The Making of Human Concepts
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Darwin and development: Why ontogeny does not recapitulate phylogeny for human concepts

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Abstract and Keywords

This chapter argues that human cognitive development tells us a great deal about what makes human thinking qualitatively unique, but it does so in the same way that current evolutionary biologists explain how organisms are particularly well adapted to niches; that is, the way in which human concepts are specialized, rather than the product of a linear increase in complexity. The chapter outlines a few key developmental transitions that are commonly assumed in human cognitive development and then demonstrates how these ontogenetic distinctions fail to contribute to our understanding of cross-species differences.

Keywords: cognition, cognitive development, conceptual development, ontogeny, phylogeny, evolution

Editors' Preview

Chapter 15, 'Darwin and development: Why ontogeny does not recapitulate phylogeny for human concepts', critically examines the idea that concept development in children shows an 'ontogenyrecapitulating phylogeny' pattern. In a book dedicated to understanding the similarities and differences of concepts in human infants and children, human adults, and nonhuman animal species from both developmental and evolutionary perspectives, a reasonable starting point from which to launch one's analysis would be to assume that a simple-to-complex progression of conceptual structure would be observed during both ontogenesis (development) and phylogenesis (evolution). This assumption would imply that nonhuman animal species and human infants and children would display evidence only for the simple forms of conceptual structure and only human adults would provide support for the more complex types of conceptual structure.

Chapter 15 reviews evidence for a number of different trends that have been reported for conceptual development, and finds that in each case, there is reason to question whether such development can be said to move along a straightforward progression from uncomplicated to more sophisticated. For example, it has been argued that one way conceptual development advances is from the more concrete to the more abstract. However, Chapter 15 cites counterexamples in which monkeys make abstract inferences about the causal properties of objects and in which young children reason abstractly about concepts (for instance, relying on the belief that objects have an underlying essence rather than adhering to physical appearance when determining category membership) and also seem to form concepts on a trajectory from more inclusive (more general) to less inclusive **(p. 318)** (more specific). It has also been argued that concept development can be characterized as moving from category representations based on associations to those based on rules. Once more, though, Chapter 15 describes instances where young children can overlook associations and display knowledge of rules, and neuroimaging evidence that nonhuman animals possess the different kinds of brain circuits believed to represent both associations and rules in human adults. Finally, it has been contended that conceptual development moves from implicit, procedural representations to explicit, declarative representations. Yet, as observed in the chapter, this conclusion is confounded with the fact that human adults can talk whereas human infants and nonhuman animals cannot, and as clever procedures for assessing explicit knowledge in human infants and nonhuman animals have emerged, the implicit-to-explicit developmental shift has been called into question. The review of the data thus suggests that it is difficult to pin down simple-to-complex trends in conceptual development that are also observed across species.

Chapter 15 does consider two possible candidates for what might make concepts unique in humans. One is language, with its strong potential as a combinatorial mechanism that links together distinct domains such as objects and space, and concepts of different levels of specificity (e.g. object- and basic-level category). It is also the case that language may boost the range of concepts acquired by humans through communication of culturally accumulated forms of knowledge. This latter consideration leads to a second possibility for what may promote the uniqueness of human concepts, namely, the socially embedded nature of our interactions in a world populated by conspecifics. Chapter 15 notes that humans are capable of complex forms of social reasoning that are rooted in the perception of intentionality and the ability to make inferences about goal-directedness. These abilities connect to the world of concepts more generally by allowing humans to use the intentional actions of others to infer the causal structure of artefacts in ways that nonhuman animals do not.

Developmental biologists have for some time rejected the idea that ontogeny recapitulates phylogeny in terms of the development of the physical body. It is useful to briefly summarize this story and its neural analogue as a way of setting up the key issue of this chapter. To what extent can we understand the origins of human cognition by thinking of younger and younger children as simpler and simpler species on a phylogenetic scale? In the end, we suggest that such an approach is doomed to failure, but that it seems to implicitly, and sometimes even explicitly, recur in our field again and again. In its place, we suggest that human cognitive development does tell us a great deal about what makes human thinking qualitatively unique, but it does so in the same way **(p. 319)** that current evolutionary biologists explain how organisms are particularly well adapted to niches – that is, the way in which human concepts are specialized, rather than the product of a linear increase in complexity (see Penn et al., 2008, for a similar position).

