Early word-learning entails reference, not merely associations

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Recent years have witnessed a resurgence of classic tensions concerning the fundamental nature of human knowledge and the processes underlying its acquisition. This tension, especially evident in research on the acquisition of words and concepts, arises when researchers pit one type of content against another (perceptual versus conceptual) and one type of process against another (associative versus theory-based). But these dichotomies are false; they rest upon insufficient consideration of the structure and diversity of the words and concepts that we naturally acquire. As infants and young children establish categories and acquire words to describe them, they take advantage of both perceptual and conceptual information, and relate this to both the (rudimentary) theories they hold and the statistics that they witness.

Two metaphors of development
Two different metaphors undergird recent work on early cognitive and language development. The 'child-as-data-analyst' metaphor captures human infants' impressive capacity to attend to statistical regularities in their environments [1,2], and the rich sensory, perceptual and computational resources that they bring to the task of acquisition. The 'child-as-theorist' metaphor captures infants' impressive array of conceptual capacities, including core knowledge of physical objects, skeletal theories of animate objects and a sensitivity to the distinct principles governing the behavior of each [3–7].

The basic thesis of this article is simple: these two metaphors should not be in competition. As infants and young children establish concepts and acquire words to describe them, they rely on both the (rudimentary) theories that they hold and the statistics that they witness [8–11]. This might seem like an uncontroversial point, and indeed it has been embraced by researchers across a broad theoretical spectrum, including those focusing primarily on at the perceptual and the conceptual ends of the spectrum [11–15]. Of course, this does not mean that researchers now speak in a single voice. On the contrary, strong differences remain on matters as fundamental as whether our conceptual capacities arise from a bedrock of perceptual primitives or are built upon conceptual primitives (including domain-specific frameworks for interpreting data). However, it is now clear that marrying these two metaphors has

yielded productive interchange and supported vigorous debate [13–15].

Nonetheless, this marriage has not been recognized unanimously. Strong endorsements for using the child-as-data-analyst metaphor alone persist: '...early in development, cognitive processes do not depend on top-down conceptual knowledge. Instead, they are grounded in powerful learning mechanisms...' ([16], p. 180, emphasis added). The claim is that the very nature of word meaning undergoes a qualitative shift, relying at first on exclusively similarity-based content and only later on conceptual content, 'a shift that appears to occur between 8 and 11 years...' ([17], p. 1695). Here, our goals are to identify the limitations of this most recent instantiation of the empiricist program, and to reveal the complexity underlying the seemingly simple act of learning a word and mapping it to a concept.

Focusing exclusively on the child-as-data-analyst
In their version of the child-as-data-analyst view, Sloutsky and colleagues [16–19] have promoted a strict and exclusively associationist approach to early word learning and conceptual development. This work rests on three core assumptions: that the only building blocks for words and concepts are sensory and perceptual experiences, that these experiences are operated upon strictly by general-purpose processes (including associative learning, similarity assessment and attentional weighting), and that higher-level conceptual processes are unnecessary to account for the developmental evidence. This work is valuable in many ways, highlighting children's sensitivity to statistical regularities in perceptual information, and the power of certain domain-general processes in development. But this work has not ruled out the child-as-theorist model.

Retaining a place for the child-as-theorist
In our view, capturing the processes underlying early word-learning and conceptual development requires that we also consider the child-as-theorist model. Our concern reflects more than an empirical disagreement; it reflects a fundamentally different set of assumptions concerning words, concepts and development. We draw upon a rich intellectual history within psychology, linguistics and philosophy [20–22] to focus on four crucial points, which are each considered in turn:
- Words do not merely associate; they refer. Words are quintessentially symbolic elements.

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- Words and concepts are more than a collection of sensory and/or perceptual features. Even as infants and young children build their lexical and conceptual repertoires, they are also guided by abstract conceptual knowledge (e.g. animacy, intention and cause).
- Words and concepts are not unitary constructs. There are different kinds of words and different kinds of concepts, and sensitivity to this variety emerges within the first years of life.
- Words are located within intricate linguistic and social systems. Thus, a word takes its meaning not merely from its history of co-occurrence with entities in the world but also and importantly from the linguistic and social systems in which it is embedded.

