

How Fresh a Look? A reply to Heyes
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Heyes (in press) argues that all of the findings of infant false-belief understanding that have been published to date can be explained in terms of perceptual novelty and other low-level domain-general processes. We object to Heyes's account on three grounds, as explained below.

False-belief understanding before age 4

Until recently, it was generally assumed that children younger than about age 4 do not understand that agents can hold false beliefs. This assumption was based mainly on results from elicited-response tasks, which require answering a direct question about the likely behavior of an agent who holds a false belief. Onishi and Baillargeon (2005) cast doubt on this assumption when they published results from a novel non-elicited-response task showing that 15-month-olds can attribute false beliefs to others. To date, over 25 reports (see Table 1) have provided converging results with children ages 7 months to 4 years, using a wide range of verbal and non-verbal non-elicited-response tasks (including violation-of-expectation, anticipatory-looking, preferential-looking, anticipatory-pointing, and prompted-action tasks). Moreover, researchers have begun to develop and test processing models explaining why elicited-response tasks pose such difficulties for young children. We submit that it is this large and highly consistent body of work, and not just the "data from these infant false belief studies", as Heyes (in press) believes, that is "establishing a new consensus in developmental science" (p. 3).

Psychological reasoning in infancy

Heyes (in press) argues that the existing experiments on infant false-belief understanding "fall short of demonstrating that infants have even an implicit theory of mind" (p. 2), and that infants may represent the events in these experiments "as colours, shapes, and movements, rather than as actions on objects by agents" (p. 6). These arguments ignore the fact that the experiments on infant false-belief understanding did not take place in a vacuum: The research on early psychological reasoning over the past 20 years makes clear that infants represent simple psychological events as "actions on objects by agents", rather than as "colours, shapes, and movements" (for a comprehensive review, see Baillargeon et al., in press). It is true that researchers disagree about the specific nature and origins of infants' psychological-reasoning abilities; but they generally agree that infants' responses to agents' actions are not merely driven by perceptual novelty, because there is overwhelming evidence to the contrary.

As an example, consider Woodward's (1998) seminal preference task and the myriad of findings that it has generated. In a typical task, infants first receive familiarization trials in which agent-1 repeatedly reaches for object-A as opposed to object-B. Next, infants receive a display trial in which agent-1 is absent and infants can observe that the locations of object-A and object-B have been switched. Finally, in the test trials, the agent returns and reaches for either object-A or object-B. Based on the consistent choice information provided in the familiarization trials, infants typically attribute to agent-1 a preference for object-A, they expect agent-1 to continue acting on this preference in the test trials, and they therefore detect a violation when agent-1 reaches for object-B instead. However, infants do *not* show this expectation: (1) if they are uncertain whether agent-1 is really an agent (e.g., Luo & Baillargeon, 2005; Shimizu & Johnson, 2004; Woodward, 1998); (2) if object-B is absent during the familiarization trials or is present but hidden from agent-1, so that agent-1's repeated actions on object-A no longer provide choice information (e.g., Bíró, Verschuur, & Coenen, 2011; Luo & Baillargeon, 2005, 2007; Luo &

Johnson, 2009); (3) if agent-1 uses inefficient actions to retrieve object-A (e.g., Woodward & Sommerville, 2000); (4) if the goal of agent-1's actions on object-A is unclear (e.g., agent-1 places the back of her hand against object-A, instead of grasping it; e.g., Woodward, 1999); (5) if object-A and object-B are perceptually distinct but belong to the same taxonomic category (e.g., two different trucks; Spaepen & Spelke, 2007; Woodward & Sommerville, 2000); and (6) if agent-1 is replaced by agent-2 in the test trials (e.g., Buresh & Woodward, 2007; Henderson & Woodward, 2012). Conversely, infants *do* expect agent-1 to reach for object-A even if: (7) it is paired with novel object-C in the test trials (Robson & Kuhlmeier, 2013); (8) object-A is the only object present in the familiarization trials, provided agent-1 must go to some effort (e.g., must first open a container) in order to retrieve it (e.g., Bíró et al., 2011; Hernik & Southgate, 2012); (9) agent-1 merely looks intently at object-A in the familiarization trials, provided there is an explanation for her failure to reach for object-A (e.g., her hands are occupied holding the handles of a sippy cup; Luo, 2010); and (10) agent-2 replaces agent-1 in the test trials, provided agent-1 used ostensive pedagogical cues prior to expressing her preference for object-A (Egyed et al., 2013). These results provide overwhelming evidence that infants are not merely responding to the perceptual novelty of “colours, shapes, and movements”; rather, they are representing agents acting on objects, and they are showing remarkably nuanced and context-sensitive responses to these actions.