The biology story

The idea that an organism's development progresses in a way that mirrors a continuum of species complexity has roots in classical antiquity (Gould, 1977). However, it is probably most strongly associated with Darwin's contemporary, Ernst Haeckel (1899). Haeckel was convinced (for almost mystical reasons) that the evolutionary history of species was directly causally linked to embryology – countless medical students have been misleadingly told that the human embryo 'recapitulates' the evolutionary history of organisms with the 'simplest' ones developing sooner. Dr. Spock helped further the myth by describing in detail how human babies go through a fish-like stage while in the womb (Spock, 1957).

This view can be discredited in many ways, ranging from distortion of the empirical facts to conceptual problems. For example, Haeckel's drawings are quite different from accurate renderings of the embryological stages of fishes, mammals, and the like. Human embryos at earlier stages of development do not really look identical to the embryos of other species. Moreover, the problem is conceptually muddled because it assumes a *scala natura,* or 'great chain of being', in which organisms can be neatly arranged along a single continuum of progress, in which every organism has a certain degree of primitiveness relative to another. Clearly, this is false because whereas human development happens along a single continuum, evolution is inherently not a single line of progression and is instead most aptly described in terms of a branching tree structure. One could see the development of a species as a single line going back to a single-celled organism, but one cannot see current species as ordered along a continuum since they long ago branched off from now-extinct common ancestors and acquired new specializations and complexities that may be unique on that branch. Thus, although the myth of a *scala natura* perseveres, especially in some creationist circles (for unclear reasons), it certainly has no traction among contemporary biologists.

The same theme has also been proposed with respect to brain development. John Hughlings Jackson, for example, proposed a theory of 'neurophylogenesis', in which the development of the brain recapitulates the evolution of the brain across species of increasing complexity (Jackson, 1884). Thus, the brain stem precedes midbrain structures, which in turn precede the cortex; and accordingly, the least-complex species are largely brain-stem creatures, followed by moderately complex midbrain creatures, followed by organisms with complex cortical structures. Jackson and others went further to tell the same story again in the cortex with sensory-projection areas maturing before cortical-association areas, which in turn matured earlier than the frontal and prefrontal cortical areas. However, this 'neuro' version of ontogeny recapitulating phylogeny runs into the same problems that occurred for whole-body embryology. A close examination of brains in early development does not mirror the brains of simpler species (Huttenlocher, 1990). Moreover, it is just as impossible to order brains **(p. 320)** along a neat, single chain of increasing complexity, as it is to order whole bodies. Nonetheless, it is still common today for 'lower-brain' structures to be discussed as those that we inherited from our more 'primitive' evolutionary ancestors.

As is often the case with myths, there are grains of truth that help perpetuate them. In this case, there are rough correlations that can support the general idea. For example, some of the design features of development may converge moderately with those of evolution (Gould, 1977). Thus, in development it might make sense that the first structures to appear are those that are most essential to the survival of an organism and those that directly support the functioning of other organisms. In addition, developing organisms, unlike artefacts, must remain functional (i.e. alive) at all points in their development – so, both in ontogenetic and phylogenetic development, there is the clear pressure to find workable solutions that meet the demands of the environment (Gilbert, 2006).

Consider how these ideas together, cause a rough correlation between phylogeny, evolutionary history, and development. One of the first challenges facing organisms that existed early in evolution related to energy collection and utilization. This was accomplished via chemical senses that caused an attraction towards nutrient-rich sources and mechanisms for releasing energy from organic molecules. Similarly, the first task facing the fertilized egg is to engage in energy recovery and use. As the embryo increases in complexity, it soon needs a circulatory system to bring nutrients to all locations and take the waste away. Hence, a beating heart emerges very early in development, around week 5, while functional eyes are not needed until much later. Finally, consider that development is also related to evolution by the idea that critical control points in development are ideal places for natural selection to operate – for example, by extending or minimizing the duration of a particular developmental period through changes in gene regulation. Thus, in places where adaptation occurred via leveraging off prior patterns of development, more complex organisms will often have some vestiges of those earlier developmental patterns.

In sum, while the notion of embryonic and neural recapitulation is flatly wrong for both factual and theoretical reasons, there are still a number of apparent similarities between ontogeny and phylogeny that result from common environmental pressures and common solutions to those demands. However, the story for biology is much more that just an interesting bit of history. It also helps to explain why similar biases may exist for theories of cognitive development. In the following sections, we outline a few key developmental transitions that are commonly assumed in human cognitive development and demonstrate how these ontogenetic distinctions fail to contribute to our understanding of cross-species differences.

