experience takes place even in childhood, without the infrastructure of adult science.

This book tries to resolve that conceptual tension by a sort of division of labor between nativism and empiricism. Cognition in infancy and early childhood reflects "core cognition" – the nativist option. Conceptual change is a later development that operates on the representations of core cognition but requires language, and the somewhat mysterious process of "Quinian bootstrapping." However, new empirical and computational work, much of it done only in the past few years, suggests that there are more coherent ways of solving this dilemma. We need not propose a radical discontinuity between the processes that are responsible for abstract structure and those that are responsible for learning and conceptual change. They are, in fact, both part of the same system, and they are in place from the beginning.

Empirically, we've discovered that even infants have powerful learning capacities (Woodward & Needham 2009). We can give children particular types of evidence and observe the types of structure that they induce. These studies have already shown that infants can detect complex statistical patterns. But, more recently, it has been discovered that infants can actually use those statistics to infer more abstract non-obvious structure. For example, infants can use a statistically nonrandom pattern to infer someone else's desires (Kushnir et al. 2010), and can use statistical regularities to infer meanings (Graf Estes et al. 2007; Lany & Saffran 2010). In other experiments, giving infants relevant experience produces novel inferences both in intuitive psychology and in intuitive physics (Meltzoff & Brooks 2008; Somerville et al. 2005; Wang & Baillargeon 2008).

By the time children are 4 years of age there is consistent evidence both for conceptual change and for learning mechanisms that produce such change. Pressing children to explain anomalous behavior can induce a representational understanding of the mind (Wellman & Liu 2007), and giving them a goldfish to care for can provoke conceptual changes in intuitive biology (Inagaki & Hatano 2004). Most significantly, preschoolers can use both statistical patterns and active experimentation to uncover complex and abstract causal structure, inducing unobserved causal forces and high-level causal generalizations (Gopnik et al. 2004; Lucas et al. 2010; Schulz & Bonawitz 2007; Schulz et al. 2007; 2008). Empirically, even infants and very young children seem to use statistical inference, explanation, and experimentation to infer abstract structure in a way that goes well beyond association and could support conceptual change.

We can still ask how and even whether this sort of learning is possible computationally. Fortunately, new work in the "probabilistic models" framework, both in cognitive development and in the philosophy of science and machine learning, provides a promising answer (Gopnik & Schulz 2007; Gopnik et al. 2004; Griffiths et al. 2010; Xu & Tenenbaum 2007). On this view, from the very beginning, cognition involves the formulation and testing of abstract hypotheses about the world, and, from the very beginning, it is possible to revise those hypotheses in a rational way based on evidence.

The new idea is to formally integrate structured hypotheses, such as grammars, hierarchies, or causal networks, with probabilistic learning techniques, such as Bayesian inference. The view is that children implicitly consider many hypotheses and gradually update and revise the probability of those hypotheses in the light of new evidence. Very recently, researchers have begun to show how to use these methods to move from one abstract high-level framework theory to another: the sort of conceptual change that Carey first identified (Goodman et al. 2011; Griffths & Tenenbaum 2007). Empirically, we can induce such change, producing, for example, a new trait theory of actions (Seiver et al. 2010). Of course, there is still a great deal of work to be done. In particular, we need more realistic accounts of how children search through large hypothesis spaces to converge on the most likely options.

The new empirical work and computational ideas suggest a solution to Carey's dilemma – one that does not require either core cognition as a vehicle for abstract structure, or language and analogy as agents of conceptual change. It is also quite possible, of course, that the balance of initial structure, inferential mechanisms, and explicit representational resources might differ in different domains. Mathematical knowledge, is, after all, very different from other types of knowledge, ontologically as well as epistemologically, and might well require different resources than spatial, causal, or psychological knowledge.

In general, however, there is real hope that the empirical work and theoretical ideas that Carey has contributed can be realized in an even deeper way in the new computational theories, and that the ancient tension she has elucidated so well can finally be resolved.

Can multiple bootstrapping provide means of very early conceptual development?

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Abstract: Carey focuses her theory on initial knowledge and Quinian bootstrapping. We reflect on developmental mechanisms, which can operate in between. Whereas most of the research aims at delimitating early cognitive mechanisms, we point at the need for studying their integration and mutual bootstrapping. We illustrate this call by referring to a current debate on infants' use of featural representations.

Carey presents a theory of the ontogenesis of concepts marked by the presence of innate core knowledge and the representation of causality on one side, and by Quinian linguistic bootstrapping on the other (Carey 2009). We endorse most of this view. We find the evidence for the core knowledge of *agents* and *objects* convincing, and we agree that concepts such as *electron* are learned by acquiring linguistic placeholder structures first. But what happens in-between these two developmental landmarks? Is there any genuine conceptual development, including forming new kind-sortals with theory-constrained representation of features, apart from linguistic bootstrapping? How is the integrative role of causal representations (Carey 2009, Ch. 6) being accomplished?

Something of a paradox emerges when one seeks evidence of such processes in infants less than 12 months of age. A massive body of research from the last 25 years documents impressive innate competencies and capacity for rapid conceptual development over first months and years of life (Carey 2009, Ch. 3–6). However, another body of research shows that early representations are in many aspects impoverished, and that their developmental trajectories sometime contain surprising gaps. One of the most striking is perhaps a decalage in using featural, kind-related information for object identification and object individuation (Carey 2009, Ch. 3; Xu 2007b). On the one hand, even 6-month-olds appreciate that when there are two differently colored objects in the launching event, these are two separate objects, and infants show surprise when one takes the other's causal role (Carey 2009, Ch. 6; Leslie 1982). But on the other hand, infants less than 12 months of age are not concerned either with shape, color, or kind, when determining number of occluded objects (Carey 2009, Ch. 3; Xu & Carey 1996).

