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Contrasting preschoolers' verbal reasoning in an object-individuation task with young infants' preverbal feats

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ABSTRACT

Young infants infer a second object if shown an object apparently moving on a discontinuous path (Aguiar & Baillargeon, 2002; Spelke, Kestenbaum, Simons, & Wein, 1995). In three experiments, we examined whether children aged 3–6 years and adults would do the same in their verbal explanations of an apparent continuity violation. Presenting participants with video clips (Exp. 1 and 3) as well as live events (Exp. 2) of a toy locomotive apparently passing through a tunnel without appearing in a large opening in the middle, we found virtually no evidence for generations of two-object explanations of the critical test event in preschoolers. Some of the younger children even denied a continuity violation at first. When participants were familiarized to two identical objects instead of just one, they were more likely to realize that a second object was involved in the test events but, unlike adults (Exp. 3), most children nonetheless adhered to a one-object interpretation. Analyzing 3- and 5-year-old children's and adults' eye movements (Exp. 3), we found that children's difficulties to infer a second object from an apparent continuity violation were not caused by inappropriate looking strategies. We conclude that preschoolers' physical reasoning about the numerical identity of objects is not continuous with the preverbal reasoning of infants. Rather than being exclusively constrained by the output of basic object-individuation processes, as in infants, it is also strongly influenced, in a top-down manner, by prior beliefs.

1. Introduction

1.1. The early-competence debate

Recently, the debate on the status of young infants' cognitive capabilities has been revived by research suggesting early forms of false-belief understanding. The discrepancy between the well-established fact that preschoolers do not pass traditional Theory-of-Mind tasks (see Wellman, Cross, & Watson, 2001, for a meta-analysis) and recent findings suggesting much earlier competencies in nonverbal variants of these tasks (e.g., Onishi & Baillargeon, 2005; Southgate, Senju, & Csibra, 2007) has renewed researchers' interest in the puzzle of why older children often appear so "dumb" and infants so "smart" (Keen, 2003).

Traditionally, the early-competence debate was largely restricted to the domain of intuitive physics. It revolved around criticisms of Piaget's assumption of a sensori-motor stage. Using the so-called Violation-of-Expectation (VoE) method, several research groups were able to demonstrate early forms of object permanence and physical reasoning. Since then, the picture of infants' physical reasoning has been enriched considerably using this method (for an overview and theoretical account, see Baillargeon, Li, Ng, & Yuan, 2009).

The VoE method is a derivative of the preferential-looking paradigm used in innumerable studies on early perceptual development. Usually, albeit not necessarily, after a period of familiarization or habituation, infants are presented with two stimuli, either simultaneously or sequentially, and their preferential attention to one of the stimuli is assessed, mostly operationalized as differential looking times. The rationale behind the VoE method is that infants, much like older children and adults, react with increased attention (usually measured as longer looking times with infants) if they observe something unexpected. In combination with results from additional conditions or experiments controlling for factors such as perceptual novelty, preferential attention (looking) for an impossible event is interpreted as evidence suggesting that the infant was "surprised" (i.e., that he or she experienced a violation of expectation) and hence as an indicator of intuitive knowledge.

The interpretation of demonstrations of early competencies by means of the VoE method was heavily disputed in the 1990s and

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early 2000s (e.g., Bogartz, Shinskey, & Speaker, 1997; Thelen & Smith, 1994; cf. Baillargeon, 1999, 2004, with commentaries). Today, there appears to be wider agreement, however, that--on a "middle" level, at least--infants do represent occluded objects and perform cognitive operations on these representations (e.g., Carey, 2009; Scholl & Leslie, 1999). The traditional assumption that infants are purely sensori-motor beings without any internal representations and cognitive structure (Piaget, 1954) has become hardly tenable. What is still at stake, however, is the exact nature of infants' physical reasoning as assessed indirectly, mostly via the VoE method, and how it relates (ontogenetically) to explicit forms of physical reasoning diagnosable with older children (e.g., Aschersleben, Henning, & Daum, 2013; Krist, 2010, 2013).

1.2. Young infants' preverbal feat: positing the existence of occluded objects

The present research is designed to shed new light on this issue by using what might be viewed as the most impressive of all early competencies as a benchmark for preschoolers' explicit physical reasoning: namely, young infants' ability to "infer" or "posit" the existence of occluded objects. This presumed competence is remarkable, indeed. It is closely related to the ability to posit unobserved causes, such as hidden forces or "essences", and hence to the hallmark of theoretical thinking, which some authors consider to be uniquely human (e.g., Povinelli, 2000, 2012). But can young infants really accomplish such feats, albeit on an implicit, preverbal level? What is the evidence?