Blurring the boundaries of developmental dichotomies

The study of human cognitive development is fundamentally about change – that is, we want to know how thinking at one point in development is different from thinking at another and how children progress from one level of competence to another in terms of mechanisms that mediate and cause change. This approach leads naturally to **(p. 321)** dichotomies wherein it is common to distinguish between two qualitatively different modes of thought. Moreover, relative to our discussion of ontogeny recapitulating phylogeny, such distinctions often share common assumptions: for example, the idea that one kind of thinking is 'simple', while the other kind is 'complex'; cognitive development moves in increasing complexity; and, other species have only the simple form of reasoning, while the complex form is often reserved for adult humans. In this section, we outline several of the distinctions that have been proposed over the years and explore the ways in which each of these distinctions may in fact be much more blurred than is commonly assumed. Moreover, where appropriate, we include evidence for the 'complex' form of reasoning in other species. Of course, we do not mean to argue that change does not occur in human cognitive development. Rather, our goal is merely to demonstrate why it may often be mistaken to confuse developmentally early modes of thought with the 'simple processing' of 'simple species'.

Concrete to abstract progressions

It is an old developmental story that concepts evolve from a concrete form in infants and young children to an abstract form in adults (e.g. Bruner, 1967; Inhelder & Piaget, 1958; Vygotsky, 1962; Werner, 1940). Such accounts often revolve around the representational formats of concepts, assuming either that concepts have a true internal structure that can be examined for developmental change, or that if an internal structure cannot be evinced, one can still make broad claims about the medium in which those concepts are expressed. If this idea is correct, it suggests a natural comparison across species, namely that concrete representations are widely shared across species, while abstract concepts are unique to human adults. However, this argument encounters three key problems. The first is that it is exceedingly difficult to get clarity on what is meant by 'abstract' and 'concrete' concepts in the first place. As Fodor has argued previously (Fodor, 1998), it may be difficult (if not impossible) to uncover the true internal structure for nearly all concepts. Thus, accounts of conceptual change that move from one type of representational format to another are difficult to sustain because of the challenges of precisely identifying *what* has changed at a level other than behaviour.

Second, in cases where this contrast has been made explicit, empirical findings actually argue against the idea that such a contrast exists in humans. For example, consider young children's beliefs about the underlying differences between categories. One might think that young children first differentiate between broad ontological domains such as animals and artefacts on the basis of concrete features. However, the empirical data suggest quite the opposite. Kindergartners, and in fact considerably younger preschoolers, seem to think that there are deep-seeded essential features that differentiate animals from artefacts. They know that there is 'something' that is inside living things that makes them look and behave differently from artefacts (e.g. Gelman, 2003). Yet, even when confronted with actual animal innards and actual car parts, kindergartners are frequently unable to say which ones go with which kind (Simons & Keil, 1995). Moreover, these abstract beliefs can change over time from one view to another. For example, **(p. 322)** young children, while still not knowing what insides look like, tend to think that animal essences are located in one focal point, deep in the centre of the animal, while older children and adults think of essences as evenly distributed throughout the entire body (Newman & Keil, 2008). Thus, children can apparently have a wide range of seemingly abstract beliefs about the underlying nature of different categories, while not knowing any of the particulars. This is not to say that sometimes concrete-to-abstract patterns cannot also be observed (e.g. infant spatial cognitions can be initially more influenced by distinctive perceptual features of individual objects before they use spatial relations that are more independent of object particulars, Cassasola, 2005; Quinn, 2007). In addition, even adults may, in some contexts, eschew essentialist assumptions in favour of more graded 'causal-homeostasis' models of how surfaces features are causally related (Hampton et al., 2007). The primary point is that there is no invariant progression in which abstract elements are built up out of earlier learned concrete ones.

Similarly, if one looks at the process of categorization, the earliest groupings are not necessarily the lowest ones in a hierarchical tree. By some accounts, young children might be expected to first categorize the world in terms of small local categories, such as dachshunds, then dogs, then mammals, and so on up the tree of expanding category size. Another view might argue that children will first enter the hierarchy of categories at the 'basic level' of categorization, where kinds 'bristle' with distinctive perceptual features that optimally contrast themselves from other kinds at the same level (Murphy, 2004; Rosch, 1975). Either way, the data actually seem to argue against this sort of concrete-to-abstract shift in categorization. In many cases, infants and toddlers initially apprehend categories at levels far above the basic level and will constrain their inferences about the future accordingly. For example, even infants seem to be sensitive to abstract categories such as vehicles and animals (Mandler, 2008; Mandler & McDonough, 1996; see also Chapter 12, this book), or even higher-level differences such as those between goal-directed agents and inanimate objects (e.g. Gergeley et al., 1995; Saxe et al., 2005). In some cases, broad categories may be first apprehended by young infants on the basis of simple perceptual attributes (Quinn & Johnson, 1997, 2000). When this occurs, the dichotomy between abstract and concrete starts to break down as well. A very broad category is normally considered more abstract than a local one; yet, a category constructed out of simple perceptual features seems to have concrete components as well.

