COMMENTARY

The roots of folk biology

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As adults, we think about the biological world in different ways than other realms. We are, for example, more inclined to see purposes of just the parts of animals and plants and not of the plant or animal as a whole, but we happily do so for artifacts (1). We see living kinds as occupying relatively unique locations in taxonomies (2). We make a much richer set of inferences about shared properties for all living kinds as opposed to all artifacts, we assume systematic patterns of growth and change not found elsewhere, and we often mistakenly assume there is a vitalistic force underlying all living things (3). Finally, we infer an unseen essence that is responsible for surface properties (4). In a casual walk through any environment, urban or rural, we typically are highly confident about whether we are encountering living things. Although the recognition of a distinct world of living things might seem to be a gradual consequence of culture and schooling, in PNAS, Setoh et al. (5) suggest something quite remarkable—well before they have understood a single word, infants at least as young as 8 mo have different expectations about a large part of the living world, namely animals. In particular, they expect animals to have filled interiors.

The Cognitive Challenge

These results present a major challenge. How are these expectations by preverbal infants manifested cognitively and how do they form a basis for more sophisticated forms of biological thought that emerges later in life? The patterns found here are more than simply treating animate entities differently. Preverbal infants have been shown to react to self-directed movement in a distinctive way, including moral attributions about geometric figures that behave in ways suggesting willful action (6). Similarly, contingent responding is linked to inferences about the agent having an attentional orientation (7). Those findings could, however, be assumed to be evidence for an early naïve psychology and not biology, and indeed one classic view argues that a true appreciation of the biological world as distinct from the psychological world does not emerge until the school years (8). Setoh et al., however, connect animated behavior with inferences about hidden features inside the entity. We do know that preverbal infants assume that intrinsic behaviors are associated more with distinctive insides than, say, with distinctive hats (9); however, this study reveals inferences that some kind of stuff must be present inside an entity for it to be an animal. Infants look longer when an entity is shown to have a hollow interior and is self-propelled and either responds contingently or is furry. Even if there is some partial interior that makes the object rattle when shaken, infants' expectations are violated. They seem to expect only fully filled interiors for animals.

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These results do not mean that infants have detailed expectations about insides. Even young school children can be surprisingly clueless about the details of the interiors of animals (10). Instead, infants apparently have a more abstract expectation that filled insides enable an entity to be an animal even as they are agnostic about the concrete details. How such abstract expectations are represented cognitively in the mind of a young infant remains a mystery.

Surprisingly, agentive behavior alone is not enough to trigger expectations about insides. In the real world, until the recent emergence of sophisticated robots (11), agentive behavior has always been uniquely associated with animals. If an entity responded in a socially contingent manner, it was an animal. However, the infants in Setoh et al. required more evidence—either self-propulsion or furriness is also needed. Setoh et al. speculate that self-propulsion sensitivity may have evolved first as part of simpler perceptually based predator/prey detection systems [for which there is other evidence (12)]. Agency as indicated by social contingency may have only been cognitively integrated later. This is plausible, but it cannot explain why contingency and furriness also work if self-propulsion is a foundational part of the expectations. Perhaps instead, there are initially two different systems for predators and prey: A hair-trigger detection system for predators based on self-propulsion, where the costs of false positives are minor compared with false negatives, and a more conservative system for prey detection that involves additional inferences about insides. When animals are considered as prey, an insides orientation may matter more as a guide to learning about the values of the specific insides as food.

