Of course, learning a fabricated new species of flower is a task limited in scope; the concept token referred to will not likely transform all future instances of "natural kind" encountered. But if some measure of conceptual change remains possible throughout the life course, then concepts themselves, and not just their associated categories, must respond to smaller scale regularities in the causal structure of specific instances of those concepts that are encountered.

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Conceptual discontinuity involves recycling old processes in new domains

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David Landy,[a] Colin Allen,[b] and Michael L. Anderson[c]
[a]*Department of Psychology, University of Richmond, Richmond, VA 23173;* [b]*Cognitive Science Program and Department of History & Philosophy of Science, Indiana University, Bloomington IN 47405;* [c]*Department of Psychology, Franklin & Marshall College, Lancaster, PA 17603.*
dhlandy@gmail.com **www.richmond.edu/~dlandy**
colallen@indiana.edu
michael.anderson@fandm.edu **http://www.agcognition.org**

Abstract: We dispute Carey's assumption that distinct core cognitive processes employ domain-specific input analyzers to construct proprietary representations. We give reasons to believe that conceptual systems co-opt core components for new domains. Domain boundaries, as well as boundaries between perceptual–motor and conceptual cognitive resources may be useful abstractions, but do not appear to reflect constraints respected by brains and cognitive systems.

In Carey's proposal, core cognitive processes have a strictly circumscribed conceptual domain: "A dedicated input analyzer computes representations of one kind of entity in the world and only that kind" (Carey 2009, p. 451). This leads Carey to assume that conceptual change transforms representations within a specified domain. So, for example, Carey proposes that the natural numbers are constructed from number-based core processes: either parallel representation of individuals belonging to small sets, or analog magnitude representations. On this view, a CS2 "transcends" a CS1 – two conceptual systems cover the same domain, but one covers that domain more completely and more richly than the other.

Substantial empirical evidence suggests that instead, concepts in learned theories are often built out of processes and representational vehicles taken from widely different domains. This is especially so when the topic is abstract, as in the case of mathematics. For example, Longo and Lourenco (2007) present evidence that overlapping mechanisms modulate attention in numerical and spatial tasks (see also Hubbard et al. 2005). In their experiments, participants who show a high degree of left-side pseudoneglect in a physical bisection task also showed a high degree of small-number pseudoneglect in a numerical bisection task. Furthermore, this is unlikely to result just from an analogical mapping between number and space used during learning, because numerical bisection biases, like physical biases, depend on whether numbers are physically presented in near or far space (Longo & Lourenco 2009). This fact suggests an online connection between spatial and numerical attention. Longo and Lourenco (2009) interpret these results in terms of shared mechanisms: Foundational processes that guide attention in physical space are recycled to guide attention in numerical space.

Moreover, there is ample evidence for the reuse of motor-control systems in mathematical processing. For example, that observing grip-closure movements (but not nonbiological closure motions) interferes with numerical magnitude processing; and Goldin-Meadow (2003) recounts the many ways in which gesturing aids in the acquisition of mathematical concepts. These examples suggest that the motor system offers representational resources to disparate domains.

Similarly, several authors have reported that algebraic reasoning co-opts mechanisms involved in perception and manipulation of physical objects (Dörfler 2004; Kirshner 1989; Landy & Goldstone 2007; Landy & Goldstone 2008). For example, Landy and Goldstone (2007) report that reasoners systematically utilize processes of perceptual grouping to proxy for the ordering of algebraic operations. Again, the relationship does not appear to be merely analogical. As Carey emphasizes, one expects analogies to occur over extended durations. In contrast, Kirshner and Awtry (2004) report that, at least, the use of spatial perception in interpreting equation structure happens immediately upon exposure to the spatially regular algebra notation, and must be unlearned through the process of acquiring sophisticated algebraic knowledge. The most natural interpretation is that relevant computations are performed directly on spatial representations of symbol systems, and tend to work not because of developed internal analogies but because the symbolic notation itself generally aligns physical and abstract properties.

