Can Bootstrapping Explain Concept Learning?

If concepts are the constituents of thought, the thoughts we can think are limited by the concepts we can have. It thus matters a great deal whether humans can acquire new concepts throughout their lifespans, or are forever constrained by their innate conceptual endowments. And yet, according to a powerful challenge tracing back to Plato's *Meno* and honed in recent decades by Jerry Fodor, concept learning is impossible. If humans ever acquire new concepts, it is not through learning.

Enter Susan Carey's magnum opus, *The Origin of Concepts*.1 At the heart of *Origin* is a learning process that Carey calls *bootstrapping*2 which seeks to explain how important conceptual discontinuities are generated that enable learners to think new thoughts. *Origin* is certainly a milestone in the study of conceptual development. It is unprecedented in its marriage of theoretical sophistication and empirical detail, and assembles one of the strongest cases for the existence of conceptual discontinuities to date. Nevertheless, I believe that it fails in its ambition to explain how learners generate conceptual discontinuities.

I am reluctant, however, to abandon Carey's project altogether. There is too much of value in *Origin* to give up so quickly. I thus wish to consider three strategies for making sense of bootstrapping that go beyond Carey's own formulations. My aim is not to defend any one of these strategies in particular. As we will see, each strategy confronts its own unique challenges, and it is probably premature in each case to say whether these challenges can ultimately be met. Rather, my aim is more exploratory—to chart the logical space by considering how Carey's account of bootstrapping might be reshaped to explain concept learning.

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1 Hereafter: *Origin*. Unless otherwise noted, all page references are to this book (Carey 2009a). Many of the main ideas from *Origin* are helpfully summarized in Carey (2009b).

2 Actually, Carey calls the account *Quinian bootstrapping* since she finds inspiration for the idea in Quine (p. 306). Given Quine's deep suspicion of the intentional, however, his status as an ally is questionable.
1. Carey’s Account of Bootstrapping

Carey is not interested in just any type of concept learning. A thinker that possesses the concepts FEMALE and FOX, and then learns that a vixen is a female fox, arguably learns the new concept VIXEN.\(^3\) It is doubtful, however, that the thinker alters her expressive power since the content of VIXEN is the same as the content of FEMALE FOX. Such an episode thus would not count as bootstrapping.

Nor is Carey interested in the learning of a single new primitive concept, as when you meet John Doe for the first time and thereby acquire the concept JOHN DOE. Such cases arguably count as increasing one’s expressive power (now you can think thoughts about John Doe; before you couldn’t), but Carey does not include them in her discussion of bootstrapping.

Rather, Carey is occupied by cases wherein thinkers learn a batch of new concepts all at once that are at least partially inter-defined, such as concepts of the positive integers (pp. 287–333), concepts of fractions (pp. 344–359), and concepts such as MATTER, WEIGHT, and DENSITY that together form the basis of most adults’ understanding of the physical world (pp. 379–411). According to Carey, such examples involve significant and relatively abrupt changes in thinkers’ conceptual repertoires that generate substantial discontinuities in expressive power.

Carey deploys the bootstrapping metaphor to relay the difficulty of such episodes of concept learning. But whereas hoisting oneself by one’s own bootstraps is literally impossible, Carey believes that generating substantial conceptual discontinuities is merely difficult. According to Carey, bootstrapping involves two crucial stages: the construction of a network of symbolic placeholders that are directly related to one another, but not initially mapped onto preexisting concepts; and the subsequent interpretation of those placeholders through non-demonstrative modeling processes such as analogical mapping, thought experimentation, limiting case analyses, induction, and abduction (pp. 306–7).

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\(^3\) I follow Carey (p. 5) in taking concepts to be mental representations with semantic as well as non-semantic properties that serve as the constituents of thoughts, including beliefs. This minimal characterization should suffice for our purposes.
To get a sense for bootstrapping, it is helpful to see it in action. One relatively simple example that Carey cites derives from Ned Block (1986), who recalls taking his first physics class and being introduced to terms such as “mass,” “acceleration,” “energy,” “force,” and “momentum.” At first, these terms were almost meaningless to him. He had little idea how to map them onto his pre-existing concepts, though he did learn how to map them onto each other. For example, he learned that “force” equals “mass” times “acceleration,” that “momentum” equals “mass” times “velocity,” and so on. At this stage, these terms were placeholders for him. As his studies progressed, however, he began to add content to these terms by integrating them more fully with the rest of his conceptual repertoire. This example is relatively simple because, as Carey notes, “Block... says little about how these initially largely empty terms become meaningful” (p. 419). Also absent is the rich array of experimental evidence that accompanies many of Carey’s own examples of concept learning in children. The example is nevertheless helpful since it clearly highlights the two stages of bootstrapping: the construction of placeholders and their subsequent interpretation.

More details can be gleaned from Carey’s parade case of bootstrapping, children’s acquisition of natural number concepts such as THREE, SEVEN, and TEN (pp. 287-333). According to Carey, there is considerable evidence that children do not have these concepts innately. A wide variety of tasks that make varying performance demands on children suggest that they only slowly come to represent integers over a sustained period of time between roughly two-and-a-half and four years of age. This is not to say that children lack any innate quantitative representations. On the contrary, there is evidence that they possess several primitive systems of quantitative representations that together form the base from which the bootstrap to integer concepts is launched. This base includes analog magnitude representations of approximate cardinalities, object file representations that track the numerical identity of individual objects in parallel as their spatiotemporal position changes, and natural language quantifiers that are a part of each child’s universal grammar. But Carey makes a compelling case that each of these primitives is inadequate
to represent the integers. Analog magnitude representations lack the precision to represent integers. Object files only represent numerical information implicitly, by virtue of representing individual objects, and in any case have an upper bound of four. Natural language quantifiers at most extend to dual or trial markers, and usually only distinguish one from more than one. Yet by three-and-a-half or four years of age, most children have moved beyond these primitives and acquired integer concepts such as SEVEN, as evidenced by their success on such tasks as pointing to the card that has seven fish on it, or handing over exactly seven pennies from a large collection.

According to Carey, children's acquisition of the integer concepts displays both of the hallmark properties of bootstrapping. First, at around two years of age, children memorize a portion of the count sequence, “One, two, three, ...” often up to “ten” or so, and will utter each of the words in their count sequence as they touch each object in a set once. At first, the count sequence has no meaning for the children. If asked for $n$ pennies from a pile, or to point to the card with $n$ fish, they will respond with a random number of pennies or point to a random card. At this stage, the count sequence serves merely as a placeholder structure for the children. It encodes serial order (“three” comes after “two,” which comes after “one”), but the nature of that order is not defined for the children. It’s as though they were saying “eeny, meeny, miny, mo.”

