difference was observed for the floating scenario, with a clear preference for the floater as the main cause among Germans, but not Tongans (Bender & Beller, 2011).

To sum up, the studies conducted in the physical domain indicate that people's explanations of causal relations can differ substantially across cultures. This holds not only for launching and floating, but also for other physical interactions (Bender & Beller, 2011; Peng & Knowles, 2003) and for physical concepts such as weight (Bödeker, 2006). As both the obtained findings and their theoretical interpretation diverge, however, more systematic and in-depth investigations are needed.

The Biological Domain: Animates, Essences, and Vitalistic Functions

The biological domain is populated by animates, who share with physical objects the properties of continuity and solidity, but, in the case of almost all animals, can move on their own initiative. More important, animates grow, may become ill or injured and heal, reproduce, pass on essential properties, and eventually die (Inagaki & Hatano, 2002, 2006). Causal explanations in this domain may thus be characterized by "vitalistic" principles—that is, assumptions about a vital power or energy that keeps animates alive (Inagaki & Hatano, 2004)—although there is some dispute as to whether these principles pertain to all animates alike (Goldberg & Thompson-Schill, 2009).

Research on the biological domain has focused primarily on categories and induction (see also Rehder, Chapters 20 and 21 in this volume), and although this may not seem directly relevant to causal cognition at first glance, it indeed is. While questions like whether a pig raised by cows will "oink" or "moo" ask for categorization, they also probe for understandings of deep biological causal principles. Similarly, wondering whether a property present in one biological kind is also true of another biological kind may also draw on causal reasoning. In the following, we therefore begin by presenting research on folk-biological categories and induction before explicating its implications for causal reasoning.

Folk-Biological Reasoning

The impact of culture on folk-biological concepts, taxonomies, and theories has attracted considerable attention within cognitive science (e.g., Astuti, Solomon, & Carey, 2004; Berlin, 1992; Boster & Johnson, 1989; Ellen, 2006; Inagaki & Hatano, 2002; Medin & Atran, 1999, 2004; ojalehto, Waxman, & Medin, 2013). Early work focused on taxonomic systems (Berlin, 1972; Berlin, Breedlove, & Raven, 1973; see also Atran, 1993; Berlin, 1992). It suggested that there are universal principles of folk naming and classification systems and that they correspond fairly well with classical taxonomic hierarchies. Thus, when an ethnobiologist asks an informant the local name for a tree, she or he can be reasonably sure that the answer will correspond to the level of genus or species (in local contexts, most genera have only one species), and not to a more abstract and inclusive level like *tree* or *plant*.

These observations also led to a major discovery in the cognitive science of concepts: demonstrations by Eleanor Rosch and her associates (Rosch, 1975; Rosch et al., 1976; see also Berlin, 1992) that one level in taxonomic hierarchies, the so-called basic level, is psychologically salient and privileged by a range of converging measures. This observation is highly relevant to how adults label objects for children and how children in turn acquire concepts. This level is also privileged in inductive reasoning (Coley, Medin, & Atran, 1997), but whether or not this privileging of the basic level holds equally for causal learning has received very little attention. One possibility is that different levels in a hierarchy may be selected based on the causal coherence they provide for the particular relations of interest to be explained (Lien & Cheng, 2000). For example, if (p. 721) the causal relation involved the sweetness of the sap of a maple tree, then the causal description should pick out maple tree as relevant, but if the roots of the same tree pushed up through the ground under a sidewalk to produce a bulge in it, then “treeness” and not “mapleness” would be the relevant causal factor (unless, perhaps, maple trees were especially prone to producing bulges). On this account, privilege would be relative to what one is trying to understand—and not necessarily what Rosch calls the “basic level.” To our knowledge, there has been no cross-cultural research on the question of causal privilege.

Biological Essences

The ability to pass on essential properties is distinctive for biological entities and plays a crucial role in categorization and in causal explanations. For example, one might ask why some bird has the particular song that it has. Ethologists do studies in which they vary the environment and auditory input conditions to which baby birds are exposed. If the bird has never heard its species’ own song, but nonetheless sings it perfectly as an adult, one concludes that this capacity is innate. If, instead, it is crucial for the bird to hear its species’ song, learning is implicated as a causal principle. A widely used scenario in cognitive science entails a similar logic. Participants are given a “switched at birth” scenario, as in the case of a baby pig raised by cows mentioned earlier. The belief that the pig will “oink” and not “moo” reflects the idea that the capacity for species-specific sounds is inborn and not based on experience.

Even without an elaborate model of how innate mechanisms may work (e.g., something to do with genes), people consider essential properties as causative for other surface features (Ahn et al., 2001; Medin & Ortony, 1989). Much of the literature on essentialism as a causal principle is nicely reviewed from a developmental perspective in Gelman (2003), and the role of language (e.g., use of generics) in essentialist reasoning has recently begun to be explored (Gelman et al., 2005; Waxman & Gelman, 2010).

Essentialist reasoning principles have been widely observed in different cultures (Astuti et al., 2004; Atran et al., 2001; Gelman, 2003; Sousa, Atran, & Medin, 2002). Culturally specific concepts and theories modify how essences are referred to and which inferences are drawn from them (e.g., Au & Romo, 1999; Hatano & Inagaki, 1999; Waxman, Medin, & Ross, 2007). All of this work implies that biological categories are organized by deep causal principles that determine not only physical properties and biological functions, but also patterns of behavior and psychological properties.

Finally, we should note that there is a considerable body of work concerning the cognitive consequences of extending essentialism as a causal principle to social categories (e.g., Bastian & Haslam, 2006). Essentializing social difference implies a lack of capacity for change with experience.

Taxonomic Versus Ecological Causal Reasoning

So far in discussing folk-biological reasoning, we have implied that inductive reasoning is a form of causal reasoning and have used the terms “category-based induction” and “causal induction” more or less interchangeably. A skeptic might suggest that this research is not about causal reasoning, but rather similarity-based generalization. For example, if people are told that eagles have some enzyme *x* and are asked whether hawks also have enzyme *x*, isn’t it plausible that they would say “yes” simply because hawks and eagles are fairly similar to each other, without invoking any notion about cause?

One counterargument might be that eagles have enzyme *x* for a reason, and whatever caused them to have it very likely would also cause hawks to have it. For example, if our informants knew or were told that enzyme *x* helps lubricate the eyes to counteract the wind’s drying action, they might be quite sure that hawks also have it.

One might quibble about whether the preceding example involves causal reasoning, similarity-based generalization, or some form of teleological reasoning. So, let’s turn to a more straightforward example. If people are told that field mice have enzyme *x* and are asked whether hawks also have it, they might well reason that they do, not because field mice are similar to hawks, but rather because hawks eat field mice and eating provides a mechanism for transmitting enzymes from field mice to hawks.

Research on category-based induction has shifted from an initial focus on similarity-based generalization (whatever the merits might be of its potential link to causal reasoning) to the inclusion of reasoning in terms of causal mechanisms, as in the field mice example. Early studies on category-based induction used WEIRD participants, who tend to know relatively little about biological kinds (e.g., Lynch, Coley, & Medin, 2000). When causal (p. 722) induction research was extended to other cultural groups and to informants with more biological expertise, it soon became clear that there was another causal mechanism-based reasoning strategy that had been more or less ignored (Bailenson et al., 2002; López et al., 1997; Proffitt, Coley, & Medin, 2000). As another example of this strategy, some 5-year-old Native American Menominee children reason that bears might have the same novel substance inside them that bees do. Despite the fact that bees are taxonomically distant from bears, they suggested that bees might transmit this substance to bears by bee stings or through the honey that bears eat.

So, when do reasoners consider causal mechanisms versus some general notion of similarity? First of all, *kinds* of similarity matter. Physical similarity is important for reasoning about novel physical properties, but behavioral similarity may be more important for reasoning about novel behavioral properties (Heit & Rubinstein, 1994). It now appears that inductive reasoning involving biological kinds relies on a principle of relevance. According to the relevance principle, people tend to assume that the premises are informative with respect to the conclusion (Medin et al., 2003). It is as if they ask themselves, "Why are you telling me this?" and assume that you have a good reason for doing so. When a premise involves bees and the conclusion bears, invoking a relevance principle would suggest that it was important to find some connection between bees and bears (e.g., honey, stinging). Obviously, relevance may vary with culture and expertise.

The Psychological/Social Domain: People, Mind, and Agency

The psychological/social domain is populated by sentient agents who possess mental states such as knowledge and beliefs, goals, self-reflexiveness, and possibly even free will (Leslie, 1995; Pauen, 2000). The set of core psychological principles likely includes autonomous motion, goal-directedness, efficiency, and contingent and reciprocal interactions, which is why motives and intentions play a causative role in their behavior. A second core system has been claimed for identifying potential social partners and group members and for capturing the salient features of cooperation, reciprocity, and group cohesion (Spelke & Kinzler, 2007; Spelke, Bernier, & Skerry, 2013). Among the essential prerequisites for assessing psychological-social causality are a *theory of mind* and the concepts revolving around the notion of *agency*.

Theory of Mind

A theory of mind provides the basis for inferring mental states in others and, more important, for recognizing these states as causes of behavior. It is thus an essential prerequisite for folk psychology and causal attributions. While there is likely no doubt that people eventually acquire a theory of mind regardless of cultural background, the questions of whether it uniformly emerges at around 4 years of age and as a single ability (Wellman, Cross, & Watson, 2001) are less clear. Callaghan and colleagues (2005), for instance, report that the Samoan children in their study were significantly older than the other cultural groups when they passed the false belief test. These data does not support the claim (even made in the title of that very article) that mental-state reasoning has a synchronous developmental onset across cultures. Significant differences in the onset, in spite of equal trajectories of development, were also found when comparing two North American and two Chinese groups (Liu et al., 2008). And Junín Quechua children from Peru master the appearance/reality distinction well before they seem to acquire an understanding of representational changes and false beliefs (Vinden, 1996). Of course, these assumptions and conjectures rest on the faith that measures and procedures for assessing theory of mind, developed in the West, are commensurable across cultures. As this issue is still under dispute (e.g., Wassmann, Träuble, & Funke, 2013), we consider the status of theory of mind development to be an open question.

In at least two of the three exceptional cases just mentioned, a later onset in mental-state reasoning seems to correspond to a cultural discouraging of “mind-reading.” Both Samoans and Quechua appear to be more concerned with what one can objectively know, and to be rather reluctant to speculate about feelings, thoughts, or intentions of others, especially when asked for causes of other people’s behaviors (Gerber, 1985; Shore, 1982; Vinden, 1996; for similar observations in other Pacific societies, see also Wassmann, Träuble, & Funke, 2013). Sometimes this is described as “opacity of other minds” (Robbins & Rumsey, 2008; and see Danziger, 2006; Danziger & Rumsey, 2013). Not being exposed to mental state talk, in turn, may make it more difficult for children to acquire a full-fledged theory of mind (Pyers & Senghas, 2009; Woolfe, Want, & Siegal, 2002).