Of course, any infant experiment must use appropriate controls to establish precisely what expectations are driving infants' responses and to rule out alternative possibilities. But science is a cumulative process, and researchers do not need to rule out over and over again the same classes of low-level alternative interpretations (e.g., infants cannot see, cannot remember information, and so on). The same is true here: The battle over whether infants are representing “colours, shapes, and movements” or “actions on objects by agents” (p. 6) has already been fought in the context of simple psychological events, and there is no reason to wage it again in the context of false-belief events.

Unfounded assumptions

Heyes (in press) argues that existing infant false-belief findings can be explained in terms of low-level domain-general processes including: (1) *perceptual and imaginal novelty* (infants look longer at events they perceive or imagine to have novel configurations of colors, shapes, and movements); (2) *delay-related memory limitations* (if infants see event-A in three trials, followed by event-B in a fourth trial, infants' memory of the first three trials will rapidly fade during the fourth trial and hence will have little impact on their subsequent responses); and (3) *retroactive interference* (infants' memory of an event will be disrupted if it is followed by a salient distracting event, such as the return of an agent who was briefly absent).

Many of Heyes's (in press) assumptions concerning these processes seem unlikely. For example, we know of no evidence that infants' memory of repeated events rapidly fades over a brief delay, or that infants generally view the return of an agent after a brief absence as highly disruptive. However, even if we leave these concerns aside there already is evidence from infant false-belief experiments that cannot be explained by Heyes's account.

In one experiment (Scott & Baillargeon, 2009), we asked whether 18-month-olds could attribute to an agent a false belief about the identity of an object (Figure 1). This experiment involved two toy penguins that were identical except that one could come apart (2-piece penguin) and one could not (1-piece penguin). In each familiarization trial, while a female agent watched, an experimenter's hands placed the 1-piece penguin and the two pieces of the disassembled 2-piece penguin on platforms or in shallow containers. The agent then placed a key

in the bottom piece of the 2-piece penguin and stacked the two pieces; the two penguins were then indistinguishable. During the test trials, while the agent was absent, the experimenter assembled the 2-piece penguin, covered it with a transparent cover, and then covered the 1-piece penguin with an opaque cover. The agent then entered the apparatus with her key and reached for either the transparent or the opaque cover. Infants looked reliably longer when the agent reached for the transparent cover, suggesting that they expected her to falsely assume that the penguin under the transparent cover was the 1-piece penguin, and hence to falsely believe that the disassembled 2-piece penguin was under the opaque cover.

Heyes (in press) offers a different interpretation of this result: The return of the agent (after her brief absence at the start of each test trial) caused infants to forget that the visible penguin was the stacked 2-piece penguin, and they therefore looked longer when the agent reached towards it because this was perceptually novel relative to the familiarization trials. According to this interpretation, results should be exactly the same if the agent had no key to hide: The processes of retroactive interference and perceptual novelty should still apply. This was not the case, however: In an additional experiment in which the agent had no key but performed the same actions as before (Figure 2), infants looked about equally at the two test events. In line with the preference findings reviewed above, infants did not attribute to the agent a preference for the 2-piece penguin when there was no clear motivation for doing so; as a result, they had no expectation about which penguin she would reach for in the test trials (she obtained a penguin either way). Given that the events in these two experiments were visually nearly identical¹, these results provide strong evidence against Heyes's account.

In conclusion

Any account of early false-belief understanding must take into account the broader literature on psychological reasoning that has accumulated over the past 20 years. If perceptual novelty and other low-level processes are not sufficient to explain the results of experiments that do not involve false beliefs, then they are also not sufficient to explain the results of experiments that do involve false beliefs. Infants do not leave their psychological knowledge at the door of the laboratory when they arrive for a false-belief experiment, and accounts that suppose otherwise are unhelpful.

