conceptual primitives may suffice. This approach avoids the complexities and ambiguities of interactions between separate dedicated analyzers and central concepts that Carey posits, giving learning a somewhat larger role in early concept formation.

There are few developmental psychologists who have attempted to elucidate in detail the origin of concepts in infancy. As one of that band, I applaud Carey's book (2009) but have some suggestions as to how to simplify her view of core cognition.

Carey states that it is impossible to derive concepts solely from sensorimotor information. I agree. However, elaborate conceptualizing machinery may not be necessary. Throughout her book, she defends discontinuity in development and the importance of bootstrapping. Therefore, we must consider the possibility that core cognition may be leaner than she suggests, with more of the work being accomplished by associative learning enriching a small number of innate conceptual representations (followed by linguistic and analogical bootstrapping).

Carey offers dedicated innate analyzers for objects, agents, and number plus a rather unspecified central processor that also has innate concepts. The latter can be combined with outputs from the dedicated analyzers to produce, for example, the concept of cause. Not much is said about the interactions between dedicated analyzers and innate central concepts. It is difficult to disentangle them, and this approach may allow too many alternative empirical outcomes. Furthermore, a more parsimonious system can accomplish the same goals. A single innate analyzer (such as Perceptual Meaning Analysis; Mandler 2004; 2008; 2010) that simplifies attended spatiotemporal information into a small number of conceptual primitives, can produce first concepts of objects, agency, and causality. It also allows combinations of them and provides first concepts for relations such as containment, occlusion, and support. The resulting representations, in conjunction with information directly supplied by the perceptual system, are sufficient to account for current infant data, including early language understanding (although this approach has not yet been extended to number).

The uncertainty Carey expresses as to how a concept of cause originates (Carey 2009, Ch. 6) illustrates the problem of assuming that some innate concepts are the product of separate analyzers and others part of a central mechanism. Carey argues against Michotte's (1946/1963) view that perceiving motion transferred from one object to another is obligatory and foundational for understanding causality, because she states that whether objects are inert or animate affects causal interpretation right from the beginning. However, not only is this conclusion debatable, it does not invalidate the view that motion transfer is obligatory and foundational for causal understanding. For example, the fact that infants are not surprised when animates move without contact does not refute Michotte's claim; there is no evidence that infants conceive of self-starting motion as causally based.

Carey's stronger argument depends on the claim of simultaneous emergence of concepts of contact causality and change of state causality. However, in my reading of the literature, I do not find enough evidence for simultaneous emergence. Adult-like response to both contact causality and entraining has been demonstrated at 3 to 4 months of age (Leslie 1982) whereas change of state causality has not been not shown before 8 months of age, and not even then unless a hand is involved. In infancy research, this is a sizeable gap. Leslie's experiments differ in detail from his definitive work with 6-month-olds, but the outcomes at 3 to 4 months are essentially the same.

Further, there is the dynamic aspect of causality. If forceful causality can be learned, then why cannot change of state causality also be learned, leaving motion transfer sufficient for core cognition? A way to do this (Mandler 2008; 2010) is by an innate conceptual primitive of "make move" based on seeing motion transfer from one object to another, with force added to the concept only when infants begin to move themselves around in the world and experience their own exertions in manipulating objects. Three-to-four-month-olds have little, if any, such experience. Once they do in the second six months, there is an already organized representation of caused motion available to be integrated with feelings of bodily exertion. Change of state causality is apt to be conceptualized even more slowly than adding force, because although infants may notice the relevant correlations, they need a more complex chain of associations to reach the core "make move" concept. Even adults often misconstrue change of state causality when it is not associated with motion transfer; it is not obligatory in the same way.

Carey also rejects my single analyzer approach (p. 195) because she says there is no known way that Perceptual Meaning Analysis could transform spatio-temporal properties into representations of intentional agency. But agency (goal-directed behavior) *can* be defined in spatial–temporal vocabulary, and there is evidence that this is indeed how it begins in infancy, as the observation of repeated paths of motion taking the most direct possible paths to the same end point (e.g., Csibra 2008). Infants learn early on that people are the most likely agents, but they accept inanimate boxes as agents too if they follow contingent paths. Even adults sometimes do, suggesting the obligatory character of this core concept. Understanding agency in terms of mental intentions is not part of core cognition but a late development, requiring infants' own attempts (and failures) to reach goals to become associated with the earlier established representations of agency in terms of paths of motion. Associating eyes (or head turns) with goal-directed paths is easy enough to learn, but mental intentionality is difficult and may even require language to become established.

Another concern is how Carey's core cognition enables the recall of event sequences and mental problem solving that have been demonstrated in the second six months. Such mental activities require explicit concepts, but the latter are not part of her core cognition and in her account explicit concepts appear to require language (Ch. 1). Therefore, although concepts are defined as units of thought, it is not clear how preverbal infants manage such thoughtful processes as recall and problem solving. An advantage of a mechanism such as Perceptual Meaning Analysis is that it creates iconic representations enabling imaginal simulations that even preverbal infants can use for thought.

I agree with much that Carey proposes but suggest that a single innate mechanism may suffice as the origin of core concepts.

Beyond the building blocks model[1]

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Abstract: Carey rightly rejects the *building blocks model* of concept acquisition on the grounds that new primitive concepts can be learned via the process of bootstrapping. But new primitives can be learned by other acquisition processes that do not involve bootstrapping, and bootstrapping itself is not a unitary process. Nonetheless, the processes associated with bootstrapping provide important insights into conceptual change.

