The Fluid Construction of Spatial Concepts in Infancy

Commentary on Alessandroni and Rodríguez

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Keywords

Cognitive development · Spatial concepts · Containment · Image schemas · Infancy

The development of abstract concepts has long been a key topic of human cognition. Developmental and cognitive scientists have offered a wide spectrum of theories on this topic. Several views have dominated developmental science, including the Piagetian and Vygotskian perspectives. However, they are often considered in isolation from theories of cognitive science, presenting an unnecessary chasm. The article by Alessandroni and Rodríguez [this issue] provides a theoretical integration that cross-cuts cognitive and developmental views, in particular the conceptual metaphor theory and the sociocultural perspective.

The construct for consideration here is *image schemas*, generally defined as non-propositional primitives for the building of abstract concepts through embodiment [Lakoff & Johnson, 1980/2003; see also Gibbs, 2006; Gibbs & Colston, 1995]. Alessandroni and Rodríguez argue that image schemas should be considered “a cultural product” rather than “a natural consequence of recurrent action in the world” (p. 151). Their proposal is that abstract thoughts and concepts develop, not from building on natural primitives with nonsocial bodily experience, but from culturally meaningful interactions with objects and social partners – a co-construction of meanings of the material world. Alessandroni and Rodríguez reviewed several strands of empirical evidence in support of their proposal, and sought further evidence from a 17-month-old’s interactions with his mother while using objects that can or cannot function as containers.

“Container” or “containment” – the target concept of Alessandroni and Rodríguez’s article – has been investigated by researchers of infant cognition for a few decades. As their article briefly notes, series of empirical studies have been conducted to examine the emergence and development of infants’ understanding about contain-

ment. This work demonstrates early sensitivity to the spatial relation *containment* by young infants; critical to the present purpose, it offers one of the missing pieces for theory bridging. To contextualize Alessandroni and Rodríguez's proposal in the broader literature of infant cognition, below I review the research on infants' understanding of containment, which leads to three notions relevant to their account. Next, I connect the infant cognition research with image schemas and the "pragmatics of the object" account offered by Alessandroni and Rodríguez. The commentary concludes with where this article could lead us, theoretically and empirically.

Containment Concept in the First Year

The research of spatial concepts such as containment in infancy generally follows two related directions: (a) studying containment as an emerging category [Casasola, 2005, 2008; Hespos & Piccin, 2009] and (b) studying containment as a case of rule learning [Dejonckheere, Smitsman, & Verhofstadt-Denève, 2005; Hespos & Baillargeon, 2006; Wang, Baillargeon, & Brueckner, 2004]. The first line of research, spatial categorization in infancy, typically uses the habituation paradigm. Infants are presented with several examples of a target relation (e.g., an object being lowered *inside* a box, or containment). After infants' attention to the examples decreases, they are presented with another example of the target relation or an example of a comparison relation (e.g., an object being lowered *behind* a box, or *occlusion*). Recovered attention to the comparison relation but not to the target relation is taken as evidence to support that infants form an abstract category of the target relation that excludes the comparison relation.

Using this paradigm, studies have shown that infants at 6 months are capable of forming the category of containment after seeing just a few examples [Casasola, Cohen, & Chiarello, 2003]. Moreover, the way infants demarcate this spatial category depends on the comparison provided. Rigney and Wang [2015] showed that when given occlusion as the comparison, 8-month-olds failed to differentiate containment from occlusion; in contrast, when given *support* (i.e., an object being stacked on top of another) as the comparison, infants of the same age differentiate containment from support. At 11 months old, infants readily differentiate containment from occlusion. Taken together, the research of spatial categorization demonstrates the early emergence of containment in preverbal infants and shows that *the scope of a containment concept can shift fluidly depending on what infants are comparing it with*.

