(1998) Gelman "The MIT Encyclopedia of the Cognitive Sciences"

cognitive development

Students of cognitive development ask how our young are able to acquire and use knowledge about the physical, social, cultural, and mental worlds. Questions of special interest include: what is known when; whether what is known facilitates or serves as a barrier to the accurate interpretation and learning of new knowledge; how knowledge development serves and interacts with problem solving strategies; and the relationship between initial knowledge levels and ones achieved for everyday as opposed to expert use.

Several classes of theories share the premise that infants lack abstract representational abilities and therefore CONCEPTS. The infant mind of an Associationist is a passive "blank slate" -- upon which a wash of sensations emanating from the world is recorded as a result of the associative capacity. Stage theorists need not share the no-innate knowledge assumption. Interestingly, however, PIAGET, Bruner and VYGOTSKY do, although their infants are able to participate actively in the construction of their cognitive development. For Piaget, neonates spontaneously practice their reflexes, the effect being the differentiation of inborn reflexes into different sensory-motor schemes. Active use of these yields integrated action schemes, and thus novel ways to act on the environment (PIAGET 1970). The Information processing approach emphasizes the development of general processes like ATTENTION, short term and long-term memory, organization, and problem solving. The focus is on how learning and/or maturation overcome limits on information processing demands (Anderson 1995) and the development of successful PROBLEM SOLVING (Siegler 1997). Much attention is paid to how knowledge systems are acquired and circumvent these real-time limits on various processes. When it comes to the matter of what the newborn knows, the answer almost always is "nothing" (but see Mandler 1997). Similarly, many of the models are firmly grounded on associationist assumptions.

Reports of early conceptual competencies have encouraged the development of models that grant infants some knowledge to start. These include symbolic connectionist accounts which share much with asssociation theories and modern instantiations of rationalism. In the latter case, humans are endowed with *some* innate ideas, modules and/or domain-specific structures of mind. Possible candidates for innate endowments include implicit concepts about natural number, objects, and kinds of energy sources of animate and inanimate objects (Gelman and Williams 1997; Keil 1995; Pinker 1994). These kinds of models *are* learning models, ones built on the assumption that there is more than one learning mechanism. The idea is that there is a small set of domain-specific, computational learning devices -- each with a unique structure and information processing system -- that support and facilitate learning about the concepts of their domains. Gelman and Williams (1997) refer to these as skeletal-like, ready to assimilate and accommodate domain-relevant inputs, but very sketchy to start. Knowledge is not sitting in the head, ready to spring forth the moment the environment offers one bit of relevant data. But structures, no matter how nascent, function to support movement along a domain-relevant learning path by encouraging attention to and fostering storage of domain-relevant data.

For most associationist, stage, and information processing theorists, it not only takes a long time for newcomers to the world to develop concepts, infants must first build up large memories of bits of sensory and response experiences; associate, connect, or integrate these in ways that represent things or events; associate, connect, or integrate the latter, and so on. The young mind's progress toward conceptual understandings is slow, from reliance on the sensory, then onto use of perceptions and eventually to the wherewithal to form abstract concepts and engage in intelligent problem solving. This common commitment to the traditional view that concepts develop from the concrete or perceptual to the abstract plays out differently depending on whether one is a stage theorist or not. For a non-stage theorist, the march to the abstract level of knowing is linear and cumulative. For a stage theorist, the progress usually involves movement through qualitatively different mental structures that can assimilate and use inputs in new ways. Many of the results of classification tasks used by Bruner, Piaget and VYGOTSKY encourage the concrete-to-abstract characterization of cognitive development. Repeatedly, it is found that 2- to 6-year-olds do not use classification criteria in a consistent fashion. For example, when asked to put together the objects that go together, a preschool child might make a train, another a long line of alternating colors, and so on. Another will focus on appearance as opposed to reality, and so on.