Finally, the idea that other species are limited to only concrete representations is questionable as well. For example, free-ranging rhesus macaques appear to generate causal inferences about unfamiliar objects. They will, for example, respond differently to a physically possible outcome in which a knife appears to cut an apple in half, than to an impossible outcome in which the apple appears to be cut by a glass of water (Hauser & Spaulding, 2006). Indeed, such expectations minimally require an abstract notion of physical affordances and a vague sense of cause. Of course, all of this is not to say that human concepts are identical to the concepts of other species. Rather, we are suggesting that it is probably not the case that prelingual humans and other species are restricted to concrete representations alone, at least by most ways of specifying what concrete means.

(p. 323) Associative to rule based

A different type of contrast between concepts involves the idea that simpler, earlier concepts are more associative or 'similarity based', while developmentally older ones are more rule based. There are certainly many tasks that seem to show this kind of shift, and indeed it has figured prominently in the writings of such major theorists as Vygotsky, Werner, Piaget, and Bruner. It can take many forms, but usually refers to findings that younger children seem to focus on all salient features in categorization, while older children focus on a few critical features. Consider a case involving word meanings: if young children learn about exemplars that have many salient typical features, but lack a critical defining feature, they will judge those instances to be members of the category, while older children will not. Conversely, if young children are told of instances that lack salient typical features but do have all the critical defining ones, they may often judge that such instances are not members of a category, while older children will judge that they are good members (Keil, 1989; Keil & Batterman, 1984). For example, a young child might label a kind, gift-giving adult who *is not* related to their parent to be an uncle, while rejecting a young, obnoxious boy who is. Even adults, in the right contexts can be biased so as to favour characteristic features over essential ones for natural kinds (Hampton et al., 2007); but for well-defined terms such as 'uncle' or 'island', the characteristic-to-defining shift is a very robust pattern.

This shift might seem to be a perfect example of going from holistic to analytic representations or from associations to rules. But, in fact, it seems instead to represent one way in which people of all ages go from being a relative novice to being a relative expert. The shift occurs at very different ages depending on the domain involved (Diesendruck, 2004; Keil, 1989). Thus, children shift much earlier for instances of moral categories (lying, stealing) than they do for kinship categories (Keil, 1989). Moreover, even the youngest children are never completely driven by the most typical features. Thus, even preschoolers will not assume that uncles must wear baseball caps even if all known instances happen to have done so.

When one knows little in a domain, it usually pays to hedge bets and weigh as many features as possible in terms of their frequencies of occurrence and co-occurrence. But that very reasonable strategy does not represent a fundamental change in conceptual format or imply that children before a certain age are unable to have rule-based representations. Certainly, young children may have difficulty explicitly stating the rule (especially if they have not mastered much of their native language). Nonetheless, their behaviour alone demonstrates what seems to be knowledge of a wide variety of rules, for example, in the early mastery of grammatical relations or rules of social interaction. In fact, there are vigourous debates about whether the rule-based versus associative contrast is a dichotomy that has been falsely imposed on a continuum (Hampton, 2005; Pothos, 2005), or whether it represents an important key distinction between different forms of cognition (Ashby, 2005; Diesendruck, 2005; Marcus, 2001). Both sides of this debate, however, are no longer committed to the idea that there is a stage-like shift in development from initially conceiving of the world in terms of associations to conceiving of the world in terms of principles and rules. For our purposes, whether the dichotomy between rule-based and associative representations is real or **(p. 324)** illusory is not as central as the degree to which this contrast might apply to other species – that is, is it the case that rule-based reasoning is a uniquely human capacity?

The animal literature on rules versus associations is not as extensive, but as with earlier dichotomies, it is not easy to 'rule out' rule-based knowledge in a wide variety of other species. The idea that animals have both types of representations gains support from imaging studies suggesting two different brain systems for rule-based and similarity-based reasoning in human brains (Patalano et al., 2001), and the existence of roughly comparable structures in other species (see Chapters 5, 9, and 10, this book, in which recent advances in experimental methods show a wide range of conceptual abilities in primates and other mammals). It is true that various frontal circuits seem more developed in humans (Smith et al., 2004), but less-elaborated structures along the same lines may still allow simpler versions of rule-based categorization in other species. Indeed, even pigeons have been observed to undergo shifts in the course of category learning that are strongly suggestive of a shift from associative to more rule-based forms or representation (Cook & Smith, 2006).

