Conceptual change or change of conception?

One basic issue raised by the study of both the history of science and human ontogenetic cognitive development is that of conceptual change: when should a change be interpreted as a *conceptual* change rather than as a change of *conception* (or *belief*)? This question has been at the heart of Susan Carey's developmental investigations from the very beginning. In her monumental (2009) book, *The Origin of Concepts*, she advocates a view of human ontogenetic cognitive development that rests on what she and Liz Spelke call *core* cognitive capacities and that involves rather sharp conceptual discontinuities. As she has stressed over the years, her acceptance of discontinuities in cognitive development bears some affinities to moderate versions of Thomas Kuhn's famous view of the incommensurability between scientific paradigms in the history of science. In the past, she has argued for example that human infants lack fundamental biological concepts and that naïve biology is constructed in the course of development by the cross-fertilization of basic *core* physical and psychological concepts and conceptions.

Quinean Bootstrapping

In her (2009) book, she offers a completely innovative account of how children may learn entirely new concepts (e.g. the concept *integer*), which are not part of human infants' innate core cognitive resources. At the heart of her proposal is the process that she herself calls *Quinean bootstrapping*, in reference to a couple of influential metaphors used by the philosopher Willard Van Orman Quine to capture the puzzling character of the scientific enterprise, one of which he borrowed from the logical positivist Otto Neurath: scientists try to fix their boat while at sea. Quine's other metaphor is that of "scrambling up a chimney supporting oneself by pressing against the sides one is building as one goes along" (Carey, 2009, p. 306). Carey's non-metaphorical approach to bootstrapping involves two fundamental stages. First, it involves the construction or selection of some relevant set of explicit *symbolic placeholders*. The second process is the process of *interpreting* the placeholders through some non-deductive (or non-demonstrative) process, including e.g. abduction, thought experimentation, limiting case analyses and analogical mapping (Carey, 2009, pp. 306-307).

As Carey (2009, p. 419) notes, these two stages seem well illustrated by an example from the philosopher Ned Block (1986) where he describes what he went through when he took his first physics course and was introduced to such terms as "energy, momentum, acceleration, and mass." These terms were placeholders, whose meanings he could not immediately map onto familiar concepts already available to him. What he could do instead is learn how to map them onto one another (e.g. "mass" time "acceleration" equals "force"). Later he was able to integrate them more fully within his broader conceptual repertoire.

As much experimental evidence (from Carey and colleagues) strongly suggests, human infants' core cognitive resources do not include the concept *integer*. Instead, what is available to human infants (and to non-human animals as well) are two separate core systems of representations: an *object-file* system and an analog *magnitude system*. While the former underlies the precise representations of sets of cardinality limited to 3 or 4 individuals, the latter underlies the approximate representations of sets of larger cardinality. Neither is sufficient for representing e.g. the concept 7. In her book, Carey argues that children bootstrap their way to the concept *integer* from these two core numerical systems of representation via various placeholders from their native tongue. Among these placeholders are natural language quantifiers (e.g. the English singular-plural marker and such English expressions as "some" and "all"). Children further memorize the count list "One, two, three, …" (up to "ten") more or less as they would sing "eeny, meeny, miny, moe." Only when they recognize that the list is ordered by the successor function can they interpret it numerically.

Fodorian skepticism

While Carey's bootstrapping account of children's concept of *integer* is a major contribution, it faces a pair of challenges: what counts as a genuinely *novel* concept? And how could the *interpretation* stage of the placeholders work in accordance with the requirement that the conceptual output be entirely *novel*? As Carey is well aware, this pair of challenges can be traced back to Jerry Fodor's notorious *skepticism*, first expressed in his (1975) argument for the language of thought (recently echoed by Rey, 2014). In a nutshell, Fodor's skeptical argument about conceptual change rests on the fundamental assumption that learning a new concept consists in forming a hypothesis about its content and testing it. To take a famous example from Nelson Goodman, in order to learn the new placeholder "grue," one must form and test the hypothesis that something is *grue* if and only if it is *green* before August 31 2016 or *blue* thereafter. Fodor's point is that not unless one already possesses all the conceptual ingredients necessary to represent the right side of the biconditional could one learn the meaning of the new placeholder "grue." While the placeholder "grue" may incontrovertibly be a new predicate, the question arises: to what extent is its content, i.e., the *concept grue*, a *novel* concept? All approaches to cognitive development that accept conceptual discontinuities are open to Fodor's skepticism. In response, Carey (2009, 2014) explicitly rejects Fodor's identification between learning a concept and the process of hypothesis formation and confirmation.