When it comes to adults’ folk-psychological theories of mind, cultural differences are, surprisingly, more, rather than less, pronounced (Lillard, 1998 (p. 723) ; White & Kirkpatrick, 1985). There appears to be a striking cultural variance in the willingness to adopt a first-person-like perspective on others (Hollan & Throop, 2008; Wu & Keysar, 2007), with substantial consequences for the extent to which mental causes are attributed and responsibility is ascribed. If, for example, it is difficult (or not desirable) to guess what others are thinking, people are likely held responsible for their wrongdoings, even in cases when accident or error has been acknowledged (Danziger & Rumsey, 2013; see also Astuti & Bloch, 2015). People placing high regard on the opacity of other minds thus appear to be concerned more with effects of actions than with their causes (Shore, 1982; Throop, 2008). Alternatively, one might say that they are less concerned with intentions as a source of causal explanations and are more focused on other, external factors.

Assignment of Agency in Causal Attribution

While *theory of mind* accounts are concerned with the (mental) causes of behavior, accounting for behavior as causes of events involves causal attribution (Hilton, Chapter 32 in this volume; for the relation of attribution and theory of mind, see also Alicke et al., 2015) and is thus closely related to how people perceive and/or construe agency. In this field of research, agency has been defined as the experience of being in control of one’s own actions and thus of the events they cause (Haggard & Tsakiris, 2009). The entity to which *agency* is assigned is almost exclusively the individual person, at least in many Western cultures, and consequently in most (Western) cognitive accounts. Elsewhere, agency may be assigned to non-human entities, such as plants, the ocean, or the sun (Harvey, 2005; Kohn, 2013; Narby, 2006), to social groups (Duranti, 1994; Menon et al., 1999; Morris, Menon, & Ames, 2001), and/or to supernatural entities (e.g., Bird-David, 1990, 2008; Norenzayan & Hansen, 2006)—to the extent that these agents are included in theories of mind (Knight, 2008; Knight et al., 2004). As emphasized by Widlok (2014), however, these differences in assigning personhood and agency to such entities are likely to be a matter of degree rather than kind, with equally strong intra-cultural variation in the West—and especially between the scientific model and layperson conceptions—as elsewhere.

Closely related to assigning agency to other entities is the more fundamental question of how people perceive and construe their own agency. Going far beyond the interest in responsibility ascription, this question touches on discussions of free or conscious will to include issues of embodiment and action perception (Schütz-Bosbach & Prinz, 2007). Wegner (2002, 2003), for instance, proposes that agency—the experience of conscious will—is in most cases merely an illusory add-on to perceived action. He identifies three principles for inferring agency: priority, consistency, and exclusivity. If a relevant thought reaches consciousness just before the action, is consistent with it, and is the only reasonable candidate for it, people perceive authorship, even of actions that were not theirs (Wegner, Sparrow, & Winerman, 2004), and if any of these principles is violated, they will fail to perceive authorship, even for events they did cause (Dijksterhuis et al., 2008).

Cross-cultural accounts of how universal the processes of agency construal may be are still lacking. We do know, though, that several aspects of "supernatural" experiences are closely linked to notions of agency—agency either *claimed* for actions most likely not initiated by the respective person (as in cases of "magic"), or *disclaimed* for actions evidently committed (as in cases of spirit possession)—and these are obviously culture-specific to a substantial extent. The same holds for agency disorders such as schizophrenia, which is almost universally characterized by symptoms such as hearing voices of others in one's head. Still, depending on cultural theories of mind and of inter-individual relations, these voices are experienced in culture-specific ways (e.g., as intrusive, violent, and unreal symptoms, as communication by morally good and causally powerful spirits, or as useful guidance provided by kin), and, as a consequence, they are also distinctively diagnosed and treated (Luhrmann et al., 2015; and see Ahn, Kim, & Lebowitz, Chapter 30 in this volume; Hagmayer & Engelmann, 2014; Seligman, 2010).

Relevance and (In)variance of Domain Boundaries

Many events in people's lives do not fall neatly within domains, however they are defined. If the roof of a hall collapses after heavy snowfall, one factor involved is clearly the physics of weight and structural engineering, while a second factor is the people who did the construction work or supervised it. Similarly, accounts of illnesses in the field of ethnomedicine often comprise social aspects as well as biological ones (e.g., Froerer, 2007; Nguyen & Rosengren, 2004), thus exhibiting a concept of (p. 724) psycho-physical dualism (for a more detailed treatment, see ojalehto & Medin, 2015). In this subsection, we therefore focus on cultural variability at the fringes of the ontological domains, addressing distinct, yet related topics: (1) the overlap of domains for relevant events, (2) the blending of domains in people’s concepts and representations, and (3) the role of culture in determining domain boundaries.

Overlapping of Domains: Ecosystems and Mental Models of Nature

Ecosystems involve components of more than one of the other domains. Typically, they are considered as part of the *biological domain*, because the biological species within an ecosystem are its most salient and (debatably) relevant components for humans. However, *physical* entities such as rocks, soil, water, or wind are essential components of ecosystems as well—and are perceived as thus in many indigenous groups (Medin & Bang, 2014). On the other hand, many people around the world regard *social* relationships with other inhabitants of their ecosystem as only natural (e.g., Atran & Medin, 2008; Knight, 2008; Le Guen et al., 2013). In addition to their heterogeneous composition, ecosystems contain qualitatively different properties that justify their treatment as a distinct domain. Entities within an ecosystem constitute a tight network that is characterized by complexity, non-transparent relations, non-linear processes, and emergent phenomena. Because of these properties, human interactions with ecosystems are extremely challenging, both in terms of causal perception, reasoning, and understanding, as well as in terms of problem-solving and management (Dörner, 1996; Funke, 2014; Hmelo-Silver & Azevedo, 2006; Tucker et al., 2015; White, 2000).

Causal Learning and Complexity

One important line of research focuses on how people deal with complex problems (see also in this volume, Hagmayer & Fernbach, Chapter 26; Meder & Mayrhofer, Chapter 23; Osman, Chapter 16). To some extent, complexity is a question of perspective, and even for relatively simple artifacts, laypeople may come up with different models on how they function (Keil, 2003; Lawson, 2006). Depending on their causal model, people may also handle these artifacts differently. If they conceive, for instance, of a thermostat as turning the furnace on or off according to room temperature, running at a single constant speed (in line with a "feedback" model), they will tend to set it and leave it alone. By contrast, if they conceive of the thermostat as also controlling the rate of heat flow (in line with a "valve" model), they will tend to set it higher if they wish to heat up the house faster (Kempton, 1986).

One method of experimentally investigating problem-solving strategies for complex problems is by so-called *microworlds*: computer simulations of dynamic systems that are characterized by complexity, opaqueness, and dynamic development. Such microworlds range from simple scenarios, like regulating the temperature in a cold storage facility via a thermostat, to the truly complex scenario of serving as mayor of a town (Dörner, 1996). Microworlds are also employed to investigate cultural differences in people's performance in managing complex systems (Güss & Dörner, 2011; Strohschneider & Güss, 1998).

Solving the complexity problems in such situations requires the participants to come up with at least implicit assumptions concerning the underlying causal principles as well as the consequences their decision have, which—due to the very nature of complex problems—poses severe challenges to the ordinary participant (Funke, 2014). As pointed out by Güss and Robinson (2014), efforts to manage the system are affected by cultural background in at least three different ways. First, culturally mediated experiences likely shape the knowledge, problem-solving heuristics, and perceptions of control that people bring to the table. Confucians, for instance, are expected to more likely adopt a heuristic oriented toward a middle-way solution than non-Confucians. Second, cultural values likely shape which aspects of both the problem and the solution will be prioritized, for instance, whether social and relational aspects of a decision are taken into consideration. And third, the cultural learning environment of people likely shapes the temporal horizon for planning and decision-making. Whether participants prefer, for instance, long-term observations of changes and slow adjustments to complex systems, or direct reactions to the momentary situation, seems to depend on the extent to which their cultural environment has been stable and predictable, with participants from Germany exhibiting more reliance on long-term stability than those from India (Güss & Dörner, 2011; Strohschneider & Güss, 1998).

The Special Case of Systems Learning and Ecosystems

Studies on the implications of environmentally and ecologically sound decision-making (p. 725) and behavior have been addressed during the last 25 years and have involved cross-cultural and anthropological research (e.g., Casimir, 2008; Kempton, Boster, & Hartley, 1995; McCay & Acheson, 1987). Causal knowledge is of specific relevance here, as it affects risk perception and subsequent behavioral intentions (Bennardo, 2014; Viscusi & Zeckhauser, 2006).

The third author has been part of an interdisciplinary research team aiming at a better understanding of how culture affects biological concepts, ecological models, attitudes toward nature, and their implications for resource exploitation and conflicts. For example, our studies of ecological models in Guatemala reveal that one cultural group sees plants as helping animals and animals as helping plants, while another cultural group has the same model for how plants help animals but denies that animals help plants (Atran & Medin, 2008). The richer model is associated with greater sustainability of agro-forestry practices.

Related studies of Native-American and European-American hunters and fishermen in rural Wisconsin (Medin et al., 2006; Ross, Medin, & Cox, 2007) show different resource management strategies (and conflict over such differences) linked to different understandings of nature and the relation of humans to the rest of nature. For example, if a cultural group sees itself as *apart* from nature, management practices may focus on having minimal effects, as in the strategy of “catch and release” for sports fishing, where one attempts not to kill a single fish. If, instead, a group sees itself as *a part* of nature, management strategies such as “do not waste,” where only those fish needed are taken, may be more appealing (Bang, Medin, & Atran, 2007; Medin, et al., 2006).

Broad differences in cultural models, or what one might call “epistemological orientations” (i.e., ways of looking at and understanding the world), are associated with cultural differences in ecological reasoning in particular (Medin & Bang, 2014; Unsworth et al., 2012) and causal reasoning about complex systems more generally (Olson, 2013). As one example, in one set of interviews, Ross and colleagues (2007) asked Native-American Menominee and European-American hunters questions about whether different animals help or hurt the forest. For the probe involving porcupines, the European-American hunters uniformly said that porcupines hurt the forest because they girdle the bark of trees and the trees die. Menominee hunters were more likely to say that “everything has a role to play,” and a significant minority of Menominee hunters indicated that porcupines help the forest. They agreed that porcupines girdle the bark of trees and the trees die, but they went on to say that this opens up the forest to more light, which allows for more forest undergrowth, which in turn helps the forest retain moisture. This cultural difference suggests almost a qualitative difference in causal reasoning in the domain of ecosystems.

Note that ecological cognition is rich with causal relationships and therefore opportunities for causal learning. But also note that the issues of causal learning for such complex systems are almost different in kind from the most common cognitive science paradigms for studying causal cognition. Typically, the latter type of studies asks which of a set of potential causes is responsible for some effect. Ecosystems and other complex systems often involve feedback processes where A affects B and B affects A, as well as emergent processes that take place at different levels of scale. For example, wolves prey on individual deer, but wolves may help the deer population as a whole by selectively taking the weak and the sick.