Procedural to declarative and implicit to explicit

In various forms, it has long been speculated that children switch from procedural to declarative representations early in life (Karmiloff-Smith, 1992). The idea seems simple enough. Children initially seem to learn about objects and perhaps categories through reference to actions. A brush is the kind of thing that I do *this* with, and a chair is the kind of thing that I do *that* with, etc. Only later in development via a process of translation do those procedural representations become declarative. One version of that process is called representational redescription (Karmiloff-Smith, 1992), in which the child brings action-based representations into awareness and re-encodes them into declarative terms. Karmiloff-Smith also argues that later, they can still automate widely practised declarative actions, such as reading, and make them procedural once again.

It is tempting to embrace the idea of a procedural-to-declarative shift and then map it onto a comparative analysis of species. After all, if a species is simple enough, how could its learning be anything more than procedural? Does not declarative learning require a kind of metacognitive awareness that certainly would not be present in a moth or a bee? Two problems arise here that are similar to those we encountered earlier. Traditionally, the shift was often thought to occur sometime after language was acquired and those views largely followed from the ease with which declarative knowledge could be assessed through language. However, as researchers develop nonlinguistic measures of declarative memory, it is actually beginning to look like such mechanisms may be present by at least 6 months of age (Bauer, 2004; Collie & Hayne, 1999). For example, in one task involving deferred imitation, young infants remember actions that they observe more than 24 h later, without having produced the actions themselves and often using different muscle groups from the actor. This achievement is argued to be a form of declarative memory (Bauer, 2004; Collie & Hayne, 1999; Jones & Herbert, 2006; Mandler, 2004). In addition, some studies suggest that very young children can verbally recall and describe actions that they learnt to do at an earlier age when they were preverbal (Bauer et al., 2002). It also seems to be the case **(p. 325)** that spatial terms are learned in the same order in which the concepts were learnt preverbally (Quinn, 2007). It seems much simpler to assume that these young children initially encoded the action in declarative terms and then accessed that knowledge verbally in the same format, rather than that they initially encoded it procedurally and then somehow transformed that encoding into a format that made it accessible to language at a later date. It is therefore, not obvious that even the youngest of humans are merely representing the world in terms of actions.

With nonhumans, there is not as much research examining if they are capable of declarative representations, but there are at least some arguments that they are. It has been argued, for example, that domestic hens will remember food choices in ways that are not procedural and action based but which seem to require a more declarative form of representation (Forkman, 2000). This may be because of basic functional/anatomical structures in the hippocampus that cut across a wide range of species (Eichenbaum, 2004). Indeed, it has even been argued that the presence of declarative-like memories in fish implies that they can evaluate experiences, are capable of suffering, and are therefore capable of being treated cruelly

(Chandroo et al., 2004). It is certainly far beyond the scope of this chapter to tackle questions about sentience in fish and the implications for their treatment by humans, but the mere presence of that issue in the literature suggests just how murky questions about declarative representations across species can be.

The same story seems to hold for the idea of developmental changes from implicit to explicit cognition. Instead of seeing the infant as essentially an implicit creature that only gains explicit knowledge as language becomes internalized, it is now more commonly believed that strands of both kinds of knowledge may be present from the earliest moments of infancy (Bauer, 2006, 2007; Rovee-Collier, 1997). As soon as one tries to operationalize notions of explicit cognition that are independent of language, it becomes very difficult to find a downward age limit before which humans completely lack such forms of cognition. To be sure, the robustness of such systems increases with age, but it is not clear when, if ever, they are completely absent. Moreover, when researchers turn to animals and use nonverbal assessment techniques, there are claims of episodic memory in animals as 'simple' as pigeons (Zentall et al., 2001) and of dissociations signalling an implicit/explicit contrast in a wide range of species (Cho et al., 2007).

In sum, although it is tempting to see the preverbal child as a different kind of mental creature who, in a language-free state, must represent the world in ways that are concrete, associative, procedural, tacit, and nonepisodic, these views seem to have been driven by the presence of language itself in older children. It is clearly easier to be sure of the presence of abstract, declarative thought in individuals that speak, but as soon as one attempts to disentangle these forms of thought from language and measure them in nonverbal ways, there is little evidence for developmental shifts. Without such independent accounts, claims of shifts amount to little more than stating the obvious fact that children before a certain age cannot speak or comprehend language. If the actual format of concepts is somehow related to these dichotomies, as many researchers have argued, then there is little evidence that concepts themselves undergo qualitative shifts in structure in the first few years of life. Infants' and young children's concepts may certainly differ from older children and adults, but not in ways that **(p. 326)** easily map onto these dichotomies. Moreover, it is difficult to be sure of the extent to which any of the more 'advanced' forms of representation are absent in other species as there are many instances suggesting systems strongly analogous to the purportedly more sophisticated reasoning found in humans.