With the placeholder structure at hand, children begin the process of interpretation. Some months after memorizing the count list they become “one-knowers.” They’ll give you one penny or point to the card with one fish, but respond randomly with larger values. According to Carey, this initial foothold is probably gained through natural language quantifiers, since children who grow up speaking languages with an explicit singular-plural marker (e.g., English and Russian) become one-knowers sooner than children who grow up speaking languages without an explicit singular-plural marker (e.g., Japanese and Mandarin). Six to eight months later children become “two-knowers.” They succeed on the give-me-a-number and point-to-a-card tasks for one or two, but no more. Several months later they become three-knowers, and then sometimes four-knowers.
According to Carey, children at this stage have learned to use their object file systems to place models stored in long-term memory in one-to-one correspondence with objects in the world, and to associate such states of one-to-one correspondence with the first four number words. So they know that there is "one" object when the object is in one-to-one correspondence with a model of a singleton in long-term memory \{i\}; that there are "two" objects when the objects are in one-to-one correspondence with a model of a pair of individuals in long-term memory \{j, k\}; and so on, up to four (the upper bound of the object file system). Carey calls children at this stage “subset-knowers” and calls the system they use “enriched parallel individuation.” Finally, some months later children make the outstanding induction that their count list is ordered by the successor relation. According to Carey, this happens when children notice an analogy between their numeral list and the models they have stored in long-term memory: just as the models can be ordered in accordance with the addition of one further individual, the numeral list is ordered in a similar fashion. The child thus hypothesizes that the numeral list is ordered by the successor function. Only at this point do children become “cardinal principle-knowers,” and thus associate the appropriate integer with each word in their count list.  

We can distinguish three theses that characterize Carey’s account of bootstrapping. First:  

**Discontinuity:** conceptual development involves substantial discontinuities in expressive power. Thinkers acquire new batches of concepts over development that enable them to think thoughts that they were previously incapable of thinking.  

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4 Some researchers have challenged Carey’s interpretation of the experimental data. For example, Spelke (2011) argues that Carey underestimates the role that analog magnitude representations play in children’s acquisition of natural number concepts, Gelman (2011) argues that Carey underestimates children’s innate capacity to represent discrete and continuous quantities precisely, and Davidson, Eng, and Barner (2012) present evidence that children don’t truly understand the successor relation until some time after they become cardinal principle-knowers. For our purposes, we can set such empirical worries to one side. Our question is not whether Carey has the details of any particular episode of bootstrapping just right, but whether she has succeeded in isolating a general learning process that has the potential to explain how conceptual discontinuities are bridged.

5 Carey isolates two types of discontinuities. The first, exemplified by the acquisition of integer concepts, involves a pure *increase* in expressive power, whereby the thoughts one could think prior to the bootstrap form a proper subset of the thoughts one can think after the bootstrap. The second, exemplified by children’s
In support of Discontinuity, Carey points to three considerations. First, she notes that the initial starting point is impoverished. For example, while there is evidence that children begin with some quantitative representations, she argues that those representations lack the expressive power to represent the integers. Second, she emphasizes the difficulty of the transition. For instance, it takes a year and a half for children to shift from the placeholder stage where they have memorized the count list to an appreciation as cardinal principle-knowers of what that list represents. Finally, Carey highlights the consistency in performance that each child displays across a wide range of tasks (so-called “within-child consistency”) to support the idea that children are moving from one conceptual scheme to another, and aren’t just slowly accreting context-specific beliefs. For example, children that succeed as two-knowers according to one test (e.g., “give me two pennies”) also reliably succeed on other tasks that make disparate demands on performance (e.g., “point to the card with two fish”).

The second thesis that Carey defends is:

**Placeholder:** Placeholders play an important role in generating conceptual discontinuities.

Carey defends Placeholder with several considerations. First, people that lack the relevant placeholder structures often fail to acquire new networks of concepts. For example, children who grow up in linguistic communities without a count list never become cardinal-principle knowers (pp. 302–4). Second, intelligent animals that lack language, such as chimpanzees, can laboriously learn precise integer concepts piecemeal, but never seem to extrapolate beyond those concepts to induce concepts of further positive integers (pp. 329–33). However, an African Gray Parrot that first learned “seven” and “eight” as mere placeholder terms was able to infer their cardinal

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Cf. the phenomenon of “fast mapping,” first isolated by Carey and Bartlett (1978), in which children learn the name of an object or kind after a single exposure.
meanings upon learning their serial locations in an ordered count list (Pepperberg & Carey forthcoming). Finally, curriculum interventions that place an emphasis on placeholder structures outperform other curriculum interventions in generating conceptual change (pp. 479–84).

In my opinion, Carey defends the Discontinuity and Placeholder Theses persuasively, if not conclusively. By contrast, Carey's defense of her third thesis is more problematic.

**Learning:** There exist learning processes that explain how placeholders are interpreted and conceptual discontinuities arise.

Carey explicitly takes bootstrapping to involve not just a description of succeeding discontinuous conceptual systems, but a *learning process* that explains how thinkers get from the first conceptual system to the second. Moreover, Carey maintains that any learning process must be explicable in terms of computations over representations. As she puts it, "We can characterize learning processes as those that build representations of the world on the basis of computations on input that is itself representational" (p. 12). A bootstrapping explanation of how children acquire concepts of the positive integers, for instance, must describe a computational process that takes the representations children begin with as inputs and yields concepts of the positive integers as outputs. It is far from clear, however, that Carey has successfully isolated such a process.

### 2. A Problem for Bootstrapping

If placeholders were interpreted compositionally in terms of concepts one already possessed, then we could straightforwardly explain bootstrapping in terms of a compositional semantics. There is a familiar worry, however, that any concept that is built up compositionally from concepts one already possesses isn't really new. It might abbreviate one's old concepts, but it cannot alter one's expressive power since one's old concepts could always in principle replace the "new" concept without changing the content of one's thoughts. Thus, a compositional semantics is apparently unable to substantiate Learning. In itself, this consideration does not show that Learning is false,
but it does present proponents of bootstrapping with a challenge. How, if not compositionally, might placeholders be interpreted?