Logical concepts

Since the publication of her (2009) opus, Susan Carey has turned her attention to a novel and fundamental topic of investigation: do human children learn general, i.e. *domain- independent*, *logical* concepts such as *negation*, *conjunction* and *disjunction*? This in particular is the topic of one of her recent papers with Shilpa Mody published in *Cognition*, in which they investigate the ability of preschoolers to deductively reason in accordance with the disjunctive syllogism:
A OR B,
NOT A,
THEREFORE B.
A valid piece of deductive (or demonstrative) reasoning is such that if the premises are true, so is the conclusion. In a nutshell, the broad question is: at what developmental stage are preschoolers sensitive to the logical properties of representations considered in the *abstract*?

Reasoning by exclusion

Mody and Carey report the results of two studies. The goal of the first study was to find out whether 23-month-olds can reason by *exclusion*, as required in their cups task, in which they are motivated to find a ball that was placed in one of two cups A and B, but toddlers could not see which one because the cups were occluded by a screen when the experimenter hid the ball. After the screen was removed, the toddlers were shown that one cup (e.g. A) was empty. Finally the toddlers were asked to find the ball. A large majority of 23-month-olds turned out to pass this task and therefore to be able to reason by exclusion (as older children have been shown to). While success in this task requires the ability to reason by exclusion, one fundamental question is whether the ability to reason deductively in accordance with the disjunctive syllogism is a necessary condition for being able to reason by exclusion.

As Mody and Carey rightly observe, success in this task alone cannot demonstrate that toddlers reason deductively in accordance with the disjunctive syllogism, which requires them at least to make use of logical negation and to represent the disjunctive premise, i.e. to form a single representation of a pair of possible locations for the ball. Instead of using *disjunction*, they may, for example, represent each location *separately*, in accordance with what Mody and Carey call the “maybe A, maybe B” interpretation. In which case, upon discovering that cup A is empty, they should hold the belief that the ball is in B with subjective probability less than 1. Instead of using domain-general logical *negation*, they may, according to Mody and Carey (p. 46), form domain-specific thoughts representing *emptiness*, rather than thoughts “generalizable to other situations involving negation.” However and paradoxically, it is not entirely clear whether there could be *domain-specific* thoughts about emptiness *in general*, i.e. thoughts that could represent emptiness without specifying some relevant property or other (e.g. a ball), whose presence would make the thought false.

Applying the disjunctive syllogism

Be that as it may, in order to further probe toddlers’ reasoning abilities, Mody and Carey ran two further experiments involving more than two cups. First, the *training* trials involved *three* cups: a separate cup and a pair of cups. Two stickers were successively hidden, one in the separate cup; the other in one of the pair of cups. Both hiding events took place behind a screen and thus were not visible to participants (cf. Figure 1A). Children were asked to choose one of the three cups in order to pick up one of the two stickers. 2,5-, 3-, 4- and 5- year-olds were tested. All were above chance.

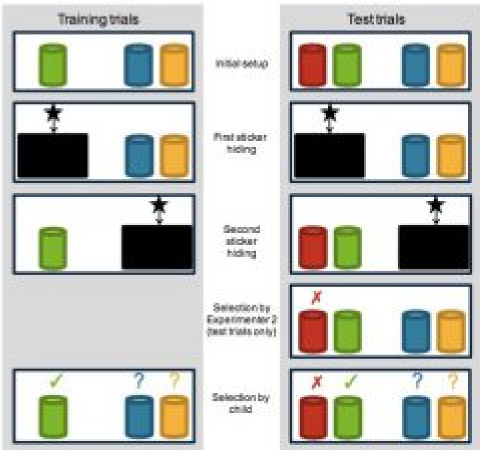

Figure 1A Figure 1B

Secondly, the *test* trials involved now two pairs of two (i.e. *four*) cups. Two stickers were successively hidden in each pair of cups by one experimenter. Both hiding events took place behind a screen (cf. Figure 1B). Children were informed that they were to play a competitive game with a second experimenter with whom they would take turns to pick a cup and win the sticker therein. If they chose a cup with a sticker, they would win the game, keep the sticker and the trial ended. The second experimenter always made the first move, selected an empty cup and showed it to be empty to the child who was then asked to choose a cup. In this case, Mody and Carey found a significant gap between age groups: 2,5-year-olds were at chance, and all older children were above chance.

Does failure in the test trials demonstrate that 2,5-year-olds are unable to reason deductively in accordance with the disjunctive syllogism, and therefore that they lack the required general logical concepts? If so, then this would count as preliminary evidence that young children must *learn* such general logical concepts. I now wish to argue (and Susan Carey has informed me that she agrees with me in personal conversation) that this conclusion does not follow from the results of Mody and Carey’s second study *alone*.