Ecosystems also typically involve a web of relationships, and simple causal reasoning may lead to incorrect inferences. If two predator species of fish target some prey species, removing one of the predators does not necessarily lead to more members of the prey species, as WEIRD college students commonly assume (White 1997, 1999, 2000). More likely, it will lead to greater numbers of the surviving predator species.

Finally, we note that it is these complex contexts that elude a comprehensive causal analysis, in which religious beliefs may serve a vital function. For example, in the tragedy of the commons (Hardin, 1968), if each person acts rationally to maximize his or her own benefit, the resource will quickly be exhausted. Individual conservation may thus only serve to subsidize the greed of others. However, if there are spiritual entities that will punish greed and disrespect for the resource, then people may restrain their behavior (e.g., Atran & Medin, 2008). Cultural models of ecosystems or “nature” thus often go hand in hand with religious frameworks (e.g., Bird-David, 1990, 2008).

Blended Concepts and Representations: Science Versus Religion?

Even if cognitive approaches succeed in identifying domain-specific concepts and domain-specific principles for causal reasoning, the boundaries (p. 726) between domains may be far less clear for laypeople than for researchers, particularly if we go beyond the average psychology lab and its population of highly educated (WEIRD) students. People do not always hold just one causal model for a specific event (see Gelman & Legare, 2011, for a review), and conceptual clusters and models are often of a heterogeneous and variable composition, pertaining to different domains.

Religion is one of the cultural domains that provide a particularly rich source for competing concepts—and sometimes for concepts that are in direct conflict with basic biological knowledge (Bering, 2006; Rice, 2003). And yet such concepts need not be incompatible (Legare et al., 2012; Malinowski, 1948; O’Barr, 2001; Watson-Jones, Busch, & Legare, 2015). The belief that a collapsing granary killing a person is *proximally* caused by termites (Evans-Pritchard, 1937), or that an illness is *proximally* caused by an infection (Legare & Gelman, 2008), does not contradict the belief that these events are also *distally* caused by witchcraft. The joint consideration of “natural” causes and “witchcraft” as supplementing each other for bringing about an effect is explained by the Azande (from which the granary example is taken) by a metaphor. Just like two spears that hit an elephant at the same time equally contribute to its death, so are the termites and the ill intentions of a witch equally contributing to the collapse of the granary (Evans-Pritchard, 1937; and see Widlok, 2014, p. 5).

Framing effects are another mechanism that accounts for assessing the same entities differently in different interpretive systems (Keil, 2007). Animals, for instance, can be regarded as objects (e.g., when falling from a tree due to gravity), as living kinds (when being wounded), or as intentional agents (when defending their offspring). Interestingly, children appear to be more likely than adults to adopt a biological perspective, rather than a supernatural one, when asked for whether death terminates all bodily and mental processes, as was indicated by a study among the Vezo of Madagascar (Astuti & Harris, 2008). These observations suggest that biological explanations may predate those based on supernatural concepts, and that these original explanations are then increasingly modified by cultural input (see also Barrett & Behne, 2005; Bering, Hernández-Blasi, & Bjorklund, 2005).

Cultural worldviews or framework theories may define domain boundaries in specific ways, thus also suggesting different causal schemata. A dynamistic conceptualization, for instance, revolves around an impersonal force, such as *mana* in Polynesia (Firth, 1970; Shore, 1989), inherent even in objects of the physical domain. Animistic conceptualizations, on the other hand, consider more entities as animate than Western biologists are prepared to accept. The more people consider such concepts, the more we can expect to encounter permeable category boundaries in causal attributions and explanations. The increasing interest in the cognitive foundations of such concepts (Legare et al., 2012; Whitehouse & McCauley, 2005) is thus also an important step in understanding the cultural constitution of domain boundaries.

The (In)variance of Domain Boundaries Across Cultures

The domain-specific approach to causal cognition seemed to be justified by the assumption that domain boundaries are invariant (Atran, 1989) and that their perception is based on innate core knowledge (Spelke & Kinzler, 2007). These domain boundaries are violated, for instance, when ascribing (psychological) intentions to an (inanimate) computer. Several researchers consider such violations that intermingle the core attributes of physical, biological, and psychological entities and processes as “category mistakes” (Carey, 1985; Keil, 1994), and some even draw on them for defining “supernatural” explanations in contrast to “natural” explanations (e.g., Lindeman & Aarnio, 2006). But whether domain boundaries do restrict generalizations may depend on culture (e.g., Rothe-Wulf, 2014). Recall the findings reported earlier, according to which attribution patterns from the social-psychological domain can extend to the physical domain (Peng & Knowles, 2003). Overlap of the physical and the biological domain was also observed in the animacy task in Bödeker’s (2006) study on the development of intuitive physical knowledge. While only a minority of the German participants regarded clouds, fire, and waves as alive, a majority of the participants on Trobriand did so. This cultural difference was modulated by the degree of formal education on Trobriand, with more non-schooled than schooled participants assigning animacy to these entities. Importantly, across cultural groups, the categorization of an entity as animate was justified with the manner of motion. Explanations for the opposite categorization as inanimate, on the other hand, differed considerably: material or inner structure of the entities and their dissimilarity with human beings were (p. 727) the main arguments of the German participants, but were not even considered by the non-schooled Trobriand participants, who exclusively focused on aspects of motion or on their nature as artifacts instead (Bödeker, 2006).

With regard to the biological/psychological boundary, findings are even more puzzling. Some studies indicate that essentialist representations are easily transferred from the biological to the social-psychological domain, more specifically to social groups (e.g., Gelman, 2003; Gil-White, 2001), and this may be a tendency that appears across cultures (Sperber & Hirschfeld, 2004). Other cross-domain generalizations appear to be more constrained by cultural background (e.g., Medin & Atran, 2004; Morris & Peng, 1994). Obviously, cultural framework theories play a more important role in defining domains and their relevance for causal explanations than previously assumed, specifically as they have implications for which causal principles apply (see also ojalehto et al., 2015; Ross et al., 2003).

While all these findings provided indirect evidence for the permeability of domain boundaries, only one study so far has directly targeted these boundaries. To investigate their susceptibility to cultural influence, Rothe-Wulf (2014) collected data on the emic constitution and delineation of domains, and on how causally relevant factors are assigned to these domains. She had Tongan participants categorize such factors from a broad range of semantic fields according to their similarity. These fields included inanimate objects, physical forces and entities (such as sun, wind, or ocean), plants, animals, people of different status and rank, social institutions, supernatural entities, and others. On a coarse level of granularity, her findings seemed to support the widespread assumption of three ontological domains for causal cognition: the physical, biological, and psychological domain. A closer look at the data revealed, however, (1) that animals and plants are rather strictly separated, (2) that the (physical) ocean and its (biological) inhabitants together constitute one distinct domain, and (3) that “supernatural” phenomena and entities are closest to, and in fact overlap with, the human domain. More important, the assumed domain boundaries appear by far more permeable than they should be if they were based on innate categories for human information processing. Rothe-Wulf’s (2014) findings also fit the general observation that the categories on which the sorting of entities—and hence domain structure—is based may shift depending on context (Atran & Medin, 2008).

Summary

The main ontological domains are defined by entities having the same kind of causal properties. Based on the amount of *agency* involved, these domains are hierarchically structured: from the physical domain with no agency involved to the social domain with a maximum of agency. The degrees of freedom for interpretation increase accordingly from the physical to the social domain, where causal explanations are necessarily based on uncertain data and fallible inferences. Cultural variability in causal explanations appears to increase along the same lines from the physical to the social domain, but nonetheless is evident for all of these domains.

Yet, the data available so far also caution against the a priori assumption that causal cognition depends on domain—or that domain boundaries are universal. If one were to take domain boundaries as fixed and non-negotiable, then a blending of domains could be considered a metaphorical extension or even a “categorial mistake,” and may be taken as the constitutive element for “supernatural” beliefs. However, such a stance would prevent us from addressing the fundamental role that culture may have in defining and delineating domains in the first place. What belongs to the domain of the ocean in Tonga may fall into either the physical or the biological domain in Germany, and what is “supernatural” from a Western perspective may be completely natural from an Azande perspective. Domains do overlap in reality and in people’s conceptualization of them (ojalehto & Medin, 2015). If we wish to understand how people with different cultural backgrounds acquire competing concepts, how they access and integrate them, and how they cognitively process them when engaging in causal explanations, we need to investigate this overlap much more thoroughly.

Moreover, new domains may emerge if we adopt multiple cultural perspectives, such as (folk-)ecology with a focus on interactions of organisms, weather, and other forces (Medin et al., 2013), or (folk-)sociology with a focus on social relations (Hirschfeld, 2013). The latter would also be able to account for cultural differences in the emphasis on consequences of human behavior relative to its causes (Danziger, 2006; Lillard, 1998; Robbins & Rumsey, 2008).

Cultural Impacts on Cognitive Processing

The cross-cultural findings compiled in the preceding section justify the call for a more thorough (p. 728) investigation of the critical role that culture may play in causal cognition. In this section, we focus on an initial set of processes that have been identified as candidates for mediating such an influence, including (1) causal attribution tendencies and implicit theories, (2) the causal asymmetry bias, and (3) linguistic factors. Most of them revolve around shifts in attention and/or the activation of additional information.

Attribution Tendencies and Implicit Theories

Earlier, we discussed the relevance of the concept of agency for causal cognition and noted that, across cultures, people may differ in the extent to which they are willing to speculate on other people's mental states as causes of their behavior. This is closely linked to research on causal attributions, which has identified a range of attribution biases, most of which lead people to attribute other people's (negative) behavior in terms of their dispositions, while underestimating the influence of circumstances (for a meta-analysis, see Malle, 2006).

None of these biases, however, is immune to cultural influence. The first swath of research on how culture may affect attribution tendencies was inspired by the allegedly deep divide between two cultural clusters: "Western" cultures (primarily US) were found to be comparatively more individualistic and analytical, to hold values that emphasize an independent self-concept, the importance of personal accomplishments for one's identity, and the focus on rights over duties; "Eastern" (or East Asian) cultures, in contrast, were found to be comparatively more collectivistic, to regard the self as interdependent and as part of larger social groups that bind and mutually obligate the person, to value duties over rights, and to be strongly concerned with social harmony (Markus & Kitayama, 1991; Miller, 1984; Norenzayan & Nisbett, 2000; Triandis, 1995). Although subject to debate (e.g., Fiske, 2002; Takano & Osaka, 1999), these observations are largely accepted as supporting an impact of culture on attribution styles (Oyserman, Coon, & Kemmelmeier, 2002), and even on basic perceptual processes (Masuda & Nisbett, 2001; Oyserman & Lee, 2007). Recall that when Morris and Peng (1994), for instance, presented animated displays of interactions between a single fish and a group of fish, their US participants were more likely than the Chinese participants to explain the single fish's behavior by internal causes. The same pattern was found in (US vs. Chinese) newspaper reports on crimes (Morris & Peng, 1994, Study 2) and participants' accounts of murder cases (Study 3).