In basic arithmetic knowledge, and in the algebraic understanding of abstract relations, distinctly perceptual-motor processing is applied to do conceptual work in a widely different domain. Despite Carey's assumption that cognitive resources are strongly typed – some are domain-specific input analyzers, some are components of core knowledge, others are parts of richer domain theories – it appears that at least some basic cognitive resources are used promiscuously in a variety of domains, and applied to a variety of contents. We suggest that this is possible for two reasons. First, on an evolutionary timescale it is more efficient to repurpose or replicate preexisting neural structures than to build entirely new ones. Second, many new symbolic environments, such as a math class utilizing a number line, or algebraic notation, form rich and multimodal experiences, which can themselves be analyzed using preexisting cognitive processes ("core" or not). Whenever such analyses yield largely successful results, a learner is likely to incorporate the relevant constraints and computational systems into the conceptual apparatus (Clark 2008). Therefore, initially dedicated mechanisms such as those governing perceptual grouping and attention, can be co-opted, given an appropriate cultural context, into performing highly abstract and conceptual functions.

When we make the claim that perceptual processes are co-opted for mathematical reasoning, for example, that automatically computed spatial arrangements of physical symbols are used as proxies for understanding generic relations, this is not a return to old-fashioned empiricism. It is not our view that all mathematical content can be reduced to perceptual content. Nor is it our view that because humans are able to co-opt perceptual processes to do mathematics, that this implies that the content of mathematical claims can be exhaustively reduced to perceptual primitives. Indeed, it is important to our story that they are not so reduced. We wish to point out that cognitive resources that are used for perceptual and motor reasoning in one domain are often usefully exploited for conceptual understanding in another domain. In fact, given the mounting evidence for the reuse of neural systems across the boundaries of traditional cognitive domains (Anderson 2010), it would be very surprising if many of our most important cognitive resources were domain-bound in the manner of Carey's core processes.

In short, whether on a cultural or evolutionary timescale, learning systems apply any available resources to the understanding of new symbol systems, without regard for whether that old system is domain-specific, "perceptual," or "conceptual." One important role of culturally constructed symbol systems is to serve, themselves, as rich environmental structures that can be the target of pre-existing cognitive mechanisms ("core" or otherwise). Carey's "Quinian bootstrapping," which treats novel symbol systems as mere placeholders, with no properties beyond conceptual role – that is, their inferential relationship to other symbols in their set – simplifies the process of learning new symbol systems at the cost of missing much of their value.

What is the significance of *The Origin of Concepts* for philosophers' and psychologists' theories of concepts?

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Edouard Machery
Department of History and Philosophy of Science, University of Pittsburgh, Pittsburgh, PA 15260.
machery@pitt.edu **www.pitt.edu/~machery/**

Abstract: Carey holds that the study of conceptual development bears on the theories of concepts developed by philosophers and psychologists. In this commentary, I scrutinize her claims about the significance of the study of conceptual development.

Psychologists will probably come to view *The Origin of Concepts* (Carey 2009) as a landmark in the history of psychology, as important as Piaget's (1954) *The Construction of Reality in the Child*. Among other virtues, it illustrates how extraordinarily successful the nativist research program in developmental psychology has been since the 1970s.

That said, *The Origin of Concepts* is not without shortcomings. Here, I focus on its significance for a general theory of concepts. In my view (Machery 2009; 2010a), philosophers and psychologists have usually focused on two distinct issues (a point Carey acknowledges; pp. 489–91):

1. *The philosophical issue*: How are we able to have propositional attitudes (beliefs, desires, etc.) about the objects of our attitudes? For example, in virtue of *what* can we have beliefs about dogs?
2. *The psychological issue*: Why do people categorize, draw inductions, make analogies, combine concepts, and so forth, the way they do? For example, why are inductive judgments sensitive to similarity?

Psychologists attempt to solve the psychological issue by determining the properties of the bodies of information about categories, substances, events, and so forth, that people rely on when they categorize, make inductions, draw analogies, and understand words.