The point here is not to abandon research trying to understand the nature of conceptual representations. It is, however, to suggest that unambiguous evidence for changes in conceptual structure over time is difficult to come by and that it is often more fruitful to look at what patterns of information organisms are able to exploit at different points in development and how they able to use that information to act. Ultimately, converging studies on the kinds of information used and how they are used may point strongly towards certain internal representational formats; but it in a great many cases, it may be more useful to first gather more detailed information on sensitivities to particular kinds of information in specific contexts and biases or constraints on how that information is tracked and used.

We have suggested so far that it is in fact quite difficult to nail down patterns of conceptual change that may be uniquely human. Moreover, many candidates, which loosely follow an ‘ontogeny-recapitulating-phylogeny’ theme, are not well supported. There are, however, two domains, language and social reasoning, in which human cognition does seem to be unique and which may provide a better way of asking if there are unique patterns to human conceptual change.

Is language the magic bullet?

The discussion so far has largely downplayed claims concerning qualitative changes in the representational formats of concepts. However, this is not meant to deny that concepts do change with development and that some human concepts are different from those found in other animals. One way to reconcile these points may simply lie in turning some of the dichotomies mentioned above into continua. Perhaps, adult concepts are less associative in nature than those in children and other animals. Perhaps, adults have richer and more elaborated episodic and declarative forms of knowledge. To some extent, this is certainly true, although it is rarely as simple as it seems. We have seen that the concrete/abstract distinction may not follow any easy developmental rule. Similarly, declarative knowledge can sometimes, with further experience, become procedural once again. Thus, even talking about these differences as differences in degree, rather than differences in kind, poses a strong challenge to the idea that these dichotomies reflect qualitatively different modes of thought.

The more important differences may not lie in the internal structures of concepts themselves but in the ways concepts are related to each other and to the social and physical world – that is, from an empirical perspective, perhaps it is more beneficial to consider the relationships between concepts, rather than their underlying nature. This perspective has the additional benefit of somewhat sidestepping controversies over whether there is any internal structure to concepts. If Fodor's (1998) worries about the decomposability of concepts are correct, then most of the contrasts considered earlier in this chapter are either misguided or have to be recast in ways that are really about the use and processing of concepts, rather than about their internal structure and the nature of representation.

(p. 327) Certainly, some proposals revolve around the idea that language provides a powerful transforming effect on cognition in general, and concepts in particular. For example, language has been argued to provide 'invitations to form categories' through the use of salient words (Waxman & Markow, 1995; see also Chapter 6, this book). Vygotsky argued that the internalization of language gave thought a more analytic and logical capacity and an ability to go beyond the here and now (Vygotsky, 1934/1962), and there are repeated accounts of language as a kind of cognitive prosthesis that enables one to keep more thoughts in mind at a time and to see more analytical relations between them. There certainly seems to be some truth to this claim. Quite simply, when we put ideas into words and sentences, we do seem to gain added power.

However, this may be an addition that is more akin to the support provided by writing things down on paper. We have all had explanations that we think we fully understand when they exist solely in thought, only to discover huge gaping holes when we actually try to articulate them in writing. The writing pad or computer screen provides a form of external support that greatly amplifies our ability to look for consistency and coherence in large chains of thought (cf. Clark, 2001). But it may well be that language does not transform unspoken thought any more than written language transforms spoken language. And, even the most ardent supporters of the effects of written language do not see it as changing the fundamental nature of thought in dramatic, qualitative ways (e.g. Olson, 1994; Olson & Torrance, 2001).

A second popular and longstanding theme has been the idea that language provides a form of cognitive glue that allows people to bring together distinct domains of thought, perhaps even modules. Several scholars have proposed that language enables a child to take relatively autonomous domains and bring them together in ways that can cause leaps forward in cognition, such as much more robust ways of tracking objects (e.g. Xu &

Carey, 1996). Moeover, language may bring together processes that engage in different kinds of operations on number, and spatial navigation; and it may unite plants and animals into a common domain ‘living things’ (Carey, 2002; Caruthers, 2002, 2004; Gentner, 2003; Inagaki & Hatano, 2003; Mithen, 1996; Spelke, 2003; Spelke & Tviskin, 2001). Such accounts are naturally appealing if for no other reason than that they move from discrete processing to a more integrated view of cognition. If one maintains, as many infant researchers do, there are only a few core domains and/or modules of thought, then a device that can combine those core elements can unleash a vastly larger and more complex set of cognitive structures.