It seems that infants use two different, separate types of object representations, and that in their first year they do not form sortal categories representing permanent object-properties, that is, kind concepts. There is evidence for sortals *object* and *agent* in early infancy (Surian & Caldi 2010), but these could be the only sortals available during the very first months.

However, some recent results suggest more permanent, feature-based representations in the first year of life, and relatively complex representations of this kind only a few months later. A series of studies by Wilcox and others (McCurry et al. 2008; Wilcox et al. 2006) demonstrated use of featural information for determining number of objects in the event even at 4.5 months. Featural representations made by 5- and 3-month-olds support success in goal-attribution tasks (Luo 2010; Schlottmann & Roy 2009). Moreover, infants between 3.5 and 10 months studied by Hamlin et al. (2007; 2010) map permanent (at least in the experimental session's time-scale) dispositional states on feature-based object representations derived from one event (different colored shapes helping or hindering one another), and use this representation either to apprehend shapes' behavior or to select an object to reach for during a different test-event. Nine-month-olds use property-to-function mapping derived form one set of objects for individuation within another set (Wilcox et al. 2009), Early in the second year, children represent occluded colors to predict others' behavior (Luo & Beck 2010) and, as our own work in progress suggests, represent feature sequences of an object undergoing self-induced transformation (Hernik & Haman 2010). However, as most of these studies either do not test directly for numerical identity processing, or use simplified procedures, or objects-to-be-represented are involved in only a single event, it can still be argued that "infants represent objects relative to the goals of agents" (Carey 2009, p. 450) and feature-based kind-sortals remain a relatively late developmental achievement.

Other explanations are also possible, however (Xu 2007b). Wang and Baillargeon developed a research program aiming at demonstrating that at least in the physical domain, infants' reliance on event-representation leads to featural representations of objects and arguably to proto-representations of kinds (see Wang & Baillargeon 2009 for review). It can be presented as a three-way bootstrapping model where: (1) object-file representations, restricted by attention span, provide spatiotemporal cues for object individuation and placeholders for features assigned both bottom-up and top-down; (2) event category representations provide causal relations and guide attention to causally-relevant features; and (3) feature-based object representations by means of which temporary information provided by the aforementioned two systems is converted into permanent mental structures. Context-independence of these representations increases with development, and can be successfully trained (Wang 2011).

Although Wang and Baillargeon (2009) present their model in the context of early physical knowledge, we are tempted to conceive it is an example of complex bootstrapping potentially more common among mechanisms of conceptual development. The structures of causal knowledge involved in different categories of physical and social events, functional representations, or perhaps object transformations, as in the studies mentioned earlier, provide scaffolding for feature- and kind-representations. Different kinds of representations are used, and each of them provides placeholders, which can bootstrap elements of other systems of representation. This multiway bootstrapping may be further supported by at least three general-purpose learning mechanisms, such as weak linguistic influence (Carey 2009, Ch. 7; Xu 2007a) and learning by means of communication (Csibra & Gergely 2009; Futo et al. 2010), which may support both kind- and feature-based representations, as well as constrained Bayesian learning, which allows for quick detection of conditional interrelations between causes, objects, and their features. So far this is only a speculative hypothesis. Although integration of mechanisms discussed here can in principle be explored in experimental designs, it rarely was. Most of the contemporary cognitive-developmental research aimed at delimitating and enumerating separate mechanisms. Whereas this strategy was justified and effective, it can be perhaps blamed for underestimating the developmental role of integrative processes, and in consequence underestimating infants' early representational potential. Now, the focus on cooperation of different systems in the first years of life is necessary (see Denison & Xu 2010 for a convergent argument focusing on Bayesian learning). We suppose that a more integrative research program could fill the gap in our understanding of how everyday concepts begin to be formed very early on, in the midst of capitalizing on two major developmental forces (initial knowledge and linguistic bootstrapping) described by Carey.

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Presuming placeholders are relevant enables conceptual change

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Abstract: Placeholders enable conceptual change only if presumed to be relevant (e.g., lead to the formation of true beliefs) even though their meaning is not yet fully understood and their cognitive function not yet specified. Humans are predisposed to make such presumptions in a communicative context. Specifying the role of the presumption of relevance in conceptual change would provide a more comprehensive account of Quinian bootstrapping.

Quinian bootstraping for conceptual change is a process that requires making use of a placeholder. Placeholders are public symbols that can induce significant changes in the mind. The external symbol leads to the acquisition of a new mental concept as it acquires its meaning. Before conceptual change is completed, however, placeholders are promissory notes as future thinking tools. They do not yet have inferential power and they are not yet fully functional cognitive tools with which to understand the world. Nonetheless, placeholders must be ascribed a role – even if an indefinite one – in cognition.

How do people undergoing conceptual change conceive of placeholders so that they can take the role they have in Quinian bootstraping? What kinds of processes and dispositions are at work? I contend that placeholders, if they are to enable conceptual change, must be thought of as potentially useful cognitive tools and that this thought is initiated by the disposition to think that what is communicated is relevant. This disposition is triggered even in cases when what is communicated is not understood. In a communicative context (archetypically, when a communicator addresses an audience) the audience presumes that the placeholder has referential and/or inferential features.

For instance, children believe that "seven comes after six" even before they understand what "six" and "seven" mean and what the relation "coming after" really implies in this context. For this, children must hold representations whose content is that the meaning of "seven" (whatever it is) bears a specific relation to the meaning of "six" (whatever it is.) It is on the basis of such partially understood beliefs that bootstrapping occurs. The counting routine is likewise involved in the bootstrapping and is used by children before they can see that it actually