Words refer; they do not merely associate
Consider the assertion that words are '. . .features of objects that contribute to their overall similarity, rather than symbols denoting category membership' ([16], p. 180]). That is, a word is nothing more than a feature of the experience(s) with which it has been associated, just as a black beret is a feature of the experience we associate with Jean Piaget. This assertion runs aground because the words of human language are more than associations. Words refer [23].

What does it mean to refer? At minimum, this means that a word links to a conceptual representation that is more abstract than the entities that happen to be present in the naming context [24]. For example, 'a dog' refers to one instance of the abstract concept 'dog', a concept that extends beyond the individual dogs that any of us will observe in our lifetimes. By two years of age, children refer to that abstract set directly, and can do so by means of generic expressions (e.g. 'Dogs have four legs') [25–29].

This crucial distinction between association and reference was illustrated concretely by Preissler and Carey [30]. An experimenter introduced 18- and 24-month-old infants to a photograph of a novel entity (a whisk) and named it ('a whisk'). Infants were then asked to extend the word – either to another photograph of a whisk or to an actual, 3D whisk. On a strictly associative account, infants should select the photograph, as it is perceptually more similar to the photograph that co-occurred with the introduction of the novel word. Yet infants almost never selected the photograph alone. Instead, they selected either the object alone (roughly half the time) or both the picture and the object (roughly half the time). This reveals that they understood something subtle and profound: words refer to concepts, and are not tethered to their associated perceptual impressions.

Early words incorporate conceptual content: they go beyond perceptible referents
Central to an exclusively associationist account is an assumption that every word links to a sensory and/or perceptual counterpart. Yet even for words that do have perceptible referents (e.g. dog, mama), word-learning cannot be characterized as simply mapping a word onto a perceptual unit. First, children map words onto concepts that share a deeper set of properties than those that are available for inspection [31–33]. Second, words often refer to absent things (e.g. 'Where's your coat?'), and children readily interpret such expressions, even acquiring new words when their referents are absent during the naming episode [34]. Thus, early in development, the process of word-learning extends well beyond the paradigm case of ostensive definition.

Moreover, infants and young children acquire words for concepts that could not, in principle, be shared via ostension or generalized on the basis of perceptual similarities among referents, words such as 'mine', 'why', 'fair', 'almost' and 'never' that map to abstract concepts with no concrete, real-world counterparts. They also learn words that refer to mental states (e.g. think, see) and encode notions of intentionality, cause and purpose [35–39]. There is considerable evidence that observation of the visual context provides insufficient evidence for establishing the meaning of such words [21]. Similarly, functional morphemes (e.g. articles like 'a' and 'the') cannot be characterized in terms of real-world referents, but are nonetheless used felicitously by young children. Finally, there are many words that do have real-world referents, but whose meaning nonetheless cannot be gleaned from observation alone. Consider, for example, a scene in which a dog is running rapidly behind a cat. This scene equally represents the concepts 'chase' and 'flee'; mapping a word onto this scene depends not on a link between a word and the context, but rather crucially on the link between the word and its arguments (e.g. 'The cat is X-ing the dog' versus 'The dog is X-ing the cat') [21].

A strict associationist account thus considers only a subset of the words that children naturally acquire and a subset of the contexts that support word-learning. At best, this account would need to posit two distinct processes: one for words that have perceptible referents (and could therefore, in principle, be acquired via ostension), and another for words that do not.

Words and concepts are not unitary constructs
Another assumption of this exclusively associationist account is that a word is an attentional spotlight, an increment of sound that when added to a previously silent context, highlights its referent in an especially salient way [18]. Notable here is the assumption that 'word' is a sufficiently precise unit of analysis, and that all words function alike, drawing children's attention to the sensory and/or perceptual experience available at the moment. But this assumption runs into serious difficulty because even before infants can produce grammatical sentences, they distinguish among different kinds of words, and expect that each is linked to a different kind of concept.