The other line of research examines containment as a case of rule learning, using various methods e.g., the violation-of-expectation paradigm, action tasks, and eye tracking. This research typically investigates how infants acquire and refine their intuitions about a spatial relation. It has been shown that for each vector (or each problem to be solved about a given relation), infants identify a rule of what object properties are relevant [Aguiar & Baillargeon, 2002; Smitsman, Dejonckheere, & De Wit, 2009; Wang et al., 2004]. With experience, infants may notice that while some outcomes support the current rule, others contradict it. When this occurs, a new rule is added to the vector or revised, allowing infants to predict outcomes in the vector more and more accurately [Baillargeon & DeJong, 2017; Baillargeon & Wang, 2002]. Briefly speaking, infants generate rules about the likely outcomes of events and revise these rules when confronted with discrepant outcomes.

For the container concept, infants begin to consider the object property *height* as relevant in occlusion events at 3.5 months of age [Baillargeon & DeVos, 1991; Hespos & Baillargeon, 2001], but they fail to do so in containment events until about 7.5 months of age [Hespos & Baillargeon, 2001; Wang, 2011]. Moreover, when watching events with a container that is placed upside down to form a cover, infants do not consider height as relevant until 12 months of age. That is, at a given age, the same rule of height may only be applied to some types of events but not others, even though they all involve container-like objects.

More strikingly, infants' successes and failures to consider height across occlusion, containment, and covering were demonstrated with the same container that served different functions, i.e., the same container to hide something behind it or to hold something inside it with the opening facing up or down [Hespos & Baillargeon, 2001, 2006; Wang, Baillargeon, & Paterson, 2005]. Furthermore, recent work shows that a particular form of containment – placing the container with its opening to the side – facilitates the comparison of object heights, resulting in earlier success (at 5 months of age) in using height for containment [Goldman & Wang, 2017]. Taken together, this work shows that before they regularly act on objects, *infants already differentiate various functions of container-like objects* (including occluders, containers, covers, and tubes) presumably through their observation of events taking place around them.

How is containment conceptualized in the two lines of research reviewed above? An event category is characterized as one type of causal interaction in which objects serve distinct roles (e.g., container, containee). It has a number of vectors, which represent separate problems that must be solved by acquiring a rule to accurately predict how the events will unfold [Baillargeon & DeJong, 2017; Wang, Zhang, & Baillargeon, 2016]. The process by which infants acquire or revise a rule has been specified as the following three steps [Wang & Baillargeon, 2008; Wang & Kohne, 2007]. First, infants notice contrastive outcomes among otherwise similar events (e.g., an object becomes fully hidden inside a box but remains partly visible inside another box). Second, noticing contrastive outcomes triggers infants to search for conditions to map onto the outcomes – a structure-mapping process [Gentner, 1983]. Third, for the condition-outcome mapping, infants must supply a causal explanation connecting the mapping and their current knowledge; this is where core principles of objects (some argue to be innate) come into play to “guard against” rules that do not make sense [Cherries, Mitroff, Wynn, & Scholl, 2008; Spelke, 1994]. Indeed, 9-month-olds in a training study failed to learn a rule when it violated core principles of objects [Wang & Baillargeon, 2008]. These lines of work demonstrated the active construction of a spatial concept by preverbal infants in the time scale of a few months [Wang et al., 2016] to a few seconds [Wang & Goldman, 2016; Wang & Onishi, 2017]. The empirical studies done to date leave little doubt that infants' container concept is more sophisticated and dynamic than it was proposed decades ago.

Extending beyond the first year, the containment concept has been shown to change its scope according to the structure of language that infants are learning or exposed to [Casasola, 2005; Casasola & Bhagwat, 2007; Casasola, Bhagwat, & Burke, 2009; Choi, 2006; Choi, McDonough, Bowerman, & Mandler, 1999]. Language invites reconstruction of early spatial concepts, such as containment and support, by providing a cognitive tool kit [Gentner, 2016; Gentner & Namy, 2006] for representing culturally distinguishable and meaningful relations.

Image Schemas in the First Months

Decades of advancements in the research of infant cognition, and of human development more broadly, are calling for updates on the theories of cognitive structure and processes. Indeed, Mandler and Pagán Cánovas [2014] argue for a more differentiated account of early cognitive structure. In lieu of a single construct of image schemas, they propose three types of structure: spatial primitives, image schemas, and schematic integrations. Among these, spatial primitives being “the first conceptual building blocks” (p. 1) seem to align with the spatial categorization research reviewed above, whereas image schemas being “the first stories built from blocks” seem to align with the aforementioned research of rule learning by which infants make sense of events.