Spelke and colleagues were the first to publish such evidence (Spelke & Kestenbaum, 1986; Spelke, Kestenbaum, Simons, & Wein, 1995). In a series of experiments, they habituated 4-month-old infants either to a continuous or to a discontinuous event. In the continuous event, a vertical rod was shown moving back and forth horizontally across a puppet stage disappearing and reappearing behind two vertical screens in turn. This event was termed "continuous" because it did not violate the continuity principle according to which objects move on uninterrupted paths (Carey & Spelke, 1994). In the discontinuous event, this principle was apparently violated because the rod did not appear between the two screens. Actually, a second rod was used to produce this apparent continuity violation: While one of the two identical rods approached the first screen, the other one was hidden behind the second screen; after the former had disappeared behind the first screen, the latter appeared from the second screen in the same manner and at the same delay as the single rod in the continuous event. After the infants had reached the habituation criterion or the maximum number of habituation trials had been presented, three pairs of test trials without any screens were shown in which either one or two rods were shown moving as in the continuous and the discontinuous event, respectively. When presented with the continuous event, infants dishabituated more strongly (i.e., looked longer) with the two-object than with the one-object event, and vice versa. In other words, infants tended to generalize the continuous habituation event to the one-object test event and the discontinuous habituation event to the two-object test event. This result suggests that infants made sense of the apparent continuity violation in the discontinuous event by "perceiving" a second object (Spelke, 1990). Yet, in comparison with baseline and control conditions, Spelke et al. (1995) obtained only mixed support for this assumption (cf. Aguiar & Baillargeon, 2002, Footnote 4).

One could also argue that the 4-month-olds tested by Spelke et al. (1995) were only realizing by hindsight, when watching the two-object test event, that two objects must have been involved in the discontinuous habituation event (see Aguiar & Baillargeon, 2002; Baillargeon, 1994). More direct, but still preliminary, evidence supporting the claim that young infants are able to infer the existence of an occluded object if confronted with an apparent continuity violation was reported by Baillargeon (1994). In her study, 5.5-month-olds were familiarized to a toy rabbit disappearing and reappearing behind a large screen and were then tested with a high- versus a low-window event. In the high-window event, the midsection of the screen's upper half was removed, while, in the low-window event, the corresponding section of the screen's lower half was cut out. Again, the rabbit disappeared and reappeared (from) behind the screen, but failed to be seen in the windows. While it was short enough to remain completely hidden by the screen in the high-window event, it should, have appeared in the low-window event, of course. Still, infants tended to look equally at both events.

Interpreting this negative finding as preliminary evidence that 5.5-month-olds posited the involvement of a second, identical object (initially occluded by the screen) to explain the apparent discontinuity in the low-window event, Aguiar and Baillargeon (2002) sought for additional evidence to support their claim. Against the backdrop of the results obtained in Spelke's lab (Spelke & Kestenbaum, 1986; Spelke et al., 1995) as well as those from their own lab (Aguiar & Baillargeon, 1999; Baillargeon, 1994; Baillargeon & DeVos, 1991), Aguiar and Baillargeon (2002) speculated that, with the low/high-window paradigm, infants should begin to posit an additional occluded object at some age between 2.5 and 4 months, but only after they are able to detect this particular continuity violation. In other words, infants should first exhibit differential looking times, indicating success in detecting the continuity violation, and then fail to do so, indicating success in explaining it by (correctly) inferring the involvement of a second object. This is exactly what they found: Three-month-old infants looked reliably longer at the low- than at the high-window event, whereas 3.5-month-olds did not.

As Aguiar and Baillargeon's (2002) experiments constitute the reference point for the present research with preschoolers, they will be described in more detail next. In their main experiment (Exp. 1), 3- and 3.5-month-olds were presented with events resembling those of the rabbit study mentioned above (Baillargeon, 1994; see also Aguiar & Baillargeon, 1999). The infants were habituated to a toy mouse ("Minnie Mouse") moving back and forth along a track disappearing and reappearing behind a large rectangular screen. Following habituation, a high- and a low-window event were presented in two pairs of alternating trials. As in the rabbit study, the toy mouse did not appear in either case although it should have done so in the low-window event. All events were produced by using two identical toy mice one of which remained hidden behind the right edge of the screen until the other one, approaching from the left, had disappeared behind the left edge. After an appropriate delay, the former appeared from behind the right edge of the screen continuing the movement of the latter, before reversing its direction and repeating the movement sequence from right to left. Each trial ended as soon as the infant looked away (for 2 s), after having looked at the event for a specified duration, or looked at the event for the maximum time allowed (90 s). The habituation phase ended if the habituation criterion was met (50% decrease in mean looking time, relative to the first 3 trials) or 9 habituation trials were completed.

As already mentioned, Aguiar and Baillargeon (2002) obtained longer looking times for the low- than the high-window event with the 3-month-old but not the 3.5-month-old infants. The negative finding with older infants was replicated in another experiment (Exp. 1A). The results from six follow-up experiments lent further support to Aguiar and Baillargeon's claim that both younger and older infants were initially surprised that the toy mouse did not appear in the low window, but that only the older infants were able to explain the apparent continuity violation by positing a second object. In Experiment 2, it was shown that 3.5-month-olds do