This challenge is related to Fodor’s (1975; 1980; 2008) well-known skepticism about the very possibility of learning new concepts that increase one’s expressive power. According to Fodor, the only thing that concept learning could be is some form of hypothesis formation and testing (HFT), in which the learner generates hypotheses about what a new concept could mean by defining it in terms of the concepts she already has, and then tests those hypotheses against her experiences. Yet Fodor argues that HFT lacks the capacity to increase one’s expressive power since any new concepts are simply defined in terms of one’s old concepts. For example, you might hypothesize that a new concept FLURG is to be defined in terms of your old concepts GREEN OR CIRCULAR. But in that case, acquiring the concept FLURG doesn’t increase your expressive power. It doesn’t allow you to think any thoughts that you couldn’t think already. You might coin a new symbol in your language of thought, but that no more endows you with the ability to think new thoughts than does learning that the French word “chien” means dog. At best, you learn to associate a new vehicle with an old content.

When Fodor says that HFT is the only thing that concept learning could be he is not claiming that HFT is the only way that concepts could be acquired. We can imagine concepts being acquired through various brute-causal processes. Perhaps Newton acquired the concept GRAVITY because an apple fell on his head, causing his neurons to jiggle in just the right way; and perhaps some futuristic neurosurgeon could implant new concepts in your brain. Less extravagantly, perhaps there is a purely neurological story to tell about how the bulk of our concepts are normally acquired (Fodor 1998; 2008). Fodor does not deny that concepts might be acquired in any of these ways. He just denies that any of these processes would count as learning.

Fodor’s critics often object that he operates with an overly restrictive conception of learning, and Carey is no exception. She takes bootstrapping to stand as an alternative to HFT, and thus
rejects Fodor’s premise that concept learning must be some form of HFT (pp. 513–14). The challenge confronting such critics, however, is to spell out in detail what an alternative to HFT might look like.

Carey, recall, identifies two stages to bootstrapping: the construction of placeholders and their subsequent interpretation. Let us grant that she can explain how placeholders are learned—for example, how children manage to memorize an ordered count list. The question then arises how those placeholders become meaningful—that is, how they are properly interpreted. At this point, Carey appeals to “modeling processes,” which she lists as consisting of induction, abduction, analogy, limiting case analyses, and thought experimentation (pp. 307, 418, 476). As Carey observes, these processes “are not deductive” (p. 307). It is thus tempting to think that they can “go beyond” their inputs and undergird the sorts of conceptual leaps that interest Carey. Any such impression is illusory, however. Consider induction, which “leaps” from a finite set of observations to a conclusion about unobservables. The conclusion clearly goes beyond the inputs in the sense that the conclusion does not deductively follow from the inputs. However, the conclusion itself is still couched in terms of concepts that are available to the thinker. Induction tells you how to transition from 1000 sightings of green emeralds to the conclusion that all emeralds are green, but it doesn’t tell you where to get the concepts ALL, EMERALD, or GREEN. In other words, induction selects an ampliative conclusion from your hypothesis space, but it doesn’t generate or expand your hypothesis space; it presupposes that space.7

A similar point arises for the other processes on Carey’s list. Insofar as abduction can be characterized computationally (and recall that it must be so characterized to qualify as a learning

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7 For this reason, the problem of explaining bootstrapping goes beyond Hume (1739/2000) and Goodman’s (1955) inductive skepticism. Hume and Goodman assume that thinkers have the conceptual resources with which to formulate various competing hypotheses, but worry that their evidence fails to support the “natural” hypothesis we intuitively favor over deviant hypotheses. By contrast, the worry about bootstrapping is that it doesn’t even tell us how thinkers can formulate the appropriate hypothesis in the first place. Thus, even if we had an inductive logic that could select the “natural” hypothesis over others, we would still lack an explanation of bootstrapping.
process according to Carey), it provides an algorithm for selecting the most explanatory hypothesis from a set of candidate hypotheses that are aimed at making sense of some data. But abductive algorithms do not specify where the set of candidate hypotheses is supposed to come from. Similarly, reasoning by analogy can help one to draw novel conclusions about a target domain by comparing it to a more familiar domain, but it presupposes that one has the concepts with which to characterize the familiar domain. Thus, it can be useful to reason about electric circuits by comparing them to hydraulic systems, but only if you have the conceptual resources to characterize the properties of hydraulic systems. Otherwise, the analogy will get you nowhere. Limiting case analyses and thought experimentation, the two other types of modeling processes that Carey mentions, are likewise constrained. To execute a thought experiment or limiting case analysis, one needs to formulate possible scenarios and draw likely conclusions, which presupposes having the concepts with which to characterize those scenarios and conclusions. Taken as a whole, the modeling processes Carey imagines are thus all unfit to explain how placeholders can be interpreted without presupposing the very concepts the placeholders are supposed to become. No amount of inducing, abducing, or analogizing can get around the fact that unless a child already has the concept SUCCESSOR, it cannot even occur to the child that the successor relation orders the items in her count list.

I claim no great originality in noticing this problem. Fodor (1980) raised essentially the same problem for Piaget several decades ago, and Fodor (2010) and Rey (2011) raise it afresh for Carey. The problem is made especially vivid by Rips, Asmuth, and Bloomfield (2006), who imagine two children that have memorized the count list up to “ten” as an uninterpreted placeholder structure, but then interpret the count list in two different ways. One child interprets the count list in the standard way, as embodying the successor relation. But the other interprets it as embodying a non-standard cyclical system according to which “one” refers to sets with 1 or 11 or 21… objects, “two” refers to sets with 2 or 12 or 22… objects, and so on. The point of their thought experiment is
that we need some explanation how children manage to give the correct interpretation to their placeholder systems. If we could suppose that children already had the concept SUCCESSOR prior to the bootstrap, we could tell a story about how innate constraints encourage them to interpret the count list in the standard way. But if they lack that concept, it is unclear how children could even formulate the standard interpretation, let alone favor it over deviants.8

At this point, we could give up on bootstrapping altogether, but I believe such despair would be premature. Although Carey’s defense of Learning is unsuccessful, she puts together a compelling case for the Discontinuity and Placeholder Theses, suggesting that children somehow manage to use placeholders to bridge conceptual discontinuities. Moreover, it is hard to believe that learning isn’t involved given that conceptual discontinuities are often bridged as a result of instruction and study, and that success at bridging such discontinuities is predicted by the particular curriculum that one’s teachers adopt. Thus, rather than throw in the towel on bootstrapping, I want to proceed in a constructive spirit by considering three strategies that seek to accommodate Learning. All of these strategies involve a reworking of Carey’s notion of bootstrapping, so I do not know whether she would endorse any of them. They also all confront their own proprietary difficulties, and so I lack full confidence that any of them will ultimately prove viable. Yet if bootstrapping is to be salvaged, some learning explanation of how placeholders are interpreted is required.