As one candidate for the mechanism by which these differences in attribution styles are driven, Morris and Peng (1994) proposed “implicit theories” (or “systems of thought” in Nisbett et al., 2001)—a cognitive framework that guides the encoding and representation of behavioral information, and that has impacts on perceptions, evaluations, and judgments involving causality. As implicit theories revolve around the relationship between the individual and the group, their influence should be constrained to the social-psychological domain (and perhaps extended to interactions in the biological domain that can be anthropomorphized), but should not generalize across domains. On this account, cultural differences in causal attribution should be found for the social domain, but not the physical domain (Morris & Peng, 1994; Morris, Nisbett, & Peng, 1995). Only if the trajectories of physical entities deviate from physical laws should impressions of animacy and thus social interpretations be invited (Heider & Simmel, 1944).

Peng and Knowles (2003) found cultural differences even in the physical domain, but still explained them along similar lines: whereas the Aristotelian folk physics prevalent in the West focuses on objects and their dispositions, such as a stone’s propensity to sink in water, Chinese folk physics is based on an inherently relational, contextual, and dialectical conceptualization, accommodating the idea that forces such as gravity may act over distance and may be exerted by a medium such as water (Needham, 1954). That the distinct influences of this folk understanding are attenuated by formal physics education (Morris & Peng, 1994; Peng & Knowles, 2003) is an interesting observation in itself, as it has been suggested that so-called naïve physics is not easily changed by formal education (much to the chagrin of physics teachers).

For studies on causal attribution, which have been primarily concerned with the relative proportions of internal and external attributions, it may have been sensible to operationalize *culture* in terms of the relationship between individual and group (Peng, Ames, & Knowles, 2001). The assumption that this single, even if central, social-psychological dimension should be sufficient to account for the full range of cultural differences in causal cognition (or even the intracultural variation), however, is neither plausible nor tenable. For example, consider the set of studies conducted on the floating scenario (described in the section “Causal Attributions (p. 729) for Launching and Floating”). The samples from Germany and Tonga constitute almost perfect complements, with Tongan participants exhibiting a more interdependent self-concept than German participants (Bender et al., 2012), and even more so than the Chinese ones (Beller, Bender, & Song, 2009a). Aggregated across scenarios, these cultural differences in social orientation indeed correlated with differences in causal attributions (Beller, Bender, & Song, 2009b), as would be predicted by attribution theorists: the (individual) floater was rated causally most relevant in Germany and least in Tonga. However, a closer look at the experimental conditions indicated that the factors *content* and *linguistic cues* not only affected participants’ assessment as well, but also did so distinctly for each cultural group. More concretely, when asked about oil (rather than wood) floating on water, judgments not only shifted, they reversed among the Chinese and Tongan sample, and even into diverging directions: the Chinese participants now focused more strongly on the floater (oil) than the carrier (water), and the Tongan participants more strongly on the carrier (water) than the floater (oil). Such effects of content emerge because people habitually access causal background knowledge that goes beyond the information explicitly given (Beller & Kuhnmünch, 2007; Waldmann, Hagmayer, & Blaisdell, 2006), and likely includes culture-specific concepts, which apparently also modulate the reasoning process, even in rather simple physical scenarios (Beller, Bender, & Song, 2009a).

Causal Asymmetry Bias

A related, yet distinct pattern to be found in this field is the *causal asymmetry bias* (White, 2006), whereby people see the forces exerted by bodies on each other as unequal, even when they are not. That is, even in strictly symmetric interactions (in physical terms defined by *action = reaction*), causal roles are assigned such as that one object is identified as being "the cause" and another as "the effect," and the force exerted by the cause object is perceived as being greater than the force exerted by the effect object (if the latter is not neglected altogether). For this reason, a scene in which one object hits another object, which then begins to move while the first one stops, is typically described as "the first object launched the second," rather than "the second object stopped the first." White (2006) considers the asymmetry bias a general feature of causal cognition that affects most of what people perceive, believe, and linguistically express with regard to causal relations and may even restrict research questions and methods of researchers.

Initially, this bias was primarily demonstrated in experiments with English-speaking participants on a variety of (dynamic) collision events (White, 2007). In a study that extended the range to static settings and to participants from two very different cultural backgrounds (i.e., German and Tongan), similar patterns were observed, yet with important culturally variable nuances (Bender & Beller, 2011). Causal asymmetries varied across tasks and cultures: in four tasks, asymmetry patterns were the same in that both groups prioritized the same entity as causally relevant; in one task (i.e., the floating scenario), they were opposing in that Tongans prioritized the carrier and Germans the floater; and in the remaining four tasks, asymmetry patterns were detected in one cultural group only. The strength and direction of the asymmetry also varied across types of physical relations (like buoyancy or mutual attraction), the entities involved (such as freshwater, wood, or cornflakes as floaters), and whether the event was described in an abstract or concrete manner (as with "celestial bodies" vs. "earth" and "moon").

Interestingly, the question on whether, overall, the cultural differences reflect differences in social orientation (or "implicit theory" in Morris & Peng's terminology) depended on the level of aggregation. Aggregated across individual ratings, the asymmetry bias was less pronounced among the Tongan participants, with average ratings close to the midpoint of the rating scale, in line with the prevailingly collectivistic values (and in contrast to the German pattern that was skewed toward the floater). On the individual level, however, Tongan participants gave substantially *more* asymmetrical ratings than the German participants, with the vast majority giving strong ratings either for the floater or the carrier (Bender & Beller, 2011)—a finding that cannot be accounted for by any of the implicit theories or ensuing attribution biases presented earlier.

Linguistic Factors

That linguistic frames and cues can influence cognitive processes and specifically memory has long been known (e.g., Loftus & Palmer, 1974). Language is also among the most potent tools for focusing attention on possible causes (for overviews, see in this volume, Solstad & Bott, Chapter 31; Wolff & Thorstad, Chapter 9). Introducing one of several equally relevant factors as "given"—as in "given enough sunlight, flowers (p. 730) grow well when a fertilizer is added"—relegates this factor (here: the sun) to an enabling condition and increases the likelihood of other factors (such as the fertilizer) to be considered as the prime causative (Kuhnmünch & Beller, 2005). The choice of a particular verb may also affect people's assessment, as it implicitly suggests a specific causal relation; "betray," for instance, spotlights the agent as likely cause, whereas "praise" shifts the focus to the patient (overview in Pickering & Majid, 2007).

The verb chosen may even reframe the entire scene: while both sentences "A launches B" and "B stops A" describe the same event, they assign agency in fundamentally different ways (e.g., Mayrhofer & Waldmann, 2014). Because languages differ systematically in how they frame causal events and express or mark agency (e.g., Bohnemeyer et al., 2010; Ikegami, 1991; Kanero, Hirsh-Pasek, & Golinkoff, 2016; Wolff et al., 2005, 2009), they are powerful candidates for mediating cultural effects on causal cognition (please note that we treat language here as one aspect of culture, while the relationship between the two is in fact much more complex). In the following, we focus on how the thematic roles of *agent* and *patient* are assigned to either entity in question, as this is not only a feature that can be individually manipulated, but also one for which cross-linguistic differences at both the structural and the conventional level have been documented.

At the structural level, languages differ with regard to how they categorize agents and patients. Consider the intransitive sentence "He walked" versus the transitive sentence "She guided them." Nominative-accusative languages treat subjects or *agents* in these two sentences alike, namely with the nominative case ("he"/"she"), while setting them apart from the objects or *patients* of transitive sentences (in the accusative: "them"). Ergative-absolutive languages, on the other hand, treat agents of intransitive and patients of transitive sentences alike (with the absolute case), while agents of transitive sentences are set apart by the ergative case. These languages thus distinguish grammatically between actions of an agent that have effects only for him- or herself and those that also have consequences for others (Duranti, 1994). According to Goldin-Meadow (2003), the patient focus inherent in the ergative pattern may be the "natural" way of viewing an action. Deaf children of English-speaking parents, for instance, direct more attention to the patient in a sentence like "The mouse eats the cheese" (Goldin-Meadow, 2003). If this holds more generally, then introducing in a phrase like "the cheese is eaten" a transitive agent ("by the mouse"), and marking it with the ergative case should provide a particularly potent tool for attributing agency in an event. This is exactly what has been observed in social interactions in Samoa, where the ergative in the sociopolitical domain is used almost exclusively by people of higher rank and predominantly for praising God or the polity for positive things (such as social order), and for blaming single persons, typically of lower rank, for violations of rules (Duranti, 1994).

Whether this tool may also affect causal attributions in other domains was investigated by Beller, Bender, and Song (2009b). One of the variations in their design involved a shift in the linguistic cue: describing wood either as *floating on* water or as *being carried by* water. In Tongan this implies a shift from absolutive to ergative marking, and this shift inverted the Tongan ratings from a preference for the floater to one for the carrier. The effect appears to be weak, however, and to depend on specific phrasings (Bender & Beller, 2011, submitted).

Another, optional way of dealing with thematic roles is by dropping the agent when turning transitive or agentive sentences (as in "Tina broke the glass") into intransitive or non-agentive sentences ("The glass broke"). Fausey and colleagues tested whether speakers of different languages have distinct preferences for using either type of sentence when describing events, and how this might affect eyewitness memory. They presented videos of an intentional or accidental version of various events. Participants were asked to describe the event and to identify the person involved in it. Speakers of English as well as Spanish (or Japanese) alike described intentional events agentively, but the latter were less likely to use agentive descriptions also for the accidental events. The same pattern emerged in the memory task, with the two groups remembering the agents of intentional events equally well, but with Spanish (Japanese) speakers being less likely to remember the agents of accidental events (Fausey & Boroditsky, 2011; Fausey et al., 2010). And finally, after having listened to a series of non-agentive phrasings with the goal of identifying the corresponding picture, even English speakers became less likely to remember the agents of accidental events in a subsequent task than participants who had listened to agentive phrasings (Fausey et al., 2010, Study 3). In other words, priming a non-agentive speech pattern effectively shifted English speakers' (p. 731) attention away from the agents of accidental events. Habitual patterns of linguistic framing thus appear to affect whether people pay attention to, encode, and remember different aspects of the same event.

Summary

This section has demonstrated that, across domains, the way in which people reason causally about certain events may vary depending on their cultural background. We have addressed the question of whether cognitive processes may also vary depending on their cultural background, thus mediating such cultural influences. It appears that cultural background affects the readiness to attribute behavior and events to internal versus external causes or the tendency to single out one of several possible factors and to pay more or less attention to the agent. Most accounts revolve around shifts in the focus of attention and/or the activation of additional information, and alternatively identify implicit theories, habituation processes, and/or linguistic factors as the driving force for them. To address the exact manner in which culture exerts this influence, we will need more sophisticated conceptions of culture that go beyond values on a single dimension of cultural differences. One aspect of a more nuanced conception of culture is the question of whether separation in content and processing is a sensible thing to begin with. We turn to both issues in the next sections.

