

of objects that is most 'natural' and that is acquired first by children. The global categories that children demonstrate first, such as *animate*, are abstract, not based on specific perceptual features, a finding that fits well with the claim that 'gist' memory predominates in the early years (Brainerd & Reyna, 1990).

It would be no service to Jean Mandler to pretend that I agree with all of her conclusions. For example, I would place more emphasis on the motor side of infancy, particularly on the infant's active participation in events, not simply on the perceptual observation of them. I would also question some of the clear distinctions made, for example, that imitation is meaningful while perception is unconscious. Is that always the case? I would urge more attention to the social figures in the infant's world with the suspicion that these are the first to be conceptualized. I would also debate issues of representation (although her expertise in this area is unassailable), such as the question of the representational status of the replicas that infants use in her tasks: Are they real? Symbols? Or both? How do they relate to later symbolic development, for example in DeLoache's (1990) work? And I would not reject the basic level of categorization, based not on similarity but on their common use as names, the basis of Brown's (1958) original observation of the most functional level of naming. These points of divergence do not in any major way conflict with Mandler's foundational theory, but might suggest places for further inquiry and testing of assumptions.

Up to now, consciousness and meaning have largely been missing from infant research and from the theoretical controversies swirling around it, lacunae that Mandler's work means to fill. Now that these have become acceptable constructs in studies of adult cognition, they

may also be welcomed in distinguishing among facts and fantasies of infant and child research. In emphasizing children's meaning-making, their interpretation of experience as the basis for conceptual development as well as for language, inductive reasoning and memory of the past, this theory provides an important bridge to post-infancy developments. Among other things, taking consciousness into account has enabled differentiating and integrating discrepant findings, in addition to formulating a developmental theory of differentiation and integration in the infant-child mind. This work thus paves the way for a fresh look at meaningful cognitive development as an overall process.

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Straddling the perception-conception boundary

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This is a commentary on Jean Mandler's *The foundations of mind: Origins of conceptual thought* (see Mandler, 2004).

Where does perception end and thinking begin? How do conscious cognitive processes differ from unconscious

ones? What is the relation between *knowing that* and *knowing how*? These difficult and endlessly engaging

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questions are raised most often in relation to the cognitive processes and experience of human adults. In *The foundations of mind: Origins of conceptual thought*, Jean Mandler asks us to consider these questions when we study human infants.

Mandler's mission is bold and challenging because infants have such limited means to communicate their concepts and experience to us. How can we know whether an infant has conscious, explicit, conceptual knowledge? Infants cannot put their beliefs and experiences into words, or use their knowledge to guide elaborate sequences of coordinated action. Can astute observers of infants' limited actions, and of ways in which their actions vary in accord with the objects and tasks that they face, shed light on their concepts and consciousness?

For 20 years, Mandler has argued that we can. Much of her research focuses on sorting tasks. In one such task, young children are given a collection of representational toys, such as toy animals or vehicles, and their sequential actions are recorded. In another task, infants are given a succession of representational toys, one at a time, and their attentive examination of each object is assessed. In the first case, under certain conditions, children will touch sequentially all the toys that depict objects in a single global category, such as all the animals. In the second case, infants who are allowed to examine each of a set of objects in a single category (e.g. animals) will subsequently scrutinize a test object more fully if the object lies outside that category (e.g. a vehicle). Both patterns provide evidence that children confer some similarity on all the animals or vehicles. Debate has raged over the nature of this similarity relation.

In *The foundations of mind: Origins of conceptual thought*, Mandler proposes that the basis of infants' response is conceptual: infants have a global category that includes all the toy animals and excludes all the vehicles, and the reverse. Her evidence is three-fold. First, infants categorize together objects that are featurally diverse (e.g. toy bears and toy seagulls) and categorize separately objects that are featurally similar (e.g. toy seagulls and toy airplanes). Second, infants often fail these categorization tasks when presented with perceptually well-defined categories of objects that fall within the same global category (e.g. toy dogs versus toy cats). Third, somewhat older infants act appropriately on objects in different global categories, using a key to pretend to activate a toy airplane but not a toy bear, and bringing the bear but not the airplane to a water bowl for pretend-drinking.