Image schemas are traditionally defined as schematic representations of bodily experience [Gibbs, 2006]. Clearly, evidence has converged to show that bodily experiences shape and change infants’ perception and conception of the world [e.g., Gerson & Woodward, 2014; Soska, Adolph, & Johnson, 2010]. For example, using “sticky mittens,” Needham, Barrett, and Peterman [2002] showed that first-hand experience obtaining objects gave rise to changes in 3-month-olds’ approach to interacting with the objects in the future. Developmental accounts of embodied cognition that describe how experiences through time and space operate as self-organizing systems and change the way infants perceive and interact with the world [e.g., Gibson, 1988; Gibson & Pick, 2000; Smith & Gasser, 2005] are particularly relevant to the update of image schemas.

On the other hand, as image schemas are proposed within the framework of conceptual metaphors that not all theorists consider crucial to understanding human concepts [Murphy, 1997], they are subject to the same fundamental scrutiny. To this end, taking into consideration recent findings and accounts on infants’ and adults’ [Strickland & Scholl, 2015] construction of spatial relations could be theoretically illuminating.

Sociocultural Construction of Objects

Despite the demonstrated importance of first-hand experiences in perceptual and cognitive development, the influence of cultural experiences in the development of spatial concepts in infancy has not been adequately studied. Although the role of culture in the emergence and development of concepts is imaginable, empirical research that focuses on the first two years is still limited [Karasik, Tamis-LeMonda, Adolph, & Bornstein, 2015]. Alessandrini and Rodríguez’s work [this issue] helps fill this critical gap.

Alessandrini and Rodríguez [this issue] showed, in the 17-month-old boy’s playing with container objects with his mother, that the meaning of container was constructed by the sociocultural conventions of actions afforded by given objects. Rather than building on preexisting primitives, the boy arrived at the container concept with the mother through her verbal and nonverbal scaffolding. One could imagine in another dyad, family, or community, the same objects might afford and encourage children to produce a different set of actions and interactions, thus leading to the building of a different spatial relation (e.g., support, collision, balance, or oc-

clusion). The sociocultural contributions to conceptual formation in infancy are scarcely investigated (albeit not rejected) in the existing work. Alessandroni and Rodríguez [this issue] bring this research question into the spotlight, offering a theoretically and empirically refreshing approach to future inquiries.

The pragmatics of the object proposal challenges the notion of preexisting natural primitives for abstract concepts and instead argues that structure primitives are socioculturally constructed. In empirical practice, mapping observed activities to the emergence of a “developmental, pragmatic, and cultural” product necessitates appropriate interpretations of intended interactions by the child and adult with the objects. Cross-culturally, different forms/activities may serve the same function/meaning, whereas the same form/activity can serve different functions/meanings [Bornstein, 1995]. Performing a culturally appropriate mapping for activities involving very young children or preverbal infants will require researchers to have a deep understanding of sociocultural contexts in which the activities occur.

Conclusions

In this commentary, I reviewed two related lines of empirical studies on the container concept in the first year. This past work leads to three notions relevant to Alessandroni and Rodríguez’s pragmatics of the object proposal: (a) the scope of the concept shifts fluidly depending on the context of comparison infants are making; (b) by the end of the first year, infants already differentiate various functions of container objects; (c) the concept is more sophisticated than proposed decades ago. These notions give rise to the possibility that by the end of the first year, infants have already built fairly complex stories of the container concept. However, they do not dismiss Alessandroni and Rodríguez’s call for the sociocultural approach to studying the development of early concepts.

The early mind of space is fluid and dynamic, subject to experiences of action and language that occur socially. The development of early cognition is still primarily studied ethnocentrically, assuming a universal pathway in place. Examining children’s everyday lived experiences situated in their cultural community [Rogoff, 2003] can provide theoretically important insights into how concepts are co-constructed by young learners and their social partners. Alessandroni and Rodríguez [this issue] gave an example of such attempts. But more needs to be done.

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