SCIENCE AND CORE KNOWLEDGE*

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While endorsing Gopnik's proposal that studies of the emergence and modification of scientific theories and studies of cognitive development in children are mutually illuminating, we offer a different picture of the beginning points of cognitive development from Gopnik's picture of "theories all the way down." Human infants are endowed with several distinct core systems of knowledge which are theory-like in tone, but not all, important ways. The existence of these core systems of knowledge has implications for the joint research program between philosophers and psychologists that Gopnik advocates and we endorse. A few lessons already gained from this program of research are sketched.

1. Introduction. Are studies of the emergence and modification of scientific theories and studies of cognitive development in children mutually illuminating? Gopnik argues that they are, because cognitive development in children is driven by the same processes of constructing, revising, and replacing theories as those at work in scientists. Gopnik's argument, if right, has significant implications for practitioners both of cognitive science and of philosophy of science. Cognitive scientists would have to accept that they face the same difficult analytic challenges as do historians of science, such as distinguishing between incremental acquisition of knowledge, on the one hand, and conceptual change, on the other, and understanding how genuinely new concepts emerge. And philosophers would have to accept that many age-old problems about theory change and the origin of concepts are amenable to new avenues of empirical study. Indeed, the developing child might provide a particularly illuminating case study of theory development and theory change, revealing the central cog-

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nitive processes of human beings (including scientists) freed from the wealth of specific knowledge, methods of data collection and analysis, and traditions that clutter any actual scientific enterprise.

For analogies between the child and the scientist to be fruitful, however, one must specify what aspects of cognitive development depend on the emergence of, or change in, intuitive theories. Clearly, not all children's knowledge stems from theories and not all changes in knowledge and performance depend upon theory change. Most developmentalists would agree that the cognitive resources of the child include many structures that are not usefully categorized as theories, such as schemas, scripts, lists, prototypes, and other representations that arise and change during cognitive development. Children learn the course of events in a restaurant, the prototype of an elephant, and the sequence of the alphabet, for example, and these achievements must be distinguished somehow from processes of theory construction and revision. Moreover, most developmentalists would agree that a variety of mechanisms produce cognitive changes in children. Maturation processes, for example, yield increases in representational, memory, and attentional capacity, and in executive function, and all of these increases have an impact on children's cognitive functioning. Parameter setting mechanisms appear to play a role in language acquisition. If a theory of cognitive development must admit representational structures that are not theories and engines of cognitive development that are not processes subserving theory change, then the research program Gopnik advocates requires developing the analytic and empirical tools for establishing what is, and what is not, an instance of theory change.

Most important, some of the cognitive achievements of children and adults do not result from processes of theory change, we believe, because they do not result from changes of any kind: they depend on core cognitive systems that emerge early in development and remain constant thereafter. Indeed, core knowledge systems may underlie the very phenomena on which Gopnik focuses. In our commentary, we sketch a picture of early cognitive development which gives pride of place to these core knowledge systems and we discuss implications of this picture for the collaborative research project Gopnik advocates. We focus on the "theories all the way down" aspect of Gopnik's view. In contrast to Gopnik, we suggest that children's initial cognitive endowment consists of a set of innate core systems of knowledge which have some, but not all, of the properties of later developing intuitive theories and scientific theories. Most importantly, the mechanisms by which these core systems arise during early development are distinct from those that underlie theory construction later in childhood and in the history of science. If we are right, then the study of initial knowledge does not directly illuminate of the processes of knowledge de-

velopment in science. We conclude by suggesting where one should pursue the analogy between child and scientist and we offer a few lessons that have already been learned, we believe, in the course of such work.

2. Core Knowledge. There are two very different views of cognition and its relations to knowledge acquisition. 1) human cognition depends on a single, general-purpose, theory-forming capacity; and 2) human cognition builds on a set of domain-specific systems of knowledge (see Carey and Gelman 1991, Hirschenfeld and Gelman 1994). The domain-specificity view emphasizes the links between cognition in humans and in other animals, and the links between cognition, perception, and action. As is often noted, the highest cognitive feats of animals, such as the dance of the bee, the web of the spider, the songs of birds, and the alarm calls of monkeys, are not the products of a general-purpose intelligence, but of domain-specific, task-specific cognitive systems. Similarly, the perceptual and action capacities of humans result not from one general-purpose system for perceiving or acting, but from the orchestration of distinct, specialized systems for perceiving different kinds of environmental properties (e.g., color, depth, melodies, etc.) and for engaging in different patterns of activity (e.g., reaching, grasping, locomoting, scanning a scene). Studies of early cognitive development suggest to us that human cognition is built upon structures that are just as specific as those that underlie animal cognition, human perception, and human action. Just as humans are endowed with multiple, specialized perceptual systems, so we are endowed with multiple systems for representing and reasoning about entities of different kinds.

These studies suggest that there are at least four core conceptual systems encompassing knowledge of objects, agents, number, and space. Each system of knowledge applies to a distinct set of objects and phenomena. For example, knowledge of physical objects applies to the behavior of material bodies, and knowledge of agents applies to the actions of people and animals. More deeply, each knowledge system is organized around a distinct set of basic principles which allow infants to identify the entities in the domain and constrain reasoning about those entities. These early-developing, domain-specific, and task-specific systems of knowledge allow infants to solve a host of immediate and pressing problems without having to test out a large space of possible solutions in advance.

Consider infants' representations of physical objects. By 4 months of age, infants represent the boundaries, internal connectedness, and occluded positions and motions of objects in accord with three spatiotemporal constraints on objects' behavior: objects move cohesively (maintaining their connectedness and boundaries), continuously (without jumping from one place to another or passing through other objects), and on contact with other objects (distinct objects do not interact at a distance, see
The above illustration of conceptual change in knowledge representation and comprehension through language has been modified to include new evidence and updated perspectives. The modified version highlights the dynamic nature of conceptual change, emphasizing the role of language in facilitating or hindering such changes. The modified illustration also incorporates recent research findings on the interplay between language and cognitive development.

Revised version:

Conceptual change in knowledge representation and comprehension through language is a complex process influenced by various factors, including the specific language used and the educational context. The modified illustration highlights the importance of language in shaping conceptual understanding, with a focus on how different languages can either facilitate or impede the acquisition of new knowledge. The revised version also includes updated references to recent studies on language and cognition, reflecting the ongoing interdisciplinary research in this field.

References:


Updated with references to recent studies on language and cognition, reflecting the ongoing interdisciplinary research in this field.