The Cultural Context of Causal Cognition

Causal inferences often depend on the causal field, that is, they depend on what is seen as background and hence of little causal relevance (such as birth being a *condition* for death and thus part of its causal field, but still not its *cause*), in contrast to factors that make a difference (Einhorn & Hogarth, 1986). Given that so much of these causal inferences appear to be sensitive to circumstances—the question of when and how domain boundaries are relevant, for instance, or the concepts activated during processing—it seems only natural to also focus more explicitly on the context in which causal cognition occurs as one of its three major dimensions besides content and processing.

Specific attention has been paid to situations in which religious (or “supernatural”) versus “natural” explanations for events are activated (e.g., Astuti & Harris, 2008; Legare et al., 2012; Malinowski, 1948; Tucker et al., 2015; Walker, 1992). A very prominent example is Evans-Pritchard’s (1937) chapter on the collapsing granary and how it is explained by the Azande (see the section “Blended Concepts and Representations: Science Versus Religion?”). Whether this event is attributed to an infestation with termites or to witchcraft depends on the question at stake: if the issue is the proximal cause of why the granary collapsed, then its destabilization by termites is the appropriate level to focus on. But there is also the question of the distal cause: Why did the granary collapse exactly at that point in time when a particular person was sitting underneath, resulting in his injury or death? By Azande sensibilities, such an apparent coincidence of unfortunate circumstances is much more likely to be accounted for by the ill intentions of a powerful person than by chance. The main difference between the European and the Azande approach, as identified by Evans-Pritchard (1937), arose thus not so much from how people internally construe causality, but from how far (proximal vs. distal) causal explanations are expanded and from which entities are included as causal agents (Widlok, 2014).

Similarly, Vezo participants from rural Madagascar have been shown to more likely describe death as terminating all bodily and mental processes when the context of the question is related to the corpse than when it related to the ancestral practices associated with the afterlife (Astuti & Harris, 2008; for similar studies in Nigeria and Vanuatu, see also Walker, 1992; Watson-Jones et al., 2015). More recently, Astuti and Bloch (2015) also investigated the conditions under which Malagasy people take intentionality into account when assessing acts of wrongdoing, and again found an important effect of context (for psychological treatments of this topic, see Lagnado & Gerstenberg, Chapter 29 in this volume). A sharp distinction between intentional wrongdoing and wrongdoing through negligence or by accident is drawn for mundane events, less so for breaches of ancestral taboos, and almost never for instances of incest. While intentionality is recognized as an important factor in cases of wrongdoing, its consideration depends on the importance of the issues at stake—in the case of incest, the catastrophic consequences for the whole community (Astuti & Bloch, 2015).

In a nutshell, depending on culture and context, people appear to differ in their willingness to make causal attributions and ascribe responsibility, especially being less inclined to do so when cultural values emphasize the secrecy or privacy of people's mental life (Danziger & Rumsey, 2013; Robbins & Rumsey, 2008). They also differ in the extent to which they actively search for information for (p. 732) causal attributions and ascriptions of responsibility, either because they rely on what they already know, or because they take the potential causal factor not as enduring and hence irrelevant for anticipating future events (Beer & Bender, 2015). People differ in the number of possible causes they take into consideration, in the extent to which they trace causal links in the system (e.g., in seeking distal as compared to more proximal causes and consequences), in their sensitivity to covariation, and in their likeliness to anticipate changes based on previous trends (Choi et al., 2003; Maddux & Yuki, 2006). And even within cultural groups, the concern with these topics, the usage of respective vocabulary, and the conceptual ingredients can change over (historic) time (Iliev and ojalehto, 2015).

Tasks for Future Research

People across the world search for causal explanations, but the degree of cultural variation in how they do so is substantial. Even the very assumption that people engage in causal considerations on a regular basis is debatable; in various cultural groups, it seems to be common practice *not* to reason about the motives of people's behavior, but to focus on its consequences instead. This observation challenges laboratory studies of causal reasoning in two ways. One is that they may be relying on participant samples, who are atypical in their focus on intentionality or motive, and the other is that studies which ask directly about intentionality bypass the issue of when intentionality is seen as relevant to causal cognition.

Moreover, the concepts upon which causal explanations are based may be drawn from a heterogeneous pool of competing concepts. The sources for these concepts range from (popular) scientific knowledge and folk wisdom to "supernatural" or religious beliefs. Both this pool of concepts and the principles for selecting among them are affected by culture and context. More important, the distinction between such categories is likely culturally construed, as may be the domain boundaries on which these categories are based. And finally, even the mechanisms underlying causal conclusions may be affected by the cultural context in which people grow up and by characteristics of the language they speak. This constitutes an additional set of challenges for laboratory studies of causal reasoning and the theories growing out of them.

Given these substantial influences of cultural background on causal cognition at a range of levels, the field of cognitive science needs to change its research practices, taking sample diversity much more seriously than it has in the past. Constraining research to participants from Western, educated, industrialized, rich, and democratic countries (Henrich, Heine, & Norenzayan, 2010) will not yield a comprehensive understanding of human causal cognition. Even the assumption that WEIRD people are all alike, or that the same methods and body of work used to describe cross-cultural differences may be useful in illuminating intra-cultural differences, is misleading (Romney, Weller, & Batchelder, 1986).

We also need to refocus our perspective on core research questions that have remained unaddressed and therefore remain unanswered. To begin with the obvious, we need to ask for the culture-specific aspects of content, processing, and context involved in causal cognition, and we need to go beyond simply documenting cultural differences to strive for explanations of how people's cultural background *constitutes* what we observe:

- What do people learn about general characteristics of causality as part of their cultural heritage, and which concrete concepts and models do they acquire that may shape their perception and reflections?
- How does culture affect the constitution of (heterogeneous) concept pools and the selection between competing concepts, and how are alternative orientations acquired and coordinated in multicultural contexts?
- How do shifting domain boundaries and extensive cross-domain interactions come to bear on causal cognition across cultures?
- Do cultural and linguistic influences already affect causal perception and learning, or are they restricted to subsequent processes of explanation, reasoning, and problem-solving?
- Which factors contribute to the emphasis that people may place on the understanding of causes and reasons (relative to an appraisal of effects and consequences)?
- When, why, and how do people search for additional information? To what extent are the attribution tendencies and reasoning biases observed in previous studies a product of our cognitive toolkit, and to what extent do they arise from learning and habituation?
- And to what extent may cultural background and context modulate agency construal?

Culture is not simply a dichotomous variable that may explain why two groups of people differ in (p. 733) some respect. It is a constitutive part of our cognitive, social, and material world—as essential, and often as oblivious to us, as the oxygen we are breathing. This is why all causal cognition is ultimately cultural; the only possible justification for relegating its treatise to a single chapter of this volume is that we still know relatively little about it.

If culture is a constitutive factor in causal cognition, then research strategies based on the idea that culture can be seen as permitting modest variation on a universal causal reasoning module are doomed to fail. There may indeed be aspects of causal cognition that are universal—to humans at least (and perhaps to our primate relatives and/or other social species such as dolphins or crows)—but these aspects can only be appreciated as universal if we have considered in our research designs the possibility that they are not (Bender & Beller, 2016).

An appreciation of the foundational role that culture plays in human cognition will help us to identify our cultural blind spots. Some of these have prevented attribution theorists from discovering that agency may be assigned to entities other than just individuals. These blind spots are largely generated by the "home-field disadvantages," the most relevant of which is the tendency to leave one's own culture unmarked, taking it as the standard from which others deviate (Medin, Bennis, & Chandler, 2010). To overcome the home-field disadvantages, we need not only question our cultural presumptions, but also consider the potential for within-group variation, in contrast to between-group variation.

A second type of blind spot is that generated by the causal asymmetry bias. The asymmetric assignment of causal roles leads us (as people) to perceive, understand, and describe interactions not as symmetric relations, but as "relations between doer and done-to" (White, 2006, p. 143). If one entity is regarded as causative, its importance will be overestimated at the expense of the other. Yet, focusing on single factors as critical may impair problem-solving for systems with any complexity—for instance, with regard to technical malfunctioning (for severe cases, see Dörner, 1996), ecosystem management, or social conflicts. This asymmetry also biases the methods with which we (as scientists) investigate causal understanding, the causal inferences we draw from our findings, and, more important even, the questions we ask in the first place (White, 2006, p. 144; and see Bender & Beller, 2011).

A third type of blind spot has to do with our scientific traditions, such as the distinction in content versus processing, reflected in a division of labor between anthropology and its search for cultural variability, on the one hand, and psychology and its focus on universal principles and mechanisms, on the other (D'Andrade, 1981). The very ways in which our subfields of science are organized may reflect the cultural history of Western science, and different histories might well lead to different organizational schemes (e.g., Cajete, 1999). This partitioning of content and process between anthropology and psychology has not only led to a fragmentation of research approaches and findings, but has also obstructed a perspective on content and processes as intricately linked and as affecting each other. While recent years have seen a revision of this distinction as neither reasonable nor tenable (Bang, Medin, & Atran, 2007; Barrett, Stich, & Laurence, 2012; Kitayama & Uskul, 2011; Medin and Atran, 2004), it takes much longer to overcome the scientific boundaries (Bender, Beller, & Nersessian, 2015; Bender, Hutchins, & Medin, 2010; Bloch, 2012; and see the debate in Bender, Beller, & Medin, 2012). For real scientific progress in this field, however, this is a challenge we need to rise to.

Conclusions

Causality is a core concept of human cognition, perhaps even *the* core concept. As we have seen, culture plays a critical role in causal cognition on various levels and in all domains, albeit with graded intensity. Importantly, culture affects not only how, but even whether people engage in causal explanations, by defining the settings in which causal cognition occurs, the manner in which potential factors are pondered, and the choices for highlighting one of several potential causes or for expressing them linguistically.

Our cultural background affects which situations we perceive as problems, how we communicate with respect to them, and how we try to solve them. In an increasingly globalized world, and with a diversity of stakeholders involved, cultural differences in how we perceive, communicate, and handle causal relations may have critically important implications. Given that questions about causes and reasons loom large in our lives—and are answered in such diverse ways across cultures—a systematic and thorough investigation into the cultural dimension of causal cognition is long overdue.

References

Ahn, W.-k., Kalish, C. W., Gelman, S. A., Medin, D. L., Luhmann, C., Atran, S., Coley, J. D., & Shafto, P. (2001). (p. 734) Why essences are essential in the psychology of concepts. *Cognition*, *82*, 59–69.

Alicke, M. D., Mandel, D. R., Hilton, D. J., Gerstenberg, T., & Lagnado, D. A. (2015). Causal conceptions in social explanation and moral evaluation: A historical tour. *Perspectives on Psychological Science*, *10*, 790–812.

Astuti, R., & Bloch, M. (2015). The causal cognition of wrong doing: Incest, intentionality and morality. *Frontiers in Psychology*, *6*(136), 1–7.