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8 Margolis and Laurence (2008) argue that Rips et al. go wrong in underestimating the innate numerical concepts that subset knowers have available to them prior to the bootstrap. In particular, they claim that subset knowers already have the concepts (EXACTLY) ONE, (EXACTLY) TWO, and (EXACTLY) THREE, and have mapped the first three count words onto these concepts. As a result, there is nothing stopping subset-knowers from representing that “successive words exhibit a difference of one” and thus “that ‘four’ picks out four (the property of collections with one more than three), ‘five’ picks out five (the property of collections with one more than four), and so on” (Margolis & Laurence 2008, p. 932). Margolis and Laurence conclude that there is no mystery how children could acquire concepts of the positive integers rather than some deviant cyclical numerical system. Yet Margolis and Laurence’s proposal faces a dilemma. If children are supposed to innately have the concept (EXACTLY) ONE MORE THAN, then their proposal smuggles the concept SUCCESSOR in through the back door. As a result, the bootstrap no longer increases children’s expressive power since any child that has the concepts ONE and SUCCESSOR has the conceptual resources to represent all of the positive integers. If, however, Margolis and Laurence do not mean to imply that children have the concept (EXACTLY) ONE MORE THAN innately, then their account is incomplete since it doesn’t explain where that concept comes from.
3. The Deflationary Strategy

The first strategy I want to consider maintains that bootstrapping is, after all, just a particular type of HFT. At first blush, it might seem that any such strategy will contravene Discontinuity, but the issues here are subtler than they first appear. To lay the groundwork for appreciating these subtleties, I begin with some distinctions.

If a person is currently using a concept, I will say that she is *deploying* the concept. For example, when you actively think that the cat is on the mat, you deploy the concept *CAT*. By contrast, let us say that a concept is *available* to a person just in case she could deploy it in reasoning, thinking, categorizing, remembering, and other cognitive processes without much effort, simply by endogenously shifting her attention. For example, if you are busy thinking about the cat being on the mat, then presumably you are not deploying your concept *PENGUIN*. Nevertheless, the concept is available to you. You could deploy it simply by initiating the appropriate shift in your attention. Precisely how many concepts a person can deploy at any one time is open to debate, but will depend on such factors as the capacity of working memory and the extent to which occurrent thought operates serially or in parallel. Whatever the number, it is surely quite small in comparison to the number of concepts that are available to a person.

I want to further recognize a class of *latent* concepts that are encoded in a thinker’s mind despite being neither deployed nor available. There are various ways that a concept might be latent. For our purposes, however, there is one way that is particularly important. A concept might be latent because it is *unobviously* composed from one's available concepts, such that putting the available constituent concepts together and deploying them requires more than an easily executed endogenous shift in attention. Suppose, for example, that you are a participant in a concept-learning experiment, and your job is to separate things that are *burse* from those that are not. Suppose further that the experimenter has generated a highly gerrymandered definition for *burse*, such that something is burse just in case it is either green and circular, or blue and enclosed by a
prime number of sides, or red and preceded in presentation by a yellow triangle. We can suppose that each of the constituent concepts in this definition—GREEN, CIRCULAR, OR, AND, PRIME, ...—are available to you. But of course you do not normally go around categorizing things in this rather peculiar way, and would find it difficult to do so. This particular combination of concepts isn’t available for you to deploy in cognition even though each constituent is. As a result, BURSE counts as latent. It takes more than a simple endogenous shift in attention for you to put the individual concepts that constitute BURSE together and deploy them.9

Not all complex concepts will count as latent. For example, the concept HAPPY MAN is plausibly composed from the concepts HAPPY and MAN, but for typical human thinkers it is available, not latent. There may be individual differences. Concepts that are latent for me might be available to you, and vice-versa. Moreover, the line between latency and availability is unlikely to be sharp. Although the distinction does admit of some clear cases on either side, there will be many borderline cases that are difficult to classify.

Finally, let us say that a concept is foreign just in case it is not encoded in the thinker’s mind in any way, and thus is neither deployed, available, nor latent. For example, the Newtonian concept MASS is presumably foreign for dogs. It is not available for dogs to think with, nor is it latent in their minds. Presumably there are likewise concepts that are currently foreign for all humans, though of course we cannot say what they are. Whether any concepts that are currently available to a thinker were at one point foreign for that thinker is controversial. For example, it is controversial whether MASS was foreign for you prior to your first physics class, or merely latent in you. Notice, however, that even if MASS was foreign for you, it would not automatically follow that you learned the concept in your physics class since you could have acquired it brute-causally.

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9 Although BURSE admits of a Boolean definition, other latent concepts might have different sorts of structures. For example, perhaps certain concepts have prototype structures. If so, some latent concepts might be constituted by sufficiently unobvious complexes of weighted features. Or (more relevant to Carey’s project) perhaps certain concepts are defined by their place in a theory. If so, some latent concepts might be constituted by sufficiently unobvious Ramsey sentences (an idea I’ll return to presently).
I will call any learning process that makes foreign concepts available *Immaculate Conception*, since it would need to introduce new concepts from (seemingly) nowhere. Given Discontinuity, it might seem that bootstrapping just *has* to be some form of Immaculate Conception. Yet there is reason to proceed with caution, for once latent concepts are distinguished from foreign concepts, we can see that there is an ambiguity in the notion of a discontinuity in expressive power, leading to two versions of Discontinuity.

**Strong Discontinuity:** conceptual development involves substantial discontinuities in expressive power. Thinkers acquire new batches of concepts over development that enable them to think thoughts that were previously *foreign* to them.

**Weak Discontinuity:** conceptual development involves substantial discontinuities in expressive power. Thinkers acquire new batches of concepts over development that enable them to think thoughts that were previously *unavailable* to them.

While marrying Learning to Strong Discontinuity requires Immaculate Conception, a happy union between Learning and Weak Discontinuity would be guaranteed by learning processes that make latent concepts available. One strategy for making sense of bootstrapping is thus to reject Strong Discontinuity in favor of Weak Discontinuity, thereby eliminating the need to accommodate Immaculate Conception. I call this the *deflationary strategy*.¹¹

Even when conceptual discontinuities are deflated, it is clear that not just any learning process will make sense of bootstrapping. It will not do, for example, to appeal to what I call *Singular HFT*, which makes latent concepts available piecemeal, by defining each new latent concept compositionally in terms of already available concepts. The problem is *not* Fodor’s worry that you cannot increase your expressive power by defining a new concept in terms of old ones.