However, there are two issues that still need further elaboration in attempts to understand such accounts. First, it is important to specify in some detail how language allows two autonomous domains to be integrated. What work does it do to make the connections apparent? Second, if language is to play such a pivotal role in accomplishing conceptual integration, it is important to show that the integration cannot occur in the absence of language either in humans or in other species. Why, for example, can’t similar integrations occur through various forms of imagery or spatial reasoning, or through prelinguistic thought, or even through another domain such as theory of mind (Atran, 2002; Hampton, 2002)? If language can be shown to have a unique facilitating effect, these arguments will be stronger. One promising example is an **(p. 328)** argument about how the quantifier structure of language ‘bootstraps’ the analogue number estimation system and the small discrete number system into a more sophisticated concept of discrete, symbolically represented numbers of indefinite size (Carey, 2004; Le Corre & Carey, 2007; Chapter 13, this book). Evidence for the importance of language to such a process comes from cultures that lack formal count systems. In these cultures, even adult speakers do not possess a fully developed concept of number that can conceptually distinguish between magnitudes larger than 4 or 5 (Gordon, 2004). At the same time, the bootstrapping process has been criticized as lacking in explanatory detail (Bloom & Keil, 2001; Gallistel, 2007; Rips et al., 2005).

It is important to note that there is, however, an alternative account in which all children, well before they learn language and probably from birth, are endowed with a ‘language of thought’, which is similar to spoken language in that it has propositional nature with quasi-logical principles of inference and entailment. This account assumes that spoken language is mapped onto the language of thought rather than emerging as an utterly new kind of mental structure (Fodor, 1975). By such an account, natural language in itself could not transform thought since it is not such a radical departure from the language of thought. There is still the possibility, however, that if a spoken language in some way reflects culturally accumulated and transmitted knowledge – for example, by guiding individuals to domains of expertise (Keil et al., 2008; Putnam, 1975) – it might have additional benefits that go beyond a preverbal language of thought. And, if language can amplify cognition by making salient culturally accumulated forms of knowledge, it makes sense to ask if the most dramatic aspects of conceptual development, as well as of animal/human differences, revolve around the ways in which concepts are linked to the knowledge of others. Consequently, in the following section, we turn to the nature of social knowledge and the role that social learning might play in concept formation and change.

Conceptual development and the social world

Apart from language, there are some other striking differences between humans and other animals that may have strong consequences for making human concepts different – consequences that are often revealed by the study of conceptual development in children. Many of these revolve around the perception of intentionality and inferences about other goal-directed beings. Humans are certainly not the only creatures that think differently about social beings, but they seem to have unique or greatly amplified skills in this respect, skills that in turn have consequences for concepts and conceptual change. As many scholars have noted, human infants are intensely tuned to social stimuli and seem to think about them differently from a very early age. They seem to be especially tuned to deciphering the goals of agents and using that information to make inferences about the meanings of situations. For example, infants will imitate the goals of an actor rather than the actions (Meltzoff, 1995), in some cases revealing such interpretations well before the first year of life (Woodward, 1998). Infants are also sensitive to the 'rationality' of actions, imitating an action when they assume there was an underlying goal that made it sensible (Gergeley & Csibra, 2003; Gergeley et al., 2002).

(p. 329) In general, by the time children start to learn language, they have shown a long-standing interest and skill in interpreting the goals of others and using those interpretations to guide their actions. But the most dramatic influence on concepts and conceptual change may occur in the years that follow. For example, young children rely heavily on intentions to infer word meanings, knowing that intentional actions are key indicators of likely categories of reference (Baldwin & Markman, 1996; Bloom, 2000). Similarly, they use intention to make inferences about procedural knowledge and the way in which to operate unfamiliar objects in their environment. Indeed, in some cases, the effects of social learning may be so powerful that they override rational decision making, as in the case of over-imitation: when reproducing the actions of a human trainer operating an unfamiliar device, chimpanzees will often drop out unnecessary actions to take the most efficient course of actions. However, in the same learning context, young children will reproduce all of the actions, even those that clearly seem quite unnecessary (Horner & Whiten, 2005). This phenomenon was originally thought to reflect a simple desire on the part of children to 'play the game', but later work demonstrated that children only over-imitate when they think an actor is intentionally engaging in the actions (Lyons et al., 2007). If the actor behaves unintentionally, children only reproduce the necessary actions. Even more importantly, when presented intentionally, children seem to internalize all of the actions as casually *necessary* and thereby infer that irrelevant parts of an object are actually causally important. At the same time, this seeming error that demonstrates the power of social learning may also be highly adaptive as it is an extremely useful way to learn about causal properties and relationships that are too complex to immediately figure out on one's own.