Astuti, R., & Harris, P. L. (2008). Understanding mortality and the life of the ancestors in rural Madagascar. *Cognitive Science*, *32*, 713–740.

Astuti, R., Solomon, G. E. A., & Carey, S. (2004). *Constraints on conceptual development: A case study of the acquisition of folkbiological and folksociological knowledge in Madagascar*. Boston; Oxford: Blackwell.

Atran, S. (1989). Basic conceptual domains. *Mind & Language*, *4*(1–2), 7–16.

Atran, S. (1993). *Cognitive foundations of natural history: Towards an anthropology of science*. Cambridge: Cambridge University Press.

Atran, S., & Medin, D. L. (2008). *The native mind and the cultural construction of nature*. Cambridge, MA: MIT Press.

Atran, S., Medin, D. L., Lynch, E., Vapnarsky, V., Ucan Ek', E., & Sousa, P. (2001). Folkbiology doesn't come from folkpsychology: Evidence from Yukatek Maya in cross-cultural perspective. *Journal of Cognition and Culture*, *1*, 3–42.

Au, T. K.-f., & Romo, L. F. (1999). Mechanical causality in children's "folkbiology." In D. L. Medin & S. Atran (Eds.), *Folkbiology* (pp. 355–401). Cambridge, MA: MIT Press.

Bailenson, J. N., Shum, M. S., Atran, S., Medin, D. L., & Coley, J. D. (2002). A bird's eye view: Biological categorization and reasoning within and across cultures. *Cognition*, *84*, 1–53.

Bang, M., Medin, D. L., & Atran, S. (2007). Cultural mosaics and mental models of nature. *Proceedings of the National Academy of Sciences*, *104*, 13868–13874.

Barrett, H. C., & Behne, T. (2005). Children's understanding of death as the cessation of agency. *Cognition*, *96*, 93–108.

Barrett, H. C., Stich, S., & Laurence, S. (2012). Should the study of *Homo sapiens* be part of cognitive science? *Topics in Cognitive Science*, *4*, 379–386.

Bastian, B., & Haslam, N. (2006). Psychological essentialism and stereotype endorsement. *Journal of Experimental Social Psychology*, *42*, 228–235.

Beer, B., & Bender, A. (2015). Causal inferences about others' behavior among the Wampar, Papua New Guinea—and why they are hard to elicit. *Frontiers in Psychology*, *6*(128), 1–14.

Beller, S., Bender, A., & Song, J. (2009a). Conditional promises and threats in Germany, China, and Tonga: Cognition and emotion. *Journal of Cognition and Culture*, *9*, 115–139.

Beller, S., Bender, A., & Song, J. (2009b). Weighing up physical causes: Effects of culture, linguistic cues, and content. *Journal of Cognition and Culture*, *9*, 347–365.

Beller, S., & Kuhnmünch, G. (2007). What causal conditional reasoning tells us about people's understanding of causality. *Thinking and Reasoning*, *13*, 426–460.

Bender, A., & Beller, S. (2011). Causal asymmetry across cultures: Assigning causal roles in symmetric physical settings. *Frontiers in Psychology*, *2*(231), 1–10.

Bender, A., & Beller, S. (2016). Probing the cultural constitution of causal cognition: A research program. *Frontiers in Psychology*, *7*, 245.

Bender, A., & Beller, S. (submitted). Agents and patients in physical settings: Is the assignment of causal roles affected by linguistic cues?

Bender, A., Beller, S., & Medin, D. L. (Eds.) (2012). Does cognitive science need anthropology? *Topics in Cognitive Science*, *4*(3), 342–466.

Bender, A., Beller, S., & Nersessian, N. J. (2015). Diversity as asset. *Topics in Cognitive Science*, *7*, 677–688.

Bender, A., Hutchins, E., & Medin, D. L. (2010). Anthropology in cognitive science. *Topics in Cognitive Science*, *2*, 374–385.

Bender, A., Spada, H., Rothe-Wulf, A., Traber, S., & Rauss, K. (2012). Anger elicitation in Tonga and Germany: The impact of culture on cognitive determinants of emotions. *Frontiers in Psychology*, *3*(435), 1–20.

Bennardo, G. (2014). The fundamental role of causal models in cultural models of nature. *Frontiers in Psychology*, *5*, 1140.

Bering, J. M. (2006). The folk psychology of souls. *Behavioral and Brain Sciences*, *29*, 453–498.

Bering, J. M., Hernández-Blasi, C., & Bjorklund, D. F. (2005). The development of “afterlife” beliefs in secularly and religiously schooled children. *British Journal of Developmental Psychology*, *23*, 587–607.

Berlin, B. (1972). Speculations on the growth of ethnobotanical nomenclature. *Language in Society*, *1*, 51–86.

Berlin, B. (1992). *Ethnobiological classification: Principles of categorization of plants and animals in traditional societies*. Princeton, NJ: Princeton University Press.

Berlin, B., Breedlove, D. E., & Raven, P. H. (1973). General principles of classification and nomenclature in folk biology. *American Anthropologist*, *75*, 214–242.

Bird-David, N. (1990). The giving environment: Another perspective on the economic system of gatherer-hunters. *Current Anthropology*, *31*(2), 189–196.

Bird-David, N. (2008). Relational epistemology, immediacy, and conservation: Or, what do the Nayaka try to conserve? *Journal for the Study of Religion, Nature & Culture*, *2*(1), 55–73.

Bloch, M. (2012). *Anthropology and the cognitive challenge*. Cambridge: Cambridge University Press.

Bödeker, K. (2006). *Die Entwicklung intuitiven physikalischen Denkens im Kulturvergleich: Bewegung, Kraft, Leben, Gewicht* [The development of intuitive physical thinking in cultural comparison: motion, force, life, and weight]. Münster: Waxmann.

Bohnemeyer, J., Enfield, N. J., Essegbey, J., & Kita, S. (2010). The macro-event property: The segmentation of causal chains. In J. Bohnemeyer & E. Pederson (Eds.), *Event representation in language* (pp. 43–67). Cambridge: Cambridge University Press.

Boster, J. S., & Johnson, J. C. (1989). Form or function: A comparison of expert and novice judgments of similarity among fish. *American Anthropologist*, *91*, 866–889.

Cajete, G. A. (1999). *Igniting the sparkle: An indigenous science education model*. Skyland, NC: Kivaki Press.

Callaghan, T., Rochat, P., Lillard, A., Claux, M. L., Odden, H., Itakura, S., Tapanya, S., & Singh, S. (2005). Synchrony in the onset of mental-state reasoning: Evidence from five cultures. *Psychological Science*, *16*, 378–384.

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: Bradford.

Carey, S. (2009). *The origin of concepts*. Oxford: Oxford University Press.

Casimir, M. J. (Ed.) (2008). *Culture and the changing environment: Uncertainty, cognition, and risk management in cross-cultural perspective*. Oxford: Berghahn. (p. 735)

Choi, I., Dalal, R., Kim-Prieto, C., & Park, H. (2003). Culture and judgement of causal relevance. *Journal of Personality and Social Psychology*, *84*, 46–59.

Coley, J. D., Medin, D. L., & Atran, S. (1997). Does rank have its privilege? Inductive inferences within folkbiological taxonomies. *Cognition*, *64*, 73–112.

D'Andrade, R. G. (1981). The cultural part of cognition. *Cognitive Science*, *5*, 179–195.

Danziger, E. (2006). The thought that counts: Interactional consequences of variation in cultural theories of meaning. In N. Enfield, J. Nicholas, & S. Levinson (Eds.), *Roots of human sociality: Culture, cognition and interaction* (pp. 259–278). Oxford: Berg Press.

Danziger, E., & Rumsey, A. (2013). Introduction: From opacity to intersubjectivity across languages and cultures. *Language and Communication*, *33*(3), 247–250.

Dijksterhuis, A., Preston, J., Wegner, D. M., & Aarts, H. (2008). Effects of subliminal priming of self and God on self attribution of authorship for events. *Journal of Experimental Social Psychology*, *44*, 2–9.

Dörner, D. (1989/1996). *The logic of failure: Recognizing and avoiding error in complex situations*. New York: Basic Books. [Orig. 1989: *Die Logik des Mißlingens*. Reinbek: Rowohlt].

Duranti, A. (1994). *From grammar to politics: Linguistic Anthropology in a Western Samoan village*. Berkeley: University of California Press.

Einhorn, H. J., & Hogarth, R. M. (1986). Judging probable cause. *Psychological Bulletin*, *99*, 3–19.

Ellen, R. (Ed.) (2006). *Ethnobiology and the science of humankind*. [Special Issue of the Journal of the Royal Anthropological Institute]. Oxford: Blackwell.

Evans-Pritchard, E. E. (1937). *Witchcraft, oracles and magic among the Azande*. Oxford: Clarendon.

Fausey, C. M., & Boroditsky, L. (2011). Who dunnit? Cross-linguistic differences in eye-witness memory. *Psychonomic Bulletin & Review*, *18*, 150–157.

Fausey, C., Long, B., Inamori, A., & Boroditsky, L. (2010). Constructing agency: The role of language. *Frontiers in Psychology*, *1*, 162.

Firth, R. (1970). An analysis of *mana*: An empirical approach. In T. Harding & B. Wallace (Eds.), *Cultures of the Pacific* (pp. 316–333). New York: Free Press.

Fiske, A. P. (2002). Using individualism and collectivism to compare cultures—A critique of the validity and measurement of the constructs: Comment on Oyserman et al. (2002). *Psychological Bulletin*, *128*, 78–88.

Froerer, P. (2007). Wrongdoing and retribution: Children's conceptions of illness causality in a central Indian village. *Anthropology & Medicine*, *14*, 321–333.

Funke, J. (2014). Analysis of minimal complex systems and complex problem solving require different forms of causal cognition. *Frontiers in Psychology*, *5*, 739.

Gelman, S. A. (2003). *The essential child: Origins of essentialism in everyday thought*. Oxford: Oxford University Press.

Gelman, S. A., Chesnick, R. J., & Waxman, S. R. (2005). Mother–child conversations about pictures and objects: Referring to categories and individuals. *Child Development*, *76*, 1129–1143.

Gelman, S. A., & Legare, C. H. (2011). Concepts and folk theories. *Annual Review of Anthropology*, *40*, 379–98.

Gerber, E. R. (1985). Rage and obligation: Samoan emotion in conflict. In G. M. White & J. Kirkpatrick (Eds.), *Person, self and experience: Exploring Pacific ethnopsychologies* (pp. 121–167). Berkeley: University of California Press.

Gil-White, F. (2001). Are ethnic groups biological 'species' to the human brain? Essentialism in our cognition of some social categories. *Current Anthropology*, *42*, 515–554.

Goldberg, R. F., & Thompson-Schill, S. L. (2009). Developmental "roots" in mature biological knowledge. *Psychological Science*, *20*, 480–487.