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¹⁰ Thanks to Amanda Hale for the name.

¹¹ Fodor anticipates the deflationary strategy in his early writings (Fodor 1975, pp. 84–6; 1980, p. 151; 1981, pp. 270–1), but more recently seems to ignore it (Fodor 2008). The “ecumenical view” of Gross and Rey (2012, pp. 352-3) and Rey (2011) is a version of the deflationary strategy.
Fodor is surely right that Singular HFT cannot increase one's expressive power in the stronger sense of making foreign concepts available, but that doesn't prevent it from increasing one's expressive power in the weaker sense of making latent concepts available. In a case where you introduce a new label for a complex concept that was itself already available (e.g., by introducing \textsc{email} to stand for \textsc{electronic mail}), Fodor is correct that there is no sense in which you have increased your expressive power. You have merely relabeled an already available concept. But in a case where you introduce a new symbol to stand for a complex concept that was only latent (e.g., by introducing \textsc{burse} to mean \textsc{green and circular}, or \textsc{blue and}...), there is a clear sense in which you do increase your expressive power. There are thoughts that are newly available for you to deploy.\footnote{The intuitive idea that symbols can increase the cognitive accessibility of complex concepts is supported by empirical work showing that symbols focus attention on categories (e.g., Waxman & Markow 1995; Xu 2002) and serve as mnemonics by chunking information (e.g., Miller 1956; Needham and Baillargeon 2000).}

Fodor's argument against concept learning masks this real cognitive change by blurring the distinction between relabeling a complex concept that was already available, and making a complex concept that was previously only latent available for the first time.

The problem with Singular HFT is rather that it doesn't explain another crucial property of bootstrapping that Carey isolates: the acquisition of a batch of concepts all at once. There are other forms of HFT, however, that can. Perhaps the clearest form of \textit{Batch HFT} (as I will call it) would involve a conceptual analog of the Lewis-Ramsey method for defining theoretical terms, which makes use of bound variables to introduce multiple concepts at once by defining them not only in terms of their relations to other concepts that are already in one's conceptual repertoire, but also in terms of their relations to each other (Ramsey 1931; Lewis 1970).\footnote{Peacocke's (1992, pp. 10–12) discussion of "local holisms" applies these ideas to concepts.} For example, one might introduce the concepts \textsc{force}, \textsc{mass}, and \textsc{acceleration} not by sequentially defining each concept in terms of the concepts one already has, but by defining them all at once in terms of the concepts one already has \textit{and} in terms of the relations they bear to each other (e.g., as embodied in the equation $F$...
= ma). A thinker could thereby increase her expressive power (in the weaker sense) by making a whole range of concepts available that were previously only latent.

Carey does not draw the distinctions I have drawn here between available, latent, and foreign concepts, between the Weak and Strong Discontinuity Theses, or between Immaculate Conception, Singular HFT, and Batch HFT. The present proposal thus goes beyond anything that is explicit in *Origin*, and even sits uneasily with passages where Carey distances bootstrapping from HFT (e.g. pp. 513–14). But as we have seen, bootstrapping needs to be reworked in some way if Learning is to be defended. Moreover, Weak Discontinuity seems sufficient to accommodate the considerations that actually motivate Carey to posit conceptual discontinuities, including the poverty of the initial starting point, the difficulty of the transition, and within-child consistencies.

The fact that each of the number-relevant representations children start with (analog magnitudes, parallel individuation, natural language quantifiers) cannot represent the integers is compatible with the integers being definable through an elaborate Ramsey sentence that makes use of a range of the child’s available representations all at once. Similarly, the difficulty of bootstrapping is surely compatible with Weak Discontinuity. Many proofs in mathematics and logic are exceedingly difficult to discover despite following by definition from the terms involved, and the sorts of definitions that go into Batch HFT are likely to be highly complex compared to those that are constitutive of Singular HFT. Nor is the consistency in performance that each child displays across a wide range of tasks especially troublesome for Weak Discontinuity. Since several concepts are

\[14\] Although Carey explicitly rejects identifying bootstrapping with HFT, she often formulates HFT in ways that suggest that she has Singular HFT in mind, as when she writes that hypothesis testing consists “of selection or concatenation over an existing conceptual base” (pp. 365–6). Because variables are deployed as placeholders, Batch HFT involves more than mere selection or concatenation over the concepts one already has. So perhaps Carey would welcome a deflationary interpretation of bootstrapping in terms of Batch HFT.

Interestingly, there is also textual evidence that Block intends his account of concept learning to be compatible with Batch HFT. In an endnote appended to the passage where he discusses learning concepts from physics, Block writes that his account of concept learning is not new, but is “just what you would expect” if you accepted Lewis’s account of defining theoretical terms (Block 1986, p. 672, n. 45).
learned at once in Batch HFT, one would expect performance changes to be relatively abrupt and stable, rather than gradual and context-sensitive.

The deflationary strategy is not entirely unproblematic, however. Insofar as it requires new concepts to be composed from one’s available concepts, it confronts the worry that most lexical concepts (i.e., concepts that are expressed by single morphemes in natural languages) are unstructured. In support of this contention, Fodor (1981; 1998) argues that even such common concepts as DOG, PAINT, and CHAIR seem hopelessly difficult to define. This has led many philosophers, including Fodor, to conclude that most lexical concepts lack definitions altogether.

It is tempting to reply that concepts might be structured even if they lack definitions, since concepts could have non-definitional structures. It is unclear, however, what a non-definitional structure might be such that concept learning would be possible. If non-definitional structures do not provide necessary and sufficient conditions for a concept’s application, it is unclear how learning such structures would suffice for concept learning. However, if non-definitional structures do provide necessary and sufficient conditions for a concept’s application, it is questionable whether anyone has an adequate theory of them. For example, although skepticism about conceptual structure often focuses on the difficulty of providing Boolean definitions of concepts, it has proven equally difficult to imagine weighted clusters of features getting the referents of our concepts right given that concepts often have non-prototypical members in their extensions. Thus, appealing to prototype structures would not obviously help proponents of the deflationary strategy. Similarly, the proposal that concepts are structured from the roles they play in theories (as Batch HFT maintains) confronts the difficulty that no one seems to be able to say which roles are constitutive of a concept, particularly given the resistance to reference change that our concepts apparently display even as we massively modify our theories. Yet if concepts are unstructured, the deflationary strategy has to be wrongheaded. You cannot learn a concept by learning its structure if concepts lack structures.
Not everyone believes that concepts are unstructured. For instance, Carey maintains that concepts have narrow contents that are structured from their conceptual roles. Carey is aware of the difficulties of specifying which roles are constitutive of any given concept’s narrow content, freely admitting that she has “no worked-out account of which aspects of the conceptual role are content determining” (p. 523). But Carey nevertheless takes it as “an article of faith” that the problem can be overcome, and even advances a few suggestions of her own about how to approach it (pp. 523–35). Whether Fodor or Carey is right about the structure of concepts is an enormously complex philosophical issue that may be inseparable from questions about the viability of an analytic-synthetic distinction. It would thus be foolish to attempt to settle the issue here. My point is just that the deflationary strategy is committed to the controversial assumption that concepts are structured. In fact, it is committed to a stronger claim. Not only must bootstrapped concepts have some structure or other, they must be structured from concepts that are already available to the learner. For example, the mere fact that the concept SEVEN can be defined in accordance with Hume’s Principle and second-order logic does not suffice to show that children can learn SEVEN by constructing such a definition unless it can also be shown that children have the conceptual resources to represent Hume’s Principle and second-order logic. The deflationary strategy is thus hostage to the empirical claim that children have the conceptual building blocks from which to structure the concepts they arrive at through bootstrapping.