Mandler's most compelling argument, in our view, carries her beyond this evidence. She considers infants'

developing representations of objects in terms of the concepts and cognitive skills that older children must learn. In particular, children need conceptual representations, not just a perceptual quality space, to learn the terms and rules of a natural language. Natural languages are notoriously impervious to the appearances of things at the level both of words and of rules for forming complex expressions. The referent of a word like 'bear' or 'airplane' is not defined by its appearance but by its hidden, essential nature (e.g. Kelemen, 1999; Soja, Carey & Spelke, 1992). What makes an expression like 'x is on y' true of a pair of objects has little to do with their superficial spatial relation (what is common to the spatial relation of a cup on a saucer, a ring on a finger, a stain on a napkin and a fly on a ceiling?) and much to do with their non-obvious, mechanical relationship (e.g. Bowerman & Choi, 2003; see also Gelman & Wellman, 1991). Cognitive linguists explain these and other phenomena by proposing that language maps to mental representations structured by abstract concepts such as *agent* and *force* (e.g. Talmy, 1988). If such explanations are true, then the child who learns a language must somehow come to dispose of the abstract concepts on which language depends. The demands of language learning, together with the evidence from experiments on infants, make a strong case that infants attain a system of explicit concepts by the end of the first year.

Mandler's arguments for conceptual structures in infancy are compelling, but what are these structures? A major thesis of her book is that infants are endowed with two principal systems of knowledge: a perceptual system and a conceptual system. This thesis can explain a set of seemingly contradictory findings in the infant categorization literature. One line of research using a visual paired-comparison method suggests that infants as young as 3 months of age categorize objects at the basic level (e.g. cats versus dogs) more readily than at a more global level (e.g. animals versus furniture) (Quinn & Eimas, 1996; though cf. Behl-Chadha, 1996). A different line of research using the manual habituation method described above suggests that infants make global distinctions by 7 months of age but fail to make basic level distinctions until the end of the first year (Mandler & McDonough, 1998). Mandler suggests that the visual paired comparison method taps infants' implicit perceptual system of knowledge, whereas sorting methods tap infants' explicit system of conceptual knowledge.

The importance of Mandler's proposal may be judged from the vigor with which it is disputed. Some investigators have argued that a single system of knowledge, based ultimately on perception, underlies performance in all categorization tasks in infancy (e.g. Quinn & Eimas, 2000; Quinn *et al.*, 2000). We would offer a

different argument: perception and conception are not the products of two unitary, distinct systems. Instead, a larger collection of systems underlies infants' capacities to perceive and reason about entities in different conceptual domains such as objects, persons, space and number (e.g. Spelke, 2004). At least some of these systems, moreover, straddle the perception-cognition boundary.

Consider, for example, the system that underlies knowledge of objects. For infants and for adults, object representations appear to be achieved by mechanisms that are neither purely perceptual nor purely conceptual: mechanisms of mid-level vision (Carey & Xu, 2001; Leslie *et al.*, 1998; Spelke, 1988). These mechanisms, moreover, are sensitive to mechanical properties of objects that are deeply entrenched in the world's languages (Hespos & Spelke, 2004). As a second example, consider the systems that underlie knowledge of number. Although numerical cognition is a supremely conceptual achievement, it does not depend on a single system of representation but on multiple systems in adults (Dehaene & Cohen, 1997), infants (Spelke, 2000) and non-human primates (Hauser & Carey, 2003; Hauser & Spelke, *in press*). These findings suggest that the distinction between perceiving and conceptualizing the world is not as sharp as Mandler suggests.

Even if one grants that perceiving and conceptualizing are different, one may question Mandler's further thesis that some methods tap perceptual knowledge whereas others tap conceptual knowledge. Consider, for example, the habituation of looking time method. Mandler suggests that this method reveals perceptual knowledge, and we agree that sometimes it does. When a baby is habituated to a single object at different distances and dishabituates to a change in the object's size, the looking pattern provides evidence for size constancy: a perceptual capacity (Granrud, 1986; Slater, Mattock & Brown, 1990). Sometimes, however, the findings of preferential looking experiments strain intuitive notions of perception and its limits. For example, infants' looking time to a superficially ordinary event in which an object appears from behind a screen may depend on events that occurred more than a minute earlier and that render the event either consistent or inconsistent with the object's prior motion (Luo *et al.*, 2003). Moreover, infants' looking time sometimes depends on the goal of an agent's action (Woodward, 1998) or on the rationality of the action in relation both to the agent's goals and to contextual constraints (Gergely *et al.*, 1995). Just as adults may look at an object for many reasons – to take in its visible appearance, to determine who left it in its present position, or to see who is going to pick it up – so may infants. It is unlikely that preferential looking methods tap only perceptual capacities.

Mandler's studies of inductive generalization in infancy seem intuitively to bring us closer to infants' conceptual knowledge. In these studies, infants are shown an initial modeling event (e.g. the experimenter shows the infant a toy dog and demonstrates giving the dog a drink) and then are given a choice between two new objects (e.g. a bird and an airplane) on which to generalize the behavior (e.g. giving a drink). Infants generalize the behavior to the object that belongs to the same global category, even when the two test objects are very similar to one another and very different from the initial object.