Goldin-Meadow, S. (2003). Thought before language: Do we think ergative? In D. Gentner & S. Goldin-Meadow (Eds.), *Language in mind* (pp. 493–522). Cambridge, MA: MIT Press.

Goswami, U. (2002). *Blackwell handbook of childhood cognitive development*. Oxford: Blackwell.

Güss, D. C., & Dörner, D. (2011). Cultural differences in dynamic decision-making strategies in a non-linear, time-delayed task. *Cognitive Systems Research*, *12*, 365–376.

Güss, C. D., & Robinson, B. (2014). Predicted causality in decision making: The role of culture. *Frontiers in Psychology*, *5*, 479.

Haggard, P., & Tsakiris, M. (2009). The experience of agency: Feelings, judgments, and responsibility. *Current Directions in Psychological Science*, *18*, 242–246.

Hagmayer, Y., & Engelmann, N. (2014). Causal beliefs about depression in different cultural groups: What do cognitive psychological theories of causal learning and reasoning predict? *Frontiers in Psychology*, *5*, 1303.

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*, 1243–1248.

Harvey, G. (2005). *Animism: Respecting the living world*. Kent Town, Australia: Wakefield Press.

Hatano, G., & Inagaki, K. (1999). A developmental perspective on informal biology. In D. L. Medin & S. Atran (Eds.), *Folkbiology* (pp. 321–354). Cambridge, MA: MIT Press.

Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior. *American Journal of Psychology*, *57*, 243–259.

Heit, E., & Rubinstein, J. (1994). Similarity and property effects in inductive reasoning. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *20*, 411–422.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*, 61–135.

Hirschfeld, L. A. (2013). The myth of mentalizing and the primacy of folk sociology. In M. R. Banaji & S. A. Gelman (Eds.), *Navigating the social world: What infants, children, and other species can teach us* (pp. 101–106). Oxford: Oxford University Press.

Hirschfeld, L. A., & Gelman, S. A. (Eds.) (1994). *Mapping the mind: Domain-specificity in cognition and culture*. Cambridge: Cambridge University Press.

Hmelo-Silver, C. E., & Azevedo, R. (2006). Understanding complex systems: Some core challenges. *Journal of the Learning Sciences*, *15*, 53–61.

Hollan, D., & Throop, C. J. (2008). Whatever happened to empathy? Introduction. *Ethos*, *36*, 385–401.

Ikegami, Y. (1991). “Do-language” and “become-language”: Two contrasting types of linguistic representation. In Y. Ikegami (Ed.), *The empire of signs* (pp. 285–326). Amsterdam; Philadelphia: John Benjamins.

Iliev, R., & ojalehto, b. (2015). Bringing history back to culture: On the missing diachronic component in the research on culture and cognition. *Frontiers in Psychology*, *6*, 716.

Inagaki, K., & Hatano, G. (2002). *Young children's naïve thinking about the biological world*. New York; Brighton: Psychology Press. (p. 736)

Inagaki, K., & Hatano, G. (2004). Vitalistic causality in young children's naive biology. *Trends in Cognitive Sciences*, *8*, 356–362.

Inagaki, K., & Hatano, G. (2006). Young children's conception of the biological world. *Current Directions in Psychological Science*, *15*, 177–181.

Kanero, J., Hirsh-Pasek, K., & Golinkoff, R. M. (2016). Can a microwave heat up coffee? How English- and Japanese-speaking children choose subjects in lexical causative sentences. *Journal of Child Language*, *43*(5), 993–1019.

Keil, F. C. (1994). The birth and nurturance of concepts by domains: The origins of concepts of living things. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain-specificity in cognition and culture* (pp. 234–254). Cambridge: Cambridge University Press.

Keil, F. C. (2003). Folkscience: Coarse interpretations of a complex reality. *Trends in Cognitive Sciences*, *7*, 368–373.

Keil, F. C. (2007). Biology and beyond: Domain specificity in a broader developmental context. *Human Development*, *50*, 31–38.

Kempton, W. M. (1986). Two theories of home heat control. *Cognitive Science*, *10*, 75–90.

Kempton, W. M., Boster, J. S., & Hartley, J. A. (1995). *Environmental values in American culture*. Cambridge, MA: MIT Press.

Kitayama, S., & Uskul, A. (2011). Culture, mind, and the brain: Current evidence and future directions. *Annual Review in Psychology*, *62*, 419–449.

Knight, N. (2008). Yukatek Maya children's attributions of belief to natural and non-natural entities. *Journal of Cognition and Culture*, *8*, 235–243.

Knight, N., Sousa, P., Barrett, J. L., & Atran, S. (2004). Children's attributions of beliefs to humans and God: Cross-cultural evidence. *Cognitive Science*, *28*, 117–126.

Kohn, E. (2013). *How forests think: Toward an anthropology beyond the human*. Berkeley: University of California Press.

Kuhnmünch, G., & Beller, S. (2005). Distinguishing between causes and enabling conditions—through mental models or linguistic cues? *Cognitive Science*, *29*, 1077–1090.

Lawson, R. (2006). The science of cycology: Failures to understand how everyday objects work. *Memory & Cognition*, *34*, 1667–1675.

Legare, C. H., Evans, E. M., Rosengren, K. S., & Harris, P. L. (2012). The coexistence of natural and supernatural explanations across cultures and development. *Child Development*, *83*(3), 779–793.

Legare, C. H., & Gelman, S. A. (2008). Bewitchment, biology, or both: The co-existence of natural and supernatural explanatory frameworks across development. *Cognitive Science*, *32*, 607–642.

Le Guen, O., Iliev, R., Lois, X., Atran, S., & Medin, D. L. (2013). A garden experiment revisited: Inter-generational change in environmental perception and management of the Maya Lowlands, Guatemala. *Journal of the Royal Anthropological Institute*, *19*(4), 771–794.

Leslie, A. M. (1982). The perception of causality in infants. *Perception*, *11*(2), 173–186.

Leslie, A. M. (1995). A theory of agency. In D. Sperber, D. Premack, & A. J. Premack (Eds.), *Causal cognition* (pp. 121–141). Oxford: Clarendon Press.

Lewin, K. (1935). *A dynamic theory of personality*. New York: McGraw-Hill.

Lien, Y., & Cheng, P. W. (2000). Distinguishing genuine from spurious causes: A coherence hypothesis. *Cognitive Psychology*, *40*, 87–137.

Lillard, A. (1998). Ethnopsychologies: Cultural variations in theories of mind. *Psychological Bulletin*, *123*, 3–46.

Lindeman, M., & Aarnio, K. (2006). Superstitious, magical, and paranormal beliefs: An integrative model. *Journal of Research in Personality*, *41*, 731–744.

Liu, D., Wellman, H. M., Tardif, T., & Sabbagh, M. A. (2008). Theory of mind development in Chinese children: A meta-analysis of false-belief understanding across cultures and languages. *Developmental Psychology*, *44*, 523–531.

Loftus, E. F., & Palmer, J. C. (1974). Reconstruction of automobile destruction: An example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior*, *13*(5), 585–589.

López, A., Atran, S., Coley, J. D., Medin, D. L., & Smith, E. E. (1997). The tree of life: Universal and cultural features of folkbiological taxonomies and inductions. *Cognitive Psychology*, *32*, 251–295.

Lynch, E., & Medin, D. (2006). Explanatory models of illness: A study of within-culture variation. *Cognitive Psychology*, *53*, 285–309.

Lynch, E. B., Coley, J. D., & Medin, D. L. (2000). Tall is typical: Central tendency, ideal dimensions, and graded category structure among tree experts and novices. *Memory & Cognition*, *28*, 41–50.

Luhrmann, T. M., Padmavati, R., Tharoor, H., & Osei, A. (2015). Hearing voices in different cultures: A social kindling hypothesis. *Topics in Cognitive Science*, *7*, 646–663.

Maddux, W. W., & Yuki, M. (2006). The "ripple effect": Cultural differences in perceptions of the consequences of events. *Personality and Social Psychology Bulletin*, *32*, 669–683.

Malinowski, B. (1948). *Magic, science and religion*. New York: Free Press.

Malle, B. F. (2006). The actor-observer asymmetry in attribution: A (surprising) meta-analysis. *Psychological Bulletin*, *132*, 895–919.

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, *98*, 224–253.

Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology*, *81*, 922–934.

Mayrhofer, R., & Waldmann, M. R. (2014). Indicators of causal agency in physical interactions: The role of the prior context. *Cognition*, *132*, 485–490.

McCay, B. J., & Acheson, J. M. (Eds.) (1987). *The question of the commons*. Tucson: University of Arizona Press.

Medin, D. L., & Atran, S. (Eds.) (1999). *Folkbiology*. Cambridge, MA: MIT Press.

Medin, D. L., & Atran, S. (2004). The native mind: Biological categorization, reasoning and decision making in development across cultures. *Psychological Review*, *111*, 960–983.

Medin, D. L., & Bang, M. (2014). *Who's asking? Native science, Western science, and science education*. Cambridge, MA: MIT Press.

Medin, D. L., Bennis, W. M., & Chandler, M. (2010). Culture and the home-field disadvantage. *Perspectives on Psychological Science*, *5*, 708–713.

Medin, D. L., Coley, J. D., Storms, G., & Hayes, B. L. (2003). A relevance theory of induction. *Psychonomic Bulletin & Review*, *10*, 517–532.

Medin, D. L., ojalehto, b., Marin, A., & Bang, M. (2013). Culture and epistemologies: Putting culture back into the ecosystem. (p. 737) In M. Gelfand, C. Chiu, & Y.-Y. Hong

(Eds.), *Advances in culture and psychology* (pp. 177–217). Oxford: Oxford University Press.

Medin, D. L., & Ortony, A. (1989). Psychological essentialism. In I. S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 179–196). New York: Cambridge University Press.

Medin, D. L., Ross, N. O., Atran, S., Cox, D., Coley, J., Proffitt, J., & Blok, S. (2006). Folk biology of freshwater fish. *Cognition*, *99*, 237–273.

Menon, T., Morris, M. W., Chiu, C.-y., & Hong, Y.-y. (1999). Culture and the construal of agency: Attribution to individual versus group dispositions. *Journal of Personality and Social Psychology*, *76*, 701–717.

Michotte, A. (1963). *The perception of causality*. New York: Basic Books.

Miller, J. G. (1984). Culture and the development of everyday social explanation. *Journal of Personality and Social Psychology*, *46*, 961–978.

Morris, M. W., Menon, T., & Ames, D. R. (2001). Culturally conferred conceptions of agency: A key to social perception of persons, groups, and other actors. *Personality and Social Psychology Review*, *5*, 169–182.

Morris, M. W., Nisbett, R. E., & Peng, K. (1995). Causal attribution across domains and cultures. In D. Sperber, D. Premack, & A. J. Premack (Eds), *Causal cognition* (pp. 577–612). Oxford: Clarendon Press.

Morris, M. W., & Peng, K. (1994). Culture and cause: American and Chinese attributions for social and physical events. *Journal of Personality and Social Psychology*, *67*, 949–971.