In the introduction (p. 5) and in the last chapter of *The Origin of Concepts* (particularly, pp. 487–89, 503–508), Carey claims that the study of conceptual development casts light on the philosophical issue. However, the reader is bound to be disappointed, for Carey does not let the philosophical theory of reference she officially endorses – informational semantics – determine what babies' and toddlers' concepts refer to; instead, she relies on her *intuitions* to determine what their concepts refer to, and she uses philosophical theories of reference to *justify* her intuitions.

Two aspects of Carey's discussion support this claim. First, quite conveniently, the philosophical views about reference Carey discusses never lead her to conclude that babies' and toddlers' concepts refer to something different from what she intuitively takes them to refer to.

Second, although Carey endorses an informational semantics, she in fact appeals to several distinct theories of reference, and she switches from one theory to the other when convenient. When Carey discusses the reference of the concept of object, she appeals to Fodor's informational semantics (pp. 98–99), according to which a concept (e.g., the concept of dog) refers to the property that nomologically causes its tokening (e.g., the property of being a dog). Elsewhere (pp. 17, 99), she seems to endorse some (quite unspecified) version of a teleological theory of reference (of the kind developed by Millikan and Neander): a concept refers to a particular property because the evolutionary function of this concept (roughly, what this concept evolved to do) is to be tokened when this property is instantiated. According to this view, the concept of dog refers to the property of being a dog because its function is to be tokened when dogs are perceived (whether perceiving dogs actually causes its tokening or not). Finally, when she discusses the reference of the analog magnitude representations (e.g., pp. 293–95), she implicitly endorses an isomorphism-based conception of reference (of the type developed by Cummins), according to which the reference of our thoughts depends on an isomorphism between the laws that govern them and the laws that apply to some domain of objects. On this view, thoughts about natural numbers are about natural numbers if and only if they obey laws that are isomorphic to the arithmetic operations defined over natural numbers.

These theories of reference are fundamentally distinct. They disagree about what determines the reference of concepts (their current nomological relations with properties outside the mind, their past evolutionary history, or the isomorphism between the laws that govern their use and other laws), and they also occasionally disagree about what concepts refer to. Furthermore, it would do no good to propose to combine these theories into an encompassing theory of reference because it would be unclear why this encompassing theory should be preferred to each of these theories considered on its own. Nor would it do to simply state that different theories of reference apply to different types of representations because one would then need to explain why a particular theory applies to a particular type of concept.

Carey also holds that the study of conceptual development casts some light on the psychological issue (p. 487), but what is curious is that, she overlooks much of the psychological research on concepts (for review, see Murphy 2002; Machery 2009), and she promptly dismisses the principal theories of concepts developed by psychologists working on categorization, induction, and concept combination (pp. 496–99). Her main argument is that one needs to distinguish people's concepts from their beliefs or conceptions, that the psychological theories of concepts (prototype, exemplar, and theory theories) were developed to explain categorization, and that research on categorization casts light only on the nature of people's conceptions because categorization is holistic (pp. 490–491, 498). She also holds that psychologists' theories of concepts are descriptivist and that descriptivism is false.

I will briefly deal with Carey's second argument. Psychologists' theories of concepts are not committed to descriptivism because they can be combined with any theory of reference (Machery 2010a, p. 235). In addition, Carey's appeal to Kripke's and Putnam's anti-descriptivist views is problematic in light of the cross-cultural variation in intuitions about reference (Machery et al. 2004; Mallon et al. 2009; Machery et al. 2009).

I now turn to the first argument. A theory of concepts that attempts to explain categorization (as prototype, exemplar, and theory theories do) is able to distinguish concepts and conceptions, for one can, and should, distinguish the information that is used by default, in a context-insensitive manner in categorization (people's concepts) from the information used in a context-sensitive manner (their conceptions; Machery 2009, 2010b). Furthermore, the bodies of information that are used by default in categorization are also used by default in induction, in concept combination, and so forth. For example, typicality effects found in categorization, induction, and concept combination show that prototypes are used in the processes underlying all these cognitive competences. Therefore, the main psychological theories of concepts can not only distinguish concepts from conceptions, they are also essential to solve the psychological