It is important to recognize that *all* theories of cognitive development grant infants some innate abilities. The abilities to receive punctate sensations of light or sound, or pressure, etc., and form associations according to the laws of association (frequency and proximity) are foundational for associationists. Associations between sensations and responses is the groundwork for 'knowledge' of the world at a sensory and motor level. These in turn support knowledge acquisition at the perceptual level. Experiences at the perceptual level provide the opportunity for cross-modal associative learning and the eventual induction of abstract concepts that are not grounded on particular perceptual information. Although there are important differences in the foundational assumptions of the association and traditional stage accounts, their characterizations of an infant's initial world are more similar than not. For example, associations are not Piaget's fundamental units of cognition; sensori-motor schemes are. But his infant's initial knowledge is limited to innate reflexes and is combined with an inclination to actively use and adapt these as a result of repeated interactions with objects. Eventually, this leads to the development of inter-coordinated schemes and movement to action-based representations that take the infant from an out-of-sight, out-of-mind stage to internalized representations, the mental building blocks of a world of 3-dimensional objects in a 3-dimensional space.

Piaget's basic assumptions about the nature of the data that feed early development apply to other stage theorists. In general, what initially counts as relevant inputs are simple motoric, sensory or perceptual features. His emphasis is more on children's own active participation in their own cognitive development. Bruner and Vygotsky concentrate more on how others help the young child develop coherent knowledge about their social, cultural and historical environments. Still, all concur that initial 'concepts' are sensori-motor or perceptual in form and content; these are variously labeled as graphic collections, pre-concepts, complexes, pseudo concepts, and chain-concepts. Thus, whether the account of the origins of knowledge is rooted in an associationist, information processing, or stage theory, the assumption is that first-order sense data, for example sensations of colored light, sound, pressure, etc., serve as the foundation upon which knowledge is developed. Principles or structures that organize the representations of concepts are a considerably advanced accomplishment, taking hold somewhere between 5 and 7 years of age.

Those who embrace more rationalist accounts assume that the mind starts out with much more than the ability to sense and form associations or schemas about sensations and reflexes. There is a very different take on what counts as foundational data. On the assumption that beginning learners have some skeletal structures with which to actively engage the environment, domain-relevant inputs are those that can be brought together and mapped to the existing mental structure. Put differently, skeletal mental structures are attuned to information in the environment at the level of structural universals, not the level of surface characteristics. Thus the nature of relevant data, even for beginning learners, can be rather abstract. It need not be bits of sensation or concrete. Young learners can have abstract concepts.

We now know that preschool-age children appeal to invisible entities to explain contamination, invoke internal or invisible causal forces to explain why objects move and stop, reason about the contrast between the insides and outsides of unfamiliar animals, choose strategies that are remarkably well suited to arithmetic problems, pretend that the same empty cup is first a full cup and then an empty cup, etc. Five-month-old infants respond in ways consistent with the beliefs that one solid object cannot pass through another solid object; an inanimate object cannot propel itself; and that mechanical and biomechanical motion are very different. (See Wellman and S. Gelman 1997 for details and more examples.)

With development, core knowledge systems can become extremely rich, whether or not formal schooling is available -- so much so that the existing knowledge structure behaves like a barrier for learning new structures in the domain (Gelman 1993). For example, the intuitive belief that an inanimate object continues to move in a circle because it currently has such a trajectory is inconsistent with the theory of Newtonian mechanics. Yet the belief is held by many college students who have had physics courses. Similarly, our well-developed NAIVE MATHEMATICS, sometimes called "street mathematics" (Nunes, Schliemann, and Carraher 1993) makes it hard to learn school mathematics. In these cases, school lessons do not suffice to foster new understandings and kinds of expertise. Be they nativist or non-nativist in spirit, efforts to account for the course of cognitive development will have to incorporate this fact about the effect, or lack of effect, of experience on learning and concept acquisition.

See also

DOMAIN-SPECIFICITY
INFANT COGNITION
MODULARITY OF MIND
NATIVISM
RATIONALISM VS EMPIRICISM

-- *Rochel Gelman*

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