Narby, J. (2006). *Intelligence in nature: An inquiry into knowledge*. New York: Penguin.

Needham, J. (1954). *Science and civilization in China*. Cambridge: Cambridge University Press.

Nguyen, S. P., & Rosengren, K. S. (2004). Causal reasoning about illness: A comparison between European and Vietnamese-American children. *Journal of Cognition and Culture*, *4*, 51–78.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review*, *108*, 291–310.

Norenzayan, A., & Hansen, I. G. (2006). Belief in supernatural agents in the face of death. *Personality and Social Psychology Bulletin*, *32*, 174–187.

Norenzayan, A., & Nisbett, R. E. (2000). Culture and causal cognition. *Current Directions in Psychological Research*, *9*, 132–135.

O'Barr, W. (2001). Culture and causality: Non-western systems of explanation. *Law and Contemporary Problems*, *64*, 317–323.

ojalehto, b., & Medin, D. L. (2015). Perspectives on culture and concepts. *Annual Review of Psychology*, *66*, 249–275.

ojalehto, b., Medin, D. L., Horton, W. S., Garcia, S., & Kays, E. (2015). Seeing cooperation or competition: Ecological interactions in cultural perspectives. *Topics in Cognitive Science*, *7*, 624–645.

ojalehto, b., Waxman, S. R., & Medin, D. L. (2013). Teleological reasoning about nature: Intentional design or relational perspectives? *Trends in Cognitive Sciences*, *17*, 166–171.

Olson, I. D. (2013). Cultural differences between Favela and Asfalto in complex systems thinking. *Journal of Cognition and Culture*, *13*, 145–157.

Oyserman, D., Coon, H. M., & Kemmelmeier, M. (2002). Rethinking individualism and collectivism: Evaluation of theoretical assumptions and meta-analysis. *Psychological Bulletin*, *128*, 3–72.

Oyserman, D., & Lee, S. W.-S. (2007). Priming 'culture': Culture as situated cognition. In S. Kitayama & D. Cohen (Eds.), *Handbook of cultural psychology* (pp. 255–279). New York: Guilford Press.

Pauen, S. (2000). Early differentiation within the animate domain: Are humans something special? *Journal of Experimental Child Psychology*, *75*, 134–151.

Peng, K., Ames, D., & Knowles, E. D. (2001). Culture and human inference: Perspectives from three traditions. In D. R. Matsumoto (Ed.), *Handbook of culture and psychology* (pp. 245–264). New York: Oxford University Press.

Peng, K., & Knowles, E. D. (2003). Culture, education, and the attribution of physical causality. *Personality and Social Psychology Bulletin*, *29*, 1272–1284.

Pickering, M. J., & Majid, A. (2007). What are implicit causality and consequentiality? *Language and Cognitive Processes*, *22*, 780–788.

Proffitt, J. B., Coley, J. D., & Medin, D. L. (2000). Expertise and category-based induction. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*, 811–828.

Pyers, J. E., & Senghas, A. (2009). Language promotes false-belief understanding: Evidence from learners of a new sign language. *Psychological Science*, *20*, 805–812.

Rice, T. (2003). Believe it or not: Religious and other paranormal beliefs in the United States. *Journal for the Scientific Study of Religion*, *42*, 95–106.

Robbins, J., & Rumsey, A. (2008). Introduction: Cultural and linguistic anthropology and the opacity of other minds. *Anthropological Quarterly*, *81*, 407–420.

Romney, A. K., Weller, S. C., & Batchelder, W. H. (1986). Culture as consensus: A theory of culture and informant accuracy. *American Anthropologist*, *88*, 313–338.

Rosch, E. (1975). Cognitive reference points. *Cognitive Psychology*, *7*, 532–547.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, *8*, 382–439.

Ross, N. O., Medin, D. L., Coley, J. D., & Atran, S. (2003). Cultural and experiential differences in the development of folkbiological induction. *Cognitive Development*, *18*, 25–47.

Ross, N. O., Medin, D. L., & Cox, D. (2007). Epistemological models and culture conflict: Menominee and Euro-American hunters in Wisconsin. *Ethos*, *35*(4), 478–515.

Rothe-Wulf, A. (2014). *Verwobene Welt: Zur Rekonstruktion der Domänengrenzen von Kausalkonzepten in der Vorstellungswelt der Tonganer* (unpublished MA thesis). Department of Anthropology, University of Freiburg, Germany.

Schütz-Bosbach, S., & Prinz, W. (2007). Perceptual resonance: Action-induced modulation of perception. *Trends in Cognitive Sciences*, *11*, 349–355.

Seligman, R. (2010). The unmaking and making of self: Embodied suffering and mind-body healing in Brazilian Candomble. *Ethos*, *38*, 297–320.

Shore, B. (1982). *Sala'ilua: A Samoan mystery*. New York: Columbia University Press.

Shore, B. (1989). Mana and tapu. In A. Howard & R. Borofsky (Eds.), *Developments in Polynesian ethnology* (pp. 137–173). Honolulu: University of Hawai'i Press.

Sousa, P., Atran, S., & Medin, D. L. (2002). Essentialism and folkbiology: Evidence from Brazil. *Journal of Cognition and Culture*, *2*(3), 195–223. **(p. 738)**

Spelke, E. S., & Kinzler, K. D. (2007). Core knowledge. *Developmental Science*, *10*, 89–96.

Spelke, E., Bernier, E. P., & Skerry, A. E. (2013). Core social cognition. In M. R. Banaji & S. A. Gelman (Eds.), *Navigating the social world: What infants, children, and other species can teach us* (pp. 11–16). Oxford: Oxford University Press.

Sperber, D., & Hirschfeld, L. A. (2004). The cognitive foundations of cultural stability and diversity. *Trends in Cognitive Sciences*, *8*, 40–46.

Strohschneider, S., & Güss, D. (1998). Planning and problem solving differences between Brazilian and German students. *Journal of Cross-Cultural Psychology*, *29*, 695–716.

Takano, Y., & Osaka, E. (1999). An unsupported common view: Comparing Japan and the U.S. on individualism/collectivism. *Asian Journal of Social Psychology*, *2*(3), 311–341.

Throop, C. J. (2008). On the problem of empathy: The case of Yap, Federated States of Micronesia. *Ethos*, *36*, 402–426.

Triandis, H. C. (1995). *Individualism and collectivism*. Boulder, CO: Westview Press.

Tucker, B., Tsiazonera, Tombo, J., Hajasoa, P., & Nagnisaha, C. (2015). Ecological and cosmological coexistence thinking in a hypervariable environment: Causal models of economic success and failure among farmers, foragers, and fishermen of southwestern Madagascar. *Frontiers in Psychology*, *6*, 1533.

Unsworth, S. J., Levin, W., Bang, M., Washinawatok, K., Waxman, S., & Medin, D. L. (2012). Cultural differences in children's ecological reasoning and psychological closeness to nature: Evidence from Menominee and European American children. *Journal of Cognition and Culture*, *12*, 17–29.

Vinden, P. G. (1996). Junín Quechua children's understanding of mind. *Child Development*, *67*, 1707–1716.

Viscusi, W. K., & Zeckhauser, R. J. (2006). The perception and valuation of the risks of climate change: A rational and behavioral blend. *Climate Change*, *77*, 151–177.

Viveiros de Castro, E. (2004). Perspectival anthropology and the method of controlled equivocation. *Tipití: Journal of the Society for the Anthropology of Lowland South America*, *2*, 3–22.

Waldmann, M. R., Hagmayer, Y., & Blaisdell, A. P. (2006). Beyond the information given causal models in learning and reasoning. *Current Directions in Psychological Science*, *15*, 307–311.

Walker, S. J. (1992). Supernatural beliefs, natural kinds, and conceptual structure. *Memory & Cognition*, *20*, 655–662.

Wassmann, J., Träuble, B., & Funke, J. (Eds.) (2013). *Theory of mind in the Pacific: Reasoning across cultures*. Heidelberg: Universitätsverlag Winter.

Watson-Jones, R. E., Busch, J. T. A., & Legare, C. H. (2015). Interdisciplinary and cross-cultural perspectives on explanatory coherence. *Topics in Cognitive Science*, *7*, 611–623.

Waxman, S. R., & Gelman, S. A. (2010). Different kinds of concepts and different kinds of words: What words do for human cognition. In D. Mareschal, P. C. Quinn, & S. E. G. Lea (Eds.), *The making of human concepts* (pp. 99–129). New York: Oxford University Press.

Waxman, S., Medin, D. L., & Ross, N. O. (2007). Folkbiological reasoning from a cross-cultural developmental perspective: Early essentialist notions are shaped by cultural beliefs. *Developmental Psychology*, *43*(2), 294–308.

Wegner, D. M. (2002). *The illusion of conscious will*. Cambridge, MA: MIT Press.

Wegner, D. M. (2003). The mind's best trick: How we experience conscious will. *Trends in Cognitive Sciences*, *7*, 65–69.

Wegner, D. M., Sparrow, B., & Winerman, L. (2004). Vicarious agency: Experiencing control over the movements of others. *Journal of Personality and Social Psychology*, *86*, 838–848.

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development*, *72*(3), 655–684.

White, G. M., & Kirkpatrick, J. (Eds.) (1985). *Person, self and experience: Exploring Pacific ethnopsychologies*. Berkeley: University of California Press.

White, P.A. (1997). Naive ecology: Causal judgments about a simple ecosystem. *British Journal of Psychology*, *88*, 219–233.

White, P. A. (1999). The dissipation effect: A naive model of causal interactions in complex physical systems. *American Journal of Psychology*, *112*, 331–364.

White, P. A. (2000). Naive analysis of food web dynamics: A study of causal judgment about complex physical systems. *Cognitive Science*, *24*, 605–650.

White, P. A. (2006). The causal asymmetry. *Psychological Review*, *113*, 132–147.

White, P. A. (2007). Impressions of force in visual perception of collision events: A test of the causal asymmetry hypothesis. *Psychonomic Bulletin & Review*, *14*(4), 647–652.

Whitehouse, H., & McCauley, R. N. (Ed.) (2005). *Mind and religion: Psychological and cognitive foundations of religiosity*. Walnut Creek, CA: Altamira.

Widlok, T. (2014). Agency, time and causality. *Frontiers in Psychology*, *5*, 1264.

Wolff, P., Jeon, G. H., & Li, Y. (2009). Causers in English, Korean, and Chinese and the individuation of events. *Language and Cognition*, *1*, 167–196.

Wolff, P., Klettke, B., Ventura, T., & Song, G. (2005). Expressing causation in English and other languages. In W. Ahn et al. (Eds.), *Categorization inside and outside of the laboratory* (pp. 29–48). Washington: APA.

Woolfe, T., Want, S. C., & Siegal, M. (2002). Signposts to development: Theory of mind in deaf children. *Child Development*, *73*, 768–778.

Wu, S., & Keysar, B. (2007). The effect of culture on perspective taking. *Psychological Science*, *18*, 600–606.

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