Further evidence that perceptual categorization is not at work in inductive generalization tasks comes from experiments testing generalization at the basic level. When a behavior is initially modeled on a dog, for example, and infants are then encouraged to reproduce the behavior either on a new dog or on a cat (a basic-level distinction), they are equally likely to generalize the behavior to the cat as to the dog. On a perceptual categorization account, this finding seems strange because a dog is more similar to another dog than to a cat. Mandler takes this finding as evidence that infants represent the initial event at the global level: when babies see a dog being given a drink, they conceptualize the event as 'animal getting a drink.' A modified perceptual-categorization account could also explain these findings, however. For example, if infants perceive the initial event as 'thing with eyes and varied texture getting a drink,' this perception would support the same pattern of generalization.

Research similar to that of Johnson, Slaughter & Carey (1998) might serve to distinguish between these interpretations. Johnson and colleagues investigated whether 12-month-old infants would follow the gaze of a novel object whose morphology (face or no face) and behavior (contingent interaction with a human or non-contingent self-propelled motion and beeping) varied systematically. Infants followed the 'gaze' of an object that lacked a face as long it had interacted contingently in the familiarization period, but they did not follow the 'gaze' of the object that lacked a face and did not exhibit contingent interaction (even though it moved and beeped as much as in the contingent condition). Infants therefore treated the very same object differently depending on its past history as an agent or non-agent. Because morphological features were held constant, they could not have been the basis of the discrimination. If Mandler's imitation studies truly call upon a conceptual system of knowledge, therefore, infants should demonstrate domain-appropriate imitation even when static features are not present in the objects, as long as infants are given some evidence about the object's category membership. Just as in the Johnson study,

infants should treat the very same object differently depending on its history.

Methods developed by Keil and his colleagues for studies of categorization in older children (Keil *et al.*, 1998) provide another way to test Mandler's claims. Keil and his collaborators asked whether young children weight the same perceptual properties of objects differently depending on the global domain to which the objects belong (e.g. animals versus machines). They found that young children know (as adults do) that properties such as size and weight are important for reasoning about machines, whereas features such as shape and texture are critical for thinking about animals. We have begun a series of studies in our laboratory aimed at examining category-specific learning and generalization in infants. In these experiments, we teach infants something about a particular object and observe their generalization of this knowledge to new objects. In one set of experiments (Shutts & Markson, 2003), for example, infants were taught that a particular animal was self-propelled. In the test phase, infants generalized this learning to animals that shared the same shape (but not the same color) as the familiar animal. Infants' privileging of shape over color in the domain of animals is consistent with Keil's data on children and adults (Keil, 1995; Keil *et al.*, 1998). We are currently investigating whether infants show contrasting, domain-specific learning and generalization patterns for food objects, as do older children (Macario, 1991) and non-human primates (Santos, Hauser & Spelke, 2001).

Behind these suggested studies is a research strategy that may prove fruitful in investigations of infants' conceptual development. For any given conceptual domain, one first specifies a set of signature properties of learning and generalization by adults or older children, and then one tests for those signatures in infants. If the conceptual system underlying the performance of older children is present and functional in infants, then infants' performance should display the same signature properties and limits. This strategy already has proven fruitful in studies of infants' cognitive abilities in the domain of number (Carey, 2001; Feigenson, Dehaene & Spelke, 2004). As methods in developmental cognitive neuroscience uncover a richer array of signatures of mature cognitive processes, this strategy may become increasingly successful.

Whatever their methods and findings, future research on the nature and origins of concepts will owe a great deal to the research and thinking that animate Mandler's book. In *The foundations of mind: Origins of conceptual thought*, Mandler lays out fundamental questions about the emergence and development of human knowledge. She helps readers to think about current empirical and

theoretical work on this topic, and she inspires us to devise new ways to address the hardest questions in developmental cognitive science.

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Multiple sources of information and their integration, not dissociation, as an organizing framework for understanding infant concept formation

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This is a commentary on Jean Mandler's *The foundations of mind: Origins of conceptual thought* (see Mandler, 2004).

What is most characteristic of perceptual representation is that it is categorial in nature... We see triangles, lines, apples, people. (Bruner, 1957)

In *The foundations of mind: Origins of conceptual thought*, Jean Mandler articulately describes her theory of how infants form concepts. This provocative book

provides important reading for investigators of early cognitive development as well as cognitive scientists more generally interested in concepts and the role they play in related mental activities, such as the representation of objects and events, language and consciousness. Piaget's (1952) argument that symbolic knowledge emerges from the compilation of infant sensorimotor activity is the

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