It may be that certain cases of concept acquisition will be more amenable to the deflationary strategy than others. In particular, because our mathematical concepts typically admit of clear definitions they are more likely to succumb to deflationary learning explanations than many other concepts humans acquire. So perhaps it is unsurprising that suggestions exist about how young children might generate concepts of natural numbers from primitive resources that are available to them. For example, Piantadosi, Tenenbaum, and Goodman (2012) propose a Bayesian statistical model whereby children build positive integer concepts from a variety of primitive operations
implemented in an innate lambda calculus, including set-theoretic and logical operations, operations over words in the counting routine, operations that test whether a set has one, two, or three members, and recursion. The model's primitives are sufficiently rich to explain how the successor function could be arrived at compositionally, but without needing to suppose that the successor function is available to children from the outset. It remains to be seen, however, whether this particular model will survive empirical scrutiny (see Rips, Asmuth, and Bloomfield draft for some compelling worries) and whether further models can be successfully extended to non-mathematical concepts where definitions are harder to come by.

4. The Causal Strategy

Concerns about defining concepts have led some philosophers to seek out non-compositional explanations of concept learning (Margolis 1998; Laurence & Margolis 2002; Weiskopf 2008). Nicholas Shea interprets Carey's account of bootstrapping along these lines.

[Carey] has a plausible, detailed story of how genuinely new atomic representations can develop out of representational resources with more limited expressive power, an account that manifestly proceeds at the psychological level. The new representations are not formed by inference from existing representations. At some stage there must be a leap, a step that is not a piece of computation-in-virtue-of-content, but one that psychology can describe causally nevertheless. (Shea 2011, p. 136)

At first, the placeholders are empty symbols; they have no content. But then they are interpreted; they are given content. Shea's basic idea is that this transition cannot be described as a computation over representations since the placeholders do not begin as representations. Rather, the step is more like transduction, where something non-representational becomes representational. Here is Shea's description of the genesis of natural number concepts:

The counting sequence provides a route into the successor relation. Carey's insight is that it can be acquired as a series of non-representational symbols. That is Quinian bootstrapping. A series of symbols are put into a set of causal relations by rote, habit or some other causal device. Initially the causal
transitions are not inferences and the symbols are not representations. Only when the symbols get wired up to the world do they acquire a content and become representations. Pre-existing representations play a causal role in setting up the sustaining mechanisms. But pre-existing symbols cannot exhaust the content of the new representations, since their content is in part determined by what have now become inferential relations between them. (Shea 2011, pp. 134–5) Shea is arguing that bootstrapping consists in a transition from a set of non-representational placeholders to a set of contentful concepts. This transition may well be causal, but it cannot be intentional since the initial state is non-representational. The placeholders have no content, and the relations between them are acquired brute-causally (e.g., "by rote"), not inferentially.

There is a subtle difference between the deflationary strategy as couched in terms of Batch HFT and Shea’s causal proposal. Both emphasize the role of a network of placeholders that initially lack content, but whereas the deflationary strategy treats placeholders as bound variables within contentful complexes, and is therefore able to tell an intentional story about how placeholders acquire their contents, Shea imagines that placeholders acquire their contents through “a step that is not a piece of computation-in-virtue-of-content.” While this feature of Shea’s proposal makes bootstrapping an instance of Immaculate Conception and allows Shea to sidestep the need to build bootstrapped concepts compositionally from already available concepts, it also puts his proposal at odds with Carey’s explicit definition of learning processes “as those that build representations of the world on the basis of computations on input that is itself representational” (p. 12, emphasis added). Shea is thus driven to the position that Carey simply erred in characterizing learning in this way (Shea 2011, p. 138). Perhaps he is right, though the causal strategy confronts its own difficulties.

One problem is that it is unclear why the process that Shea isolates should count as learning. This worry is especially pressing because Shea rejects Carey’s preferred definition of learning in terms of computations over representations, and says almost nothing about what should replace it. He does say that his proposal “manifestly proceeds at the psychological level” (2011, p. 136), but if
this is intended as a justification of why bootstrapping is learning, it is doubly unsatisfactory: firstly, because not everything that proceeds at the psychological level counts as learning; and secondly, because it is not obvious that the causal process of wiring up a series of empty symbols just so really is psychological. The thesis that Shea has isolated a learning process would thus require further defense, and it is presently an open question whether such a defense can be successfully mounted.15

There is a second, and perhaps more serious, difficulty for the causal strategy. To fully explain bootstrapping it needs to explain not only how the placeholders are introduced and ordered, but also how they are correctly interpreted. For example, a child that acquires the count list and puts it into the correct order by rote or habit still needs to infer the correct relation that the ordering is supposed to exemplify. But as Rips, Asmuth, and Bloomfield emphasize with their example of the deviant counting system, the same placeholder system can be multiply interpreted, and unless the child already has the relevant concepts (e.g. successor), it is unclear where the correct interpretation is supposed to come from. Acquisition by rote or habit might suffice to explain the genesis of the placeholders, but it does not explain how the placeholders are interpreted—not even brute-causally.