What do we mean by 'different kinds' of words? At minimum, we refer to distinct grammatical forms (e.g. nouns, adjectives and verbs) and their various subtypes (e.g. proper versus common nouns; transitive versus intransitive verbs). A fundamental property of human language is that each grammatical form picks out a distinctly different aspect of experience. This diversity of words and their candidate concepts undermines the claim that words act uniformly as 'attentional spotlights'. Moreover, infants appreciate this fundamental property: they

Box 1. What is in a word? Beyond signal-object association

Words exert a powerful, precise and nuanced influence on infants' behavior. In a series of experiments, infants ranging from six to twelve months viewed a series of familiarization objects from a single category (e.g. animals), followed by two test objects (one from the same category (e.g. a cat) and another from a new category (e.g. an apple) (Figure I). When the familiarization objects were presented in conjunction with the same novel noun (Word condition), infants successfully categorized, exhibiting a reliable novelty-preference at test. But when precisely the same objects were presented under different auditory conditions, infants were equally attentive during familiarization, but failed to categorize during familiarization. This was the case when the familiarization objects were accompanied by infant-directed speech but no novel word (No Word condition), when each familiarization object was paired with a different novel word (Variable Word condition), and when the familiarization objects were paired with melodies or tones, infants failed to categorize [50–53]. Thus, infants are sensitive to the introduction of novel words, and expect different kinds of naming episodes to have distinct conceptual consequences. Providing a common noun for a set of distinct objects promotes object categorization. But providing a unique noun for each promotes object individuation.

Another closely related experimental series reveals even more nuanced effects: different kinds of words highlight different kinds of commonalities (Figure II). When infants were familiarized to objects sharing both category-based and property-based commonalities, their construal of the relation depended upon the grammatical form of the word used to describe them [9,41]. Infants first mapped count nouns specifically to category-based (not property-based) commonalities (14-months-old); they later discovered that adjectives map specifically to property-based (not category-based) commonalities (18- to 21-months old). These nuanced effects cannot be reduced to simple word-object associations. Infants are exquisitely sensitive to distinct kinds of words, and recruit these distinctions precisely in establishing meaning. To establish meaning, infants attend not only to the novel word itself: they depend crucially upon its surrounding linguistic elements (e.g. determiners and arguments). Even in infancy, words support conceptual flexibility and engage our most fundamental logical commitments (e.g. distinct individuals, categories and kinds).
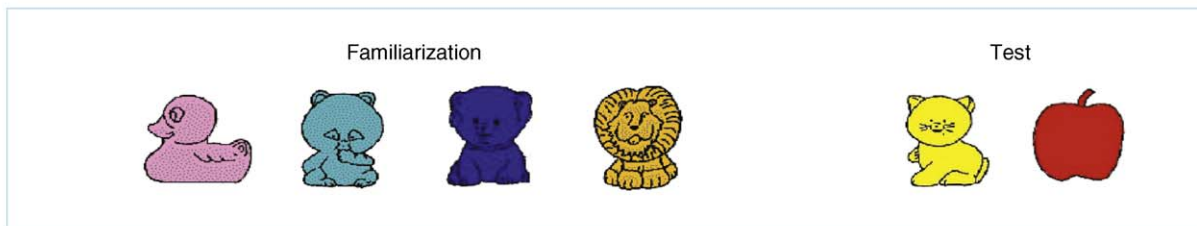
Condition	Auditory signal	Successful categorization?
Word (consistent)	"This is a toma...this is a toma", etc.	Yes.
No Word	"Look at this...", etc.	No
Word (variable)	"This is a toma"...this is a blicket", etc.	No
Melodies	♪♪♪♫ ♪♪♪♫	No