Concept learning often involves the construction of complex concepts in accordance with a compositional semantics. It is widely assumed that the primitive concepts that form the basis of all complex concepts are themselves innate – a view we call the

building blocks model of concept learning. The building blocks model is central to Fodor's (1981) case for radical concept nativism but also to moderate forms of nativism, such as Pinker's (2007), and is assumed by virtually all empiricist accounts of concept learning. A central theme in *The Origin of Concepts* (Carey 2009), however, is that the building blocks model is mistaken; new primitives can also be learned. One of the most important ways of learning a new primitive, according to Carey, is via conceptual bootstrapping.

We agree with Carey both about the limitations of the building blocks model and about the significance of bootstrapping. However, bootstrapping, as Carey herself acknowledges, is not the only way of learning new primitive concepts. Nor is bootstrapping itself a single unitary process. Rather, bootstrapping consists of a number of distinct processes that resemble one another to varying degrees.

Carey cites six criteria for bootstrapping to occur, but the two that seem especially important are (1) the reliance on initially uninterpreted (or minimally interpreted) external symbols, and (2) the reliance on modeling processes. The external symbols serve as a placeholder structure, while the modeling processes facilitate their interpretation. When all goes well, the representations that correspond to the placeholder structure take on suitable inferential roles determining the new concepts' narrow content. Although analogical reasoning is often involved, other modeling processes include the use of thought experiments, limiting-case analyses, and abduction.

Our doubts about the unity of bootstrapping have to do with the character of the placeholder structure and the variety of modeling processes. As Carey describes the role of placeholders, they are initially uninterpreted (or minimally interpreted) and it is the rich relations among these external symbols that do most of the work in constraining the interpretation that bootstrapping achieves. These aspects of bootstrapping are especially clear in her flagship example of the positive integers. In other instances, however, the placeholder itself is well-understood (even if the concepts to be acquired are not) and there are few inter-symbol relations to speak of. Take Kepler's concept of *motive force*. According to Carey, the placeholder for Kepler's bootstrapping was the abductive hypothesis that something in the sun causes the motion of the planets, and the bootstrapping process led him to the idea of a force emanating from the sun that causes the motion of the planets. Alhough Kepler fully understood the placeholder hypothesis, the analogy he eventually hit upon did not depend upon the *structure of the placeholder* – unlike the number case, where the structural mapping between the ordered list of uninterpreted number words and ordered sets is crucial.

Regarding the various modeling processes that bootstrapping relies upon, the question is how alike they are once you get into the details. Analogy perhaps is to be accounted for in terms of structure mapping (Gentner 1983). But it is doubtful that structure mapping is essential to working through a thought experiment or engaging in abductive inference, and different instances of bootstrapping will appeal to different types of modeling processes. If these processes have anything in common, it would seem to be a loose affinity in how they contrast with empiricist learning strategies, such as association and statistical analysis.

Like bootstrapping, our own (Laurence & Margolis 2002) model of concept acquisition provides an account of primitive concept acquisition. On our model, new natural kind concepts are created by a dedicated acquisition system that employs a conceptual template. For example, on exposure to a new type of animal, the system creates a new mental representation with slots for information about the animal's salient perceptual properties (a "syndrome"), while ensuring that the representation's role in inference is governed by an essentialist disposition. Together, the syndrome and the essentialist disposition establish the appropriate mind-world dependency relations to underwrite conceptual content. This account differs from Carey's in a number of important respects. One is that our account involves a dedicated system for acquiring new primitive concepts of a particular type. Also, our account does not require the use of external symbols but instead has the acquisition system directly deploy new mental representations; on our model, even an isolated individual who has no external symbol system could acquire a new animal concept. Finally, our account does not implicate modeling processes.

New primitives are not limited to those acquired via dedicated acquisition systems, however. Consider, for example, concepts for new rituals. One might acquire such concepts by deploying new representations that then serve as accretion points for conceptual roles. This might be facilitated by an external symbol system (e.g., words for aspects of the ritual), but a placeholder structure is not necessary. And since acquiring concepts on an accretion point model of this sort might be as easy as the gathering of factual information, the steps involved need not involve modeling processes or result in incommensurability. This model is inspired by Block's (1986) discussion of conceptual role semantics. But it is in fact compatible with a variety of theories of content that treat the new concepts as primitive. What allows the concepts to be primitive is the fact that the conceptual roles can be non-analytic and defeasible. As a result, there are at least two alternatives to bootstrapping – our earlier model and this accretion point model. Both of these alternatives to bootstrapping, however, are ill-suited for learning the more demanding concepts that Carey's bootstrapping account can accommodate – the kind that rely on formal education for children and intellectual breakthroughs for scientists. For this reason, bootstrapping processes are crucial.

Contrary to the building blocks model, human beings have a number of ways of fundamentally expanding their conceptual system. Though bootstrapping itself is not a single process, the sorts of cognitive operations that Carey draws attention to help us to understand some of the most challenging instances of conceptual change, particularly those that involve incommensurability.

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NOTE

1. This article was fully collaborative; the order of the authors' names is arbitrary.

Can developmental psychology provide a blueprint for the study of adult cognition?

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Abstract: In order to develop sophisticated models of the core domains of knowledge that support complex cognitive processing in infants and children, developmental psychologists have mapped out the content of these knowledge domains. This research strategy may provide a blueprint for advancing research on adult cognitive processing. I illustrate this suggestion with examples from analogical reasoning and decision making.

Carey marshals significant evidence supporting the idea that children have a series of core domains of knowledge that give them a rudimentary understanding of the world (Carey 2009). Over time, that knowledge is expanded to provide more elaborate