Shea is aware of this difficulty, and thus includes as part of his account that the placeholders are not only introduced and ordered, but also “get wired up to the world,” to each other, and to other concepts in the appropriate way. Implicit in Shea’s suggestion is that we follow Carey in assuming a dual-factor theory of conceptual content that is committed to both wide and narrow contents, with the wide content explained in terms of some sort of mind-world relation, and the narrow content explained in terms of some form of internal conceptual role. Thus, if we can give a

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causal explanation of how the placeholders enter into the appropriate mind-world relations and acquire their mature conceptual roles, we can explain how they inherit their contents.\textsuperscript{16}

Notice, however, that in order to provide a purely causal, non-intentional explanation of how a placeholder enters into the appropriate mind-world relation and acquires its mature conceptual role, we would need to characterize the relevant mind-world relation and conceptual role, and that if we were able to characterize the mind-world relation and conceptual role that determines a concept’s wide and narrow contents, we would have succeeded in reducing the intentional to the non-intentional—i.e., in reducing conceptual content to a mind-world relation and a conceptual role. For example, if we wanted to causally explain how the concept SEVEN transitions from being an empty placeholder to a concept with the appropriate content, we would need to be able to explain how SEVEN acquires the right relation to the property seven, as well as how it acquires the conceptual role that is constitutive of its narrow content. And to do that, we would need some way of characterizing the relation that SEVEN bears to seven, as well as the conceptual role that is constitutive of the narrow content of SEVEN, in which case we would have a non-intentional characterization of how the (wide and narrow) content of the concept SEVEN is determined. There are, of course, many proposals in the philosophical literature about how to reduce away the intentional, but they are all accompanied by familiar and recalcitrant problems. It thus remains highly controversial whether conceptual content can ultimately be explained in non-intentional terms. The need to provide a reductive account of conceptual content therefore poses a challenge to anyone who hopes to explain bootstrapping in terms of the causal strategy.

It is important to see that the problem here is not merely a feature of the dual-factor theory of content with which Carey operates, but would arise for the causal strategy no matter what theory of content it was wed to. Because concepts are by their nature intentional entities, if the inputs to concept learning are non-intentional (as the causal interpretation maintains), there is bound to be a

\footnote{The basic idea here is present in Margolis (1998) and Laurence & Margolis (2002).}
gap that needs bridging. We must somehow explain how non-intentional inputs can yield intentional outputs. But it is hard to see how that gap could be bridged without ultimately translating between the intentional content of the outputs and the non-intentionally characterized inputs. Hence, no matter what one’s theory of conceptual content is, it is doubtful that the causal strategy can get off the ground without accomplishing the titanic task of effecting a reduction of the intentional.

5. The Nonconceptual Content Strategy

Our guiding question is whether any sense can be made of bootstrapping as a learning process that bridges conceptual discontinuities. While the deflationary strategy attempts to make sense of bootstrapping by relaxing the notion of a conceptual discontinuity such that Immaculate Conception is not required, the causal strategy seeks to make sense of bootstrapping by relaxing the notion of learning such that “computation-in-virtue-of-content” is not presupposed. One might wonder, however, whether a serviceable notion of bootstrapping really needs to relax these notions. Can we not make sense of bootstrapping without abandoning either Immaculate Conception or intentionally characterized learning processes?

The one strategy I am aware of that attempts to reconcile bootstrapping with both Immaculate Conception and intentionally characterized learning processes makes use of a controversial idea that philosophers have put to use for other purposes: nonconceptual content. If the crux of the problem is how to provide an intentional explanation of bootstrapping without presupposing as inputs the very concepts that are supposed to be generated as outputs, nonconceptual content promises a solution. While the outputs of the bootstrapping process must be concepts, the inputs could be representations with nonconceptual content. The outputs could thus extend beyond the inputs in a genuine way, and yet the process of concept generation could still be explicable intentionally since the inputs would still have content.
Philosophers familiar with traditional discussions of nonconceptual content might recognize structural similarities between its deployment in those discussions and the strategy I am entertaining here. Typically, philosophers appeal to nonconceptual content to explain both how belief and perception represent in fundamentally different ways, and how belief can be rationally (and not just causally) grounded in perception. For example, philosophers such as Evans (1982), Peacocke (1992), Heck (2000), and Fodor (2008) argue that perception has representational features that cannot be captured by the conceptual contents that are standardly attributed to beliefs, but nevertheless has some type of content, which explains its ability to justify beliefs. My visual representation of a green light may not have the same content as my belief that there is a green light, but it must have some content or other to justify that belief and my ultimate decision to drive through the intersection. Similarly, if we take the inputs to bootstrapping to have nonconceptual content, the hope is that we can explain both how the outputs differ from the inputs, and how the outputs can be rationally (and not just causally) grounded in the inputs. Like justification, learning is a rational process. And just as nonconceptual content is deployed to explain how the epistemic transition from perception to belief is rational, perhaps it can also be deployed to explain how the formation of new concepts is rational.17

Although Carey never considers the nonconceptual content strategy, there are two places in her account of bootstrapping where nonconceptual content might enter the picture. First, we might attribute nonconceptual content to the representations from what Carey calls “core cognition,” the evolutionarily ancient system of hard-wired representations of such basic categories as objects, agents, and numbers. Carey argues that representations of core cognition are post-perceptual,

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17 Fodor (2008, p. 94) maintains that perceptual states with nonconceptual content can rationally generate perceptual judgments, but surprisingly does not anticipate the possibility that states with nonconceptual content might rationally generate new concepts. By contrast, Peacocke (2001, pp. 252-3) and Roskies (2008) do anticipate this possibility, though their discussions are limited to explaining how perceptual states with nonconceptual content can generate observational concepts (e.g. RED). To explain how the sorts of concepts that interest Carey (e.g. SEVEN) are learned it is necessary to attribute nonconceptual content to more than perception.
receive support from domain-specific input analyzers, go unchanged throughout the lifespan, and have an iconic (rather than language-like) format (pp. 10-11, 448-463).\(^{18}\) She contrasts core cognition with "explicit conceptual representations," which have a language-like format, are domain general, are embedded in explicit theories, and are susceptible to change throughout the lifespan of the thinker (pp. 22-24, 466). Carey counts analog magnitudes and object files as representations of core cognition. By contrast, the natural number concepts that are the output of the bootstrapping process are explicit conceptual representations.

Second, just as any logic needs not just axioms but rules of inference, any computational theory of mind that posits explicit representations also needs "transformation rules" that govern how those representations can be manipulated. Assuming we identify concepts solely with the constituents of explicit representations, we face the question how to characterize the transformation rules. If they are not composed of concepts, it is hard to see how they could have conceptual contents. Yet transformation rules often seem to have semantic interpretations, suggesting that they might best be characterized in terms of some type of nonconceptual content. If transformation rules can also play a role in generating new concepts, then a second place where we might appeal to nonconceptual content to help ground bootstrapping is in characterizing transformation rules that guide thinkers to their newly acquired concepts.

