BBS Commentary on "What babies know" by Elizabeth Spelke

Not all core knowledge systems are created equal, and they are subject to revision in both children and adults

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Abstract: Core knowledge systems play an important role in theories of cognitive development. However, recent studies suggest that fundamental principles of the object and agent systems can be revised by adults and preschoolers, when given small amounts of counterevidence. We argue that not all core knowledge systems are created equal, and they may be subject to revision throughout development. (Word count: 58 words)

Spelke (2022) presents a comprehensive and elegant account of the origin of knowledge. She also presents strong arguments for the existence of six core knowledge systems that guide human learning and reasoning from infancy on. We are sympathetic to her view, but recent evidence also suggests a much more nuanced picture. We make two points in this commentary: (1) Some of the core knowledge systems are subject to revision, in children and adults. New studies show that surprisingly, even with just a small amount of counterevidence, adults and preschoolers readily revise their beliefs about core principles for both objects and agents (Liu & Xu, 2021, 2022, 2023). (2) Not all core knowledge systems are created equal. Given the body of evidence we have in hand, we argue that OBJECTS and NUMBER are perceptual systems, whereas AGENTS and SOCIAL BEINGS are more likely to be part of our belief system.

Recent studies investigated whether the core principles guiding our reasoning in the object and the agent systems are revisable (Liu & Xu, 2021, 2022; 2023). Adults and preschoolers observed a few pieces of evidence that violated the core principles of objects (e.g., a ball can go through a wall) and agents (e.g., an agent always takes an inefficient path to reach her goal). Then they made predictions about new events that were progressively more different from the events they observed. They were more likely to predict outcomes inconsistent with the core principles after observing the violations. Thus, both the object and the agent systems are subject to revision in adults and preschoolers. Furthermore, adults and preschoolers had stronger prior beliefs for objects than for agents, and the physical principles were harder to revise than the psychological principles in two ways: they were less likely to generalize the revised physical principles to new objects and new events; when they were asked to explain the violations, they were less likely to accept the counterevidence and more likely to try to explain it away (e.g., "there is a gap between the wall and the screen so the ball can go through"). In contrast, learners readily generalized the revised psychological principles to new agents and new events, and they accepted the counterevidence and generated plausible reasons for the agent's unusual behavior (e.g., "the red child just likes to jump", instead of taking the most efficient path to reach her goal). What explains these domain differences? One possibility is that infants are born with stronger prior beliefs about objects (i.e., the object system is more hard-wired to begin with); another possibility is that children and adults have observed more

counterevidence about the psychological principles in everyday life, and therefore have weaker and more flexible beliefs about agents.

These findings also suggest that maybe not all core knowledge systems are created equal. We speculate that there might be two types of qualitatively different core knowledge systems – one type is more akin to perceptual systems, which are automatic, inflexible, and possibly encapsulated from conscious reasoning, and the other type resembles belief systems, which are more flexible and deliberate. We argue that the systems of objects and number (and perhaps space) may be of the first type, whereas the systems of agents and social beings (and perhaps form) are more likely to be of the second type.

A large body of research suggests that adults' object representation depends on perceptual mechanisms (Scholl, 2001), and perception of objects is disrupted when objects do not follow the core physical principles such as continuity and cohesion (Scholl & Pylyshyn, 1999; Scholl et al., 2001; vanMarle & Scholl, 2003). Furthermore, object perception seems to be unaffected by the top-down influences of cognition (Firestone & Scholl, 2016).

For the number system, past research has shown clear evidence that the Approximate Number System (ANS) activates automatically and unconsciously in all ages (Izard et al., 2009; Nieder & Dehaene, 2009). The precision of ANS increases during infancy, perhaps due to the improvement of visual acuity (Xu & Arriaga, 2007; Xu & Spelke, 2000). In addition, the neurological signatures of the ANS remain constant from infancy to adulthood, unaffected by years of mathematical education (Hyde & Spelke, 2009, 2011).

On the other hand, the systems of agents and social beings are less automatic and encapsulated, and more likely to be part of our belief systems. Three-month-old infants do not automatically expect agents' actions to be directed to objects; they flexibly learn the goal (objects or location) of an agent's actions based on the agent's previous behaviors (Woo et al., 2022). While 1-year-old infants and children older than 4 years expect agents to take efficient paths to achieve their goals, 3-year-olds fail to show this expectation, suggesting that the development of the efficiency principle might be discontinuous (Gergely & Csibra, 2003; Gönül & Paulus, 2021).

Similarly, for the system of social beings, while expectations about how individuals interact and affiliate with one another emerge at a young age, these expectations are flexible and can be changed by infants' own social experiences. For instance, infants' social environments modulate their same-race preference – White and Black infants living in monoracial environments prefer faces of their own race, but Black infants living in predominantly White environments do not show a same-race preference (Bar-Haim et al., 2006). Infants' linguistic environments also change their expectations about social groups – monolingual infants expect individuals who speak different languages to have different food preferences, but bilingual infants expect them to share food preferences (Kinzler et al., 2016).

This distinction between perceptual vs. conceptual core knowledge systems makes interesting predictions that can be tested in future research. For example, preschoolers' and adults' revision of the core physical principles in Liu & Xu (2021, 2022) may not affect the operation of these principles on the perceptual level – participants may revert to principle-consistent predictions about novel events when they are under cognitive load. More generally, learners may be more likely to accept the violations of the agent and social being systems compared to the object and number systems.

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