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Figure I. A representative sample of visual and auditory stimuli from a range of experiments designed to identify the precision of the link between words and object categories.
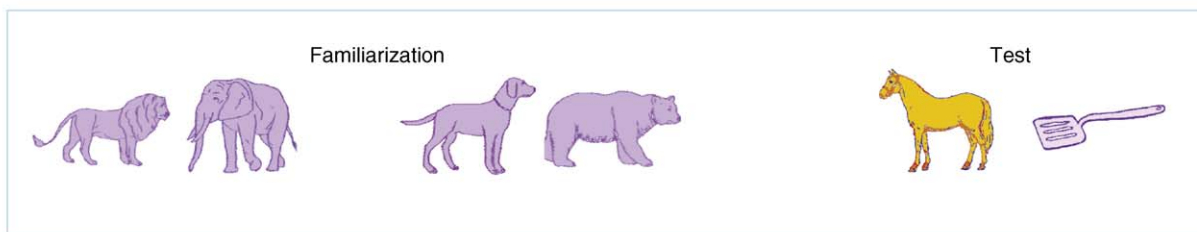
Condition	Auditory signal	Focus on shared category or property?
Noun	"This one is a dax", etc.	Category
Adjective	"This one is dax... ", etc.	Property

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Figure II. A representative sample of visual and auditory stimuli from experiments documenting that in infancy, different kinds of words link to different kinds of underlying concepts.

expect that each kind of word highlights a different aspect of the same scene. Consequently, when asked to extend a novel word beyond the particular entities on which it was introduced, infants do so in principled ways, guided by the grammatical form of the word. If words were nothing more than simple associates or general purpose attentional spotlights, then any word should exert the same kind of influence on infants' and young children's construals, and this is not the case (Box 1).

Infants' appreciation of different kinds of words is relevant not only to the establishment of meaning but also to the role of words in reasoning. The inferences that children make about any given individual depend not only on the grammatical form with which it was introduced [40] but also on the kind of concept expressed [41]. For example, when 2-year-olds were introduced to the very same word ('a dax') applied to the very same novel object, their interpretation was guided by their assumption about the ontological status (animate versus inanimate) of that object [42]. In short, different kinds of words refer to different kinds of concepts, and these concepts mediate infants' and children's reasoning and their acquisition of knowledge (Box 2).

Words participate in a complex linguistic and social system
Finally, consider the assertion that '…linguistic labels contribute to the overall similarity of compared entities: if two entities share a label, young children are more likely to say that these entities look alike' ([19], p. 248). Missing from this quote – and from an exclusively perceptually based associationist account – is the fact that each word participates in an exquisitely detailed linguistic, social and symbolic system.

Indeed, the meaning and conceptual power of a word derives not only from the word-form itself, or from an association between a word and a chunk of experience in the world. It also depends crucially on the relation of the word to other linguistic elements. In interpreting the meaning of a novel word, infants attend to its surrounding linguistic context, including the presence or absence of devices such as determiners (compare, 'This is a blick' to 'This is blick'), and the number, variety and relation among arguments (noun phrases) (e.g. 'hit' versus 'break') [21].

A hallmark of human language is that it is social and communicative. We are inherently a social and pedagogical species [43]. We learn not only from direct observation but also from the thoughts and beliefs transmitted to us by others [44,45]. These reflections are directly relevant to word-learning. In seeking to establish a word's meaning, children consider a rich array of social cues, including the eye-gaze, trustworthiness and intentionality of the speaker [46,47]. Clearly, then, infants and young children do not automatically or promiscuously map a novel word that they hear to an object with which it co-occurs. Instead, even in infancy, words are interpreted as 'names for things' only when they are embedded within a linguistic or social context [48,49].

This point ties back to our concerns about the notion of words as attentional spotlights. If words were merely attentional spotlights, then many other attention-enhancing auditory stimuli ought to serve as spotlights as well, but this is not the case. Although infants are attentive to many auditory stimuli, including words presented alone ('hey!') and a host of non-linguistic elements (e.g. tones, gestures and squeaks), they link auditory stimuli such as these to concepts only if they are presented within a social

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Box 2. Conceptual variety

An important feature of the human mind is the variety and flexibility of the concepts we can consider. John Stuart Mill [54] proposed a continuum, with inductively rich groupings, which he dubbed 'natural kinds' (e.g. 'dogs') at one end, and 'arbitrary' groupings that capture a single property at the other (e.g. 'white things'). Like adults, preschool children intuitively attribute greater inductive strength to natural kinds than to arbitrary categories [31]. Thus, any investigation seeking to assess the role of concepts in early cognition must consider this variety.