To see how nonconceptual representations from core cognition and nonconceptual transformation rules might help to explain Learning, consider Carey's account of how children acquire the first four number words in terms of enriched parallel individuation. She proposes that children learn that there is “one” F just in case the Fs can be put in one-to-one correspondence with the member of the set \{i\} in long-term memory, that there are “two” Fs just in case the Fs can be put

\(^{18}\) The idea that representations with an iconic format have nonconceptual content is defended in Fodor (2008, Ch. 6), though Fodor only considers evidence that certain perceptual states are iconic, not that core cognition is iconic. Carey primarily defends the thesis that core cognition is iconic in reference to analog magnitude representations of number (pp. 134-5, 458). Beck (forthcoming) argues that analog magnitude representations have nonconceptual content because their format is not language-like.
in one-to-one correspondence with the members of the set \( \{j, k\} \) in long-term memory, etc. In so learning, the children’s object file systems are doing double duty: they are representing the objects that belong to two sets; and they are determining that the objects from those sets stand in one-to-one correspondence. But notice that if Carey intends bootstrapping to be a form of Immaculate Conception, she cannot mean that children define the concepts _ONE_, _TWO_, _THREE_ and _FOUR_ from the concepts _OBJECT_ and _ONE-TO-ONE CORRESPONDENCE_. Otherwise, her bootstrapping proposal would just amount to a straightforward version of HFT. And if she intends to hold onto a computational-intentional account of learning, nor can object files play a merely causal role, since she would then need to abandon a learning explanation of the origin of the first few natural number concepts.

Suppose, however, that we instead understand Carey as appealing to nonconceptual core representations of objects together with a type of procedural knowledge, encoded in a nonconceptual transformation rule, which determines when the objects from two sets stand in one-to-one correspondence. We could then provide an intentional explanation of how children imbue the first few number words with their contents (since the core representations and transformation rules have contents) but without presupposing the very integer concepts whose genesis we are meant to explain.

Although Carey does not appeal to a notion of nonconceptual content, this reconstruction of her view finds echoes in her own characterization of how children learn the first few natural number concepts.

The meaning of the word “one” could be subserved by a mental model of a set of a single individual \( \{i\} \), along with a _procedure_ that determines that the word “one” can be applied to any set that can be put in 1-1 correspondence with this model. Similarly, two is mapped onto a longterm memory model of a set of two individuals \( \{j, k\} \), along with a _procedure_ that determines that the word “two” can be applied to any set that can be put in 1-1 correspondence with this model. And so on for “three” and “four.” (p. 476, emphasis added)

On the next page, Carey summarizes:
The child creates symbols that express information that previously existed only as constraints on computations. Numerical content does not come from nowhere, but the process does not consist of defining "seven" in terms of symbols available to infants. (p. 477, emphasis added)

Notice Carey’s appeal to “procedures” that exist “only as constraints on computations.” If such procedures were representations, her account would be circular. If they played a purely causal role, her account wouldn’t be intentional. Yet by treating procedures as a type of nonconceptual know-how, it becomes easier to see what she might mean. The child has innate procedural knowledge, encoded in transformation rules with nonconceptual content, which guide it to treat meaningless symbols in its count list as referring to integers. But until the child has actually directed that procedural knowledge at its newly acquired placeholder system (the count list), it doesn’t have explicit representations (concepts) of the integers.

While the strategy of appealing to nonconceptual content to explain bootstrapping promises to serve as an alternative to the causal and deflationary strategies, it is not entirely unproblematic. For one thing, it leans on a notion of nonconceptual content whose respectability and nature are still subject to lively debate (Stalnaker 1998; Byrne 2005; Speaks 2005; Heck 2007). Moreover, even if the notion of nonconceptual content can be successfully elucidated, what I call the problem of rational relations would still remain. It is one thing to explain how inferences or computations could be carried out over representations and transformation rules that have the same kind of content, and quite another matter to explain how they could be carried out over representations and transformation rules that have different kinds of content. As McDowell (1994) emphasizes, even if states with nonconceptual content enter into causal relations with states with conceptual content, it is far from obvious that such relations ought to count as genuinely rational or inferential. By analogy, consider the difference between a monolingual German speaker’s saying something and then a monolingual English speaker’s saying something back (where neither understands the language of the other), and a conversation between two individuals who speak a common language.
In the latter case, there is genuine communication. In the former case, any sense that attaches to the exchange would seem to be fortuitous. McDowell’s worry is that any exchange between mental states with fundamentally different types of content would be similarly defective. Without a “common code” the transitions among such states would not count as genuine inferences or computations. The states might be causally related, but they wouldn’t be rationally related. Of course, not everyone agrees with McDowell that the problem of rational relations is decisive.

Philosophers such as Peacocke (1992; 2001), Heck (2000), and Burge (2003) propose that a type of rationality attaches to transitions across states with different kinds of content. But my point is that there is a problem here that any proponent of the nonconceptual content strategy would need to confront, not that the problem is insoluble.

6. Conclusion

I began with a summary of Carey’s account of bootstrapping, which seeks to explain how thinkers can draw on a network of placeholders to learn a new batch of interrelated concepts. While Carey persuasively argues that substantial discontinuities in expressive power exist, and that learners somehow bridge those discontinuities with the help of placeholders, I objected that she fails to isolate a learning process that can explain how those placeholders are interpreted, her appeals to modeling processes notwithstanding. I then delineated three strategies for overcoming this limitation of Carey's account: the deflationary strategy, which understands bootstrapping to make latent (rather than foreign) concepts available through Batch HFT; the causal strategy, which understands bootstrapping as a non-intentional process akin to transduction; and the nonconceptual content strategy, which grounds concept learning in contentful, yet nonconceptual, representations and transformation rules. Each of these strategies, I argued, confronts unique challenges: the deflationary strategy is committed to finding structures for bootstrapped concepts that decompose into already available concepts; the causal strategy must explain why the
transduction-like process it isolates counts as learning and how the intentional can be reduced to
the non-intentional; and the nonconceptual content strategy is indebted for a positive account of
nonconceptual content as well as a solution to the problem of rational relations. I believe that it is
an open question whether any or all of these challenges can ultimately be met.

As it presently stands, Carey’s rich discussion of concept learning is in need of further
development, but for those who are, like me, sympathetic to Carey’s motivating idea that
substantial conceptual discontinuities can be bridged through learning, I hope to have at least
clarified some of the main avenues along which such further development might constructively
proceed.19

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