However, perhaps the most powerful influence of social learning lies in the way in which tracking intentionality allows children to benefit from the accumulated knowledge in the minds of others and the culture at large. Surely one of the most dramatic differences between human concepts and those in other animals involves the ease with which we rely on the expertise of others. An ability, that, for example, is obviously not limited to inferences about the state of the world based on the others' behaviour (as when a distress call or fleeing cues the existence of a predator), but rather incorporates highly nuanced appreciation about the ways in which knowledge itself is distributed among other people and society. For example, even kindergartners seem to be sensitive to the way in which knowledge and expertise cluster into domains that resemble academic disciplines (Keil et al., 2008). Of course, much of this knowledge could be transmitted via language, but critically much of it can also be gathered in other ways that do not seem to involve language or even direct instruction. A simple act of pointing, a gesture, a drawing, or the end-state of an action that was goal directed can clue a child into a property or relation of special importance. Critically, such learning seems to be almost immediately and effortlessly woven into a rich, overarching tapestry that unites information from these different sources and highlights the deep, underlying commonalities between them. This skill may be related to the unique nature of pedagogy in humans (Gergely & Csibra, 2006; Premack, 1984; Chapter 11, this book), but it may well go beyond any explicit goal to teach. Just the process of intentionally acting on an object may be vastly informative to a young child even when **(p. 330)** the actor is not intending to convey something to the observer (Warneken & Tomasello, 2006). By watching the intentional actions of others, children can learn a great deal about how the world works by simply assuming that intentional actions are directed towards causally important properties, parts, or junctions in events.

Also related to the idea of accumulating knowledge socially, is the process by which humans learn to defer. Children quickly learn to be comfortable with the idea that much of their knowledge is grounded in the minds of others as well as learning when and when not to rely on testimony offered by others (Harris & Koenig, 2006). For example, children believe that ferrets are different from weasels (even though they often cannot possibly tell them apart), because they believe that there are those who do know. From as early as preschool, children see themselves as part of a vast terrain of knowledge in which their concepts rely on important links to others, whose knowledge is richer than their own (Keil et al., 2008; Lutz & Keil, 2003). This last ability may also rely partly on the notion that most people intend to inform and not to deceive. Thus, at many levels of thought, children and even infants are quite sensitive to the way in which their own knowledge is immersed in a much more elaborate social network that is heavily dependent upon the ability to discern the goals and intentions of others. Moreover, this social sensitivity does seem in many ways uniquely human (Tomasello et al., 2005), though there is certainly always the possibility that this view may be revised, given the right kind of evidence.

Conclusion

In this last section we briefly return to the broader theme of the relationship between ontogeny and phylogeny. Roughly, we have outlined several cases in which an apparent conceptual division between different points in development or different species seems to blur and give way to a continuum of cognitive abilities. In many cases, it actually seems quite difficult to isolate discernable ‘break-points’ that may punctuate difference in the nature of reasoning across species or within human development (see, e.g. Chapters 10 and 11, this book).

If there is a distinctive aspect of human conceptual change, it may arise from the ways in which the acquisition of language and the embedding social context influence the endpoints of conceptual change – in other words, the way in which such mechanisms may boost the sophistication and saliency of existing conceptual structures. The potential influences of language have been heavily discussed and, while we acknowledge the possibility of such influences, we want to inject a note of caution in asking whether language is just one of many ways in which conceptual systems might be combined and amplified, as opposed to a mechanism by which qualitatively unique modes of thought are obtained.

Use of intentional behaviour, however, seems to be a powerful device for greatly expanding the power and range of concepts. We have suggested that humans are uniquely attuned to intentional behaviour as a cue to important information for grounding concepts and elaborating on them. The simple phenomenon of deference, which seems so critical to so many human concepts, may be largely absent in any other species. Even here, however, we do not see a dramatic qualitative transition as much **(p. 331)** as an important role of social context and intentionality from quite early in infancy. In sum, the ontogeny-recapitulates-phylogeny idea tends to bias one towards the view that infants start out largely as lower-order animals and then move beyond that state. We have suggested here that such a view may be deeply flawed because a great degree of analogous processing is observed between species and that whatever processing does appear to be unique to human concepts and human conceptual change may be part of the basic architecture that is present from the start.

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