¹ In the supplemental material, Heyes (in press) argues that without the key, infants were unable to discriminate between the penguins in the familiarization events. Not only is this highly unlikely, but it also contradicts Heyes's assumption that infants are attending to low-level perceptual features such as shapes (one whole penguin versus a disassembled penguin) and movements (reaching towards two objects as opposed to one).

Table 1

Reports of False-Belief Understanding Prior to Age 4, Separately by Task Type and Age Group

Task type	Reports with children 0-2	Reports with children 2-4
Anticipatory-looking	Barrett et al. (2013); Meristo et al. (2012); Senju et al. (2011); Surian & Geraci (2012)	Barrett et al. (2013); Clements & Perner (1994); Garnham & Perner (2001); Garnham & Ruffman (2001); He et al. (2012); Low (2010); Low & Watts (2013); Ruffman et al. (2001); Southgate et al. (2007);
Anticipatory-pointing	Knudsen & Liszkowski (2012a, b)	Knudsen & Liszkowski (2012a)
Preferential-looking		Barrett et al. (2013); Scott et al. (2012)
Prompted-action	Buttelmann et al. (2009); Southgate et al. (2010)	Buttelmann et al. (2009); Rubio-Fernandez & Guerts (2013)
Violation-of-expectation	Barrett et al. (2013); Kovacs et al. (2010); Luo (2011); Onishi & Baillargeon (2005); Scott & Baillargeon (2009); Scott et al. (2010); Song & Baillargeon (2008); Song et al. (2008); Surian et al. (2007); Thoermer et al. (2012); Trauble et al. (2010); Yott & Poulin-Dubois (2012)	He et al. (2011); Scott et al. (2012)

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Figure Captions

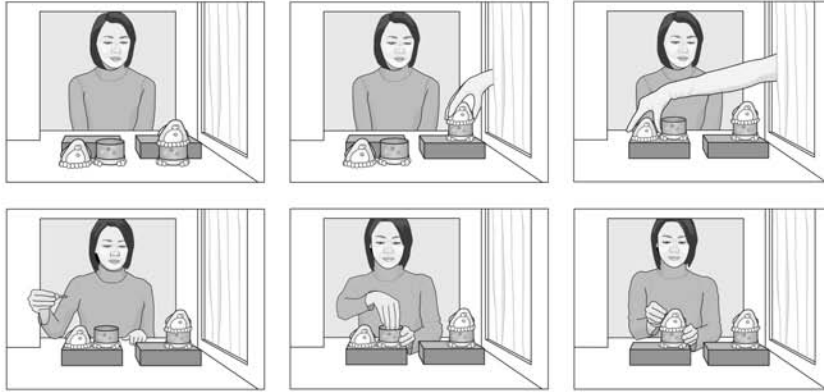
Figure 1: Events shown in the Key Experiment. Infants received four familiarization trials involving two penguins that were identical except that one could come apart (2-piece penguin) and one could not (1-piece penguin). As a female agent watched, an experimenter's gloved hands placed the 1-piece penguin and the two pieces of the disassembled 2-piece penguin on platforms in trials 1 and 2 and in shallow containers in trials 3 and 4. The agent then held up a key, placed it in the bottom piece of the 2-piece penguin, stacked the two pieces, and paused; the two penguins were then indistinguishable. During the test trials, while the agent was absent (her window in the back wall of the apparatus was closed), the experimenter assembled the 2-piece penguin, covered it with a transparent cover, and then covered the 1-piece penguin with an opaque cover. Next, the agent opened her window, held up her key, reached for either the transparent cover (transparent-cover event) or the opaque cover (opaque-cover event), and paused. The order of the two test events was counterbalanced.

Figure 2: Events shown in the No-key Experiment. The events were identical to those in the Key Experiment, except that the agent had no key. During the familiarization trials, the agent held up her open right hand (to show that it was empty) before reaching into the bottom of the 2-piece penguin. In the test trials, she held up her open hand and reached for one of the covers.