Three Possible Developmental Trajectories

What is the developmental trajectory from expectations about the insides of animals to having a full-fledged folk biology? Setoh et al. offer three alternatives: a sense of the biological world as such is present early on, a convergence of broader cognitive biases resonates uniquely with living things, and a specific predator/prey detection system appears first. Each alternative raises many additional questions. Does the early true folk biology account include plants? Do preverbal infants have any sense of an overarching commonality between plants and animals as living things? There are cues shared by all living kinds that could be observed by an infant: living kinds tend to progress over time from smaller to larger versions. By contrast, most nonliving things tend to stay constant in size or get smaller. Living things tend to be more rounded than rectilinear artifacts and have fewer sharp angles (13). Living things and their functional parts show distinctive variations in shape and size across individuals. Animals have many more distinctive features that could make the animal classification task potentially much easier, but it is possible that that 8-mo-old infants may also have special expectations about plants in contrast to other inanimate objects, perhaps not expectations about insides but about other attributes such as plant edibility.*

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*Initially proposed by A. Wertz and K. Wynn.

However, even if 8 mo olds do have distinct expectations about plants and animals, they may not have an expectation about living things more generally. Plants and animals may initially be seen as completely distinct and important classes of things with nothing in common. If so, somehow at a later point in development, a moment of insight would occur in which both are seen as kinds of living things. At least by preschool, children do start to recognize growth, self-repair, and reproduction as common to both categories, as well as attributing a vital force (replenished through food or water) to both as the driving causal factor behind such processes, and these inferences have been taken as evidence for an early folk biology (3). However, could this insight into a common category occur much earlier and, if not, what limits that inference?

In the second account, of "converging construals," plants and animals are the only entities that conjointly have essences and easily accommodate teleological interpretations. Artifacts of course have widely apparent functions but are rarely considered to have material essences (there are no scientists working on understanding the molecular essence of chairs). Nonliving natural kinds (e.g., gold or water) have material essences but typically defy functional interpretations. If an infant repeatedly attempted to interpret the properties of animals and plants in teleological and essentialist terms and found that such conjoint interpretations were uniquely beneficial for only those two classes, a gradual sense of a common larger category of living things might emerge. Studies supporting such an account should show that infants have both strong expectations about preserved functions of parts and about specific insides as causally responsible for certain surface properties and that these expectations are applied jointly and uniquely to all living things. Given that an essentialist bias may be present in infants (9) and that infants are sensitive to object-specific functions (14, 15), this developmental account is at least feasible.

The third account more squarely focuses on animals and predator and prey detection. The concept of animal, however, might not be nearly as salient early on as "dangerous agent" or "nutritious agent." Plants would be largely irrelevant in this story, and we might even expect different expectations in omnivores, carnivores, and herbivores. Highly category-specific expectations about danger and predation are present in infants. For example, infants show a strong tendency to associate a fear response to snake-like stimuli in contrast to other animals or nonanimals (16), and vervet monkeys have distinct snake, eagle, and leopard detector systems (17). However, Setoh et al. suggest a much broader detection system that picks out all and only animals because of their roles as potential predators or prey. Many species have specific detectors for narrow categories of predators and prey, but it may be more unusual to have a generic animal detector that covers both predators and prey. The benefits of having expectations about all animals would have to outweigh the costs of false alarms to nonpredators and to nonnutritive prey.

Having an essentialist bias does not entail having detailed beliefs about the nature of animal essences, which infants, let alone children and many adults, do not have (18). However, it may well entail assumptions that self-propelled motion and contingent responding require substantial insides to generate those behaviors. It is striking that partial insides are not good enough even as they are adequate for self-propelled artifacts. Self-propelled nonfuzzy artifacts clearly require some inner mechanisms to move, but infants see no need for fully filled interiors. We do not yet know if they would prefer a partial inside to none at all for artifacts. If they did, such a finding might support the presence of a domain-general causal belief that some kind of inner mechanism must support self-propulsion.

It is unclear how most infants could learn that animals cannot have partially empty insides. The average infant has minimal firsthand experiences with road kill, surgical dissections, slaughterhouses, or other graphic displays of animal interiors. In fact, they would be expected to surely have far fewer of such experiences than for many simple devices and toys that they can be quite skilled at breaking open. We are thus left with a fascinating puzzle as to how an 8-mo-old prelinguistic human not only seems to think of animals as a coherent category but then makes inferences that they alone must have filled insides.

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