Given that 2,5-year-olds were above chance in the training trials and at chance in the test trials, Mody and Carey discuss several possible explanations for this disparity. In what follows, I will assume that all children are using deductive reasoning in both tasks (which, of course, we *don’t* *know*). I wish to first stress two features shared by both the training and the test trials and then emphasize a pair of differences between them that may explain the disparity.

In both sets of trials, participants must use *descriptive* information (i.e. their beliefs) about the location of one of a pair of stickers being in one among three or four cups, in order to take a *practical decision* to choose a relevant cup and retrieve the first available sticker. In order to deduce the practical decision from their beliefs, they must keep track of, and integrate to their decision-making process, both their *motivation* to win the game and the *deontic* contents of the rules of the game. Also the first descriptive premise in both sets of trials is a *conjunction* [P&Q] and one fundamental step needed in order to reach the practical decision is to use conjunction elimination in order to *eliminate* the irrelevant conjunct and keep the relevant one as a premise in the further process whereby the *practical decision* is inferred. So if children use deductive reasoning, then success in the training trials is evidence that they are using the logical concept *conjunction*.

Turning to differences now, one difference between the training and the test trials has to do with *motivation* and understanding the contrast between *competitive* and non-competitive games. In the test trials, but not in the training trials, children are playing a competitive game. It may be less demanding for 2,5-year-olds both to keep track of their motivation to win a non-competitive than a competitive game and to memorize the rules of a non-competitive game than a competitive game, in which the two cooperative partners in the game cannot both win and thus both be happy (if they both wish to win).

A second difference has to do *conjunction elimination*. The process whereby the *irrelevant* conjunct is *eliminated* in favor of the relevant one is clearly more *costly* in the test than in the training trials. In the training trials, only one of the two conjuncts is a disjunction, the other is not: [A&[BvC]]. Since in the training trials, the irrelevant conjunct is a disjunction, but the relevant conjunct is not, it is relatively easy to select which conjunct should be eliminated. But in the test trials, both conjuncts of the initial conjunction are disjunctions: [[AvB]&[CvD]]. So it is not as easy to select which conjunct to eliminate. In the test trials, only after the second experimenter has shown participants that one of the cups from the first pair [AvB] is empty, can participants infer the location of one of the stickers using the disjunctive syllogism. Only then can they select which conjunct is suitable for elimination. In the training trials, the disjunctive syllogism is not required at all in order to apply conjunction elimination to the relevant conjunct. But in the test trials, it is necessary to use the disjunctive syllogism in order to apply conjunction elimination to the relevant conjunct. All of this may explain why if 2,5-year-olds are using deductive reasoning, they are above chance in the training trials and at chance in the test trials.

Concluding remarks

Although she agrees that the results of Mody and Carey's second study alone do not establish that 2,5-year-olds lack the general logical concepts necessary for performing the disjunctive syllogism, Susan Carey has further argued in personal conversation that "these failures converge with other hints in the literature seeking evidence that babies or animals update the probabilities of an object in B upon learning that there is no object in A, which *also* fail to find that evidence in non-human primates or 2-year-olds, suggesting that success on the cups task provides no evidence for working through a disjunctive syllogism." Neither is success in the cups task sufficient to show that 2-year-olds can deductively reason in accordance with the disjunctive syllogism, nor is failure in the training trials sufficient to show that 2,5-year-olds can't.

Clearly the fundamental questions raised by the broad disagreement between Carey and Fodor run deep and there is room for much further experimental and conceptual investigation. Suppose that further negative evidence confirms that preverbal infants fail tasks suitable to establish that they can reason in accordance with the disjunctive syllogism. One tempting thought might be to extend Carey's strategy from the case of numerical cognition to the case of logical concepts. May be human children bootstrap their way towards general logical concepts by recruiting their understanding of placeholders from natural languages (e.g. "not," "or," and "and" in English). But if so, then Fodorian skepticism is likely to rear its head again: how could the *interpretation* stage of the linguistic placeholders work in accordance with the requirement that the conceptual output be entirely *novel*? How could children learn the meanings of the English words for negation, disjunction and conjunction unless they antecedently possessed the relevant logical concepts?

References

Block, N. (1986) Advertisement for a semantics for psychology. *Midwest Studies in Philosophy*, 10, 615-178.

Carey, S. (2009) *The Origin of Concepts*, Oxford University Press.

Carey S. (2014) On learning new primitives in the Language of Thought: Reply to Rey. *Mind and Language, 29*, 133-166.

Fodor, J.A. (1975) *The Language of Thought*. Harvard University Press.

Mody, S. and Carey, S. (2016) The emergence of reasoning by the disjunctive syllogism in early childhood. *Cognition, 154*, 40–48.

Rey, G. (2014) Innate and learned: Carey, mad dog nativism, and the poverty of stimuli and analogies yet again. *Mind and Language, 29*, 109-132.