Sloutsky et al. [16] sought to examine the relative importance of conceptual and perceptual information in children's inductive inferences. An experimenter introduced children to two novel categories of bug-like animals ['ziblets' (a) and (c) and 'flurps' (b) and (d)], in which category membership was defined as the ratio of fingers to buttons (Figure I). The experimenter provided a novel noun label for each category, taught a new fact about one of the animals, and then measured whether children extended this fact to another animal from the same category (as defined by finger:button ratio), or to another animal that was more similar in appearance. Previous work with induction tasks using familiar natural kinds (e.g. birds versus bats; girls versus boys) reveals that by 3–4 years of age, children judge conceptual similarity (membership in a shared natural kind category) as relatively more important than perceptual similarity (shared features but not shared category membership) [31]. Yet Sloutsky et al. [16] reported that children were guided by perceptual similarity and not category membership. They concluded that, for children, 'looks are everything'. We offer a different interpretation, one that takes into account the kind of category under investigation. By 3 years, children share with adults clear intuitions about the kinds of categories that are inductively rich and the kinds of words that

describe them (e.g. count nouns and generics). But Sloutsky et al.'s [16] ziblets and flurbs are arbitrary categories: they differ in appearance by only a single arbitrary property (fingers:buttons ratio). There is considerable evidence that neither children nor adults generalize arbitrary, accidental or temporary properties (or words referring to such properties) to other instances of a kind [55]. If the goal is to test children's reasoning about natural kinds – or any category with strong inductive potential – Sloutsky et al.'s [16] categories fall short.
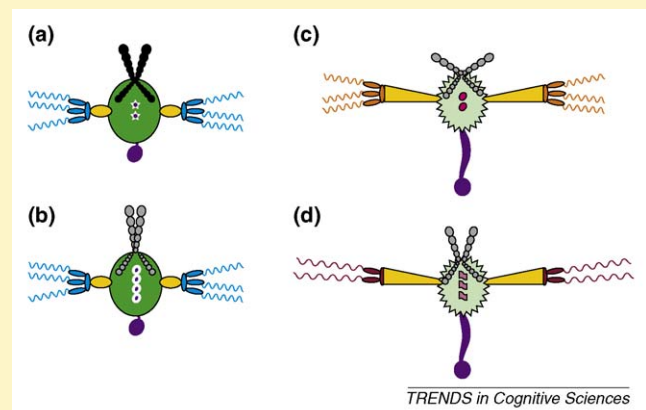

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Figure I. A representative set of visual stimuli from Sloutsky et al. [16]. A recent study illustrates how the concept one chooses to study influences the conclusions one draws. Reproduced, with permission, from Ref. [16].

Box 3. Questions for future research

- Are the processes and consequences of word-learning continuous from infancy through adulthood? Does the relative import of perceptual and conceptual information vary as a function of the learner's age or expertise within a domain?
- How does word-learning in humans compare to the acquisition of 'words' or word-like units in non-human species? Which aspects are shared and which seem to be unique?
- How are human infants' earliest words and foundational concepts shaped by the particular linguistic, social and cultural communities in which they are immersed?
- How does associative learning contribute the acquisition of commonsense theories? To what extent is associative learning constrained by causal theories? Does the process of associative learning differ across content domains?
- One striking symptom of autism is impaired language, including word-learning. These language difficulties have been linked to impairments in the interpersonal and social domain, including theory of mind. If word learning requires nothing more than establishing associations, then how might an exclusively associationist view accommodate the deficits of autism?

or linguistic context that establishes their referential status [50,51] (Box 1).

Conclusions

We have underscored that two metaphors – child-as-data-analyst and child-as-theorist – are at play in word-learning and conceptual development. As infants and young children build a repertoire of concepts and acquire words to describe them, they take advantage of both perceptual and conceptual information, and rely upon both the rudimentary theories that they hold and the statistics that they witness. Our goal in writing this article is to emphasize that our theories of acquisition should do the same (Box 3).

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