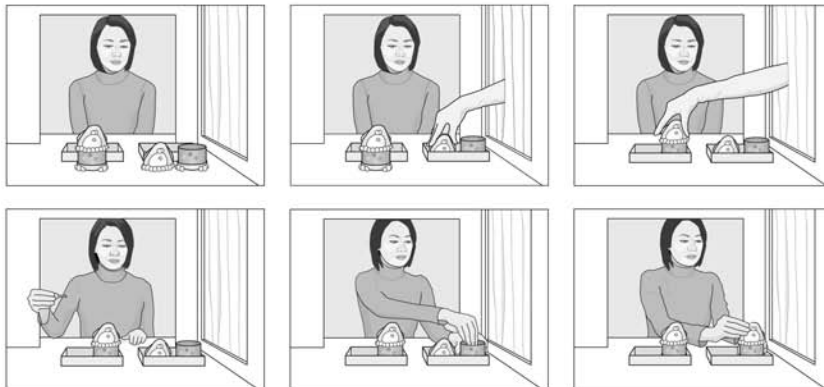
Key Experiment

Familiarization trials

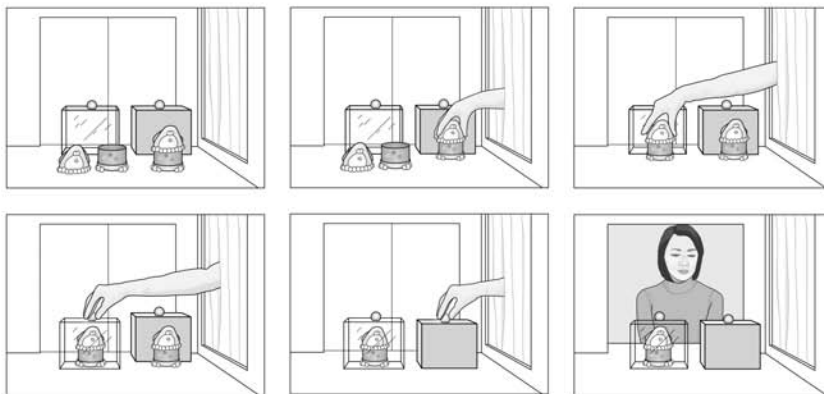
Trials 1 and 2



Trials 3 and 4



Test trials



Transparent-cover event

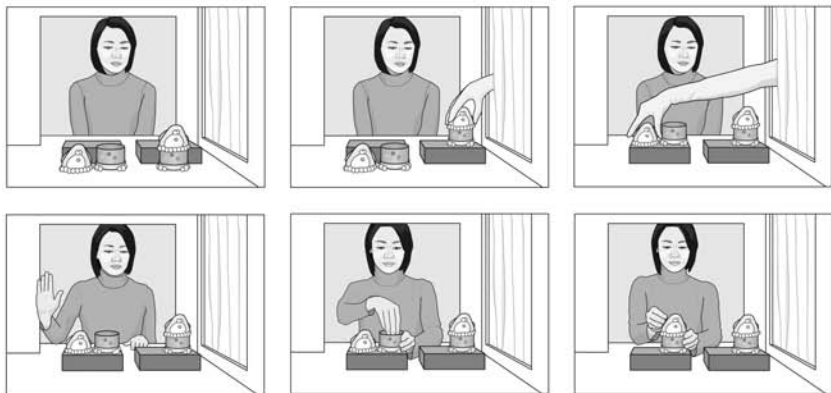


Opaque-cover event

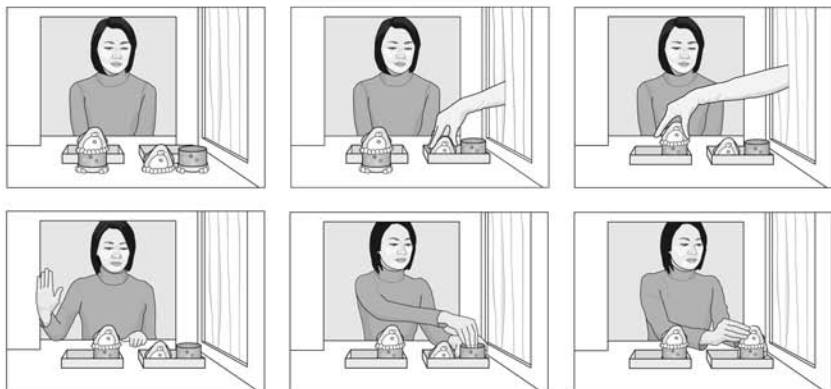
No-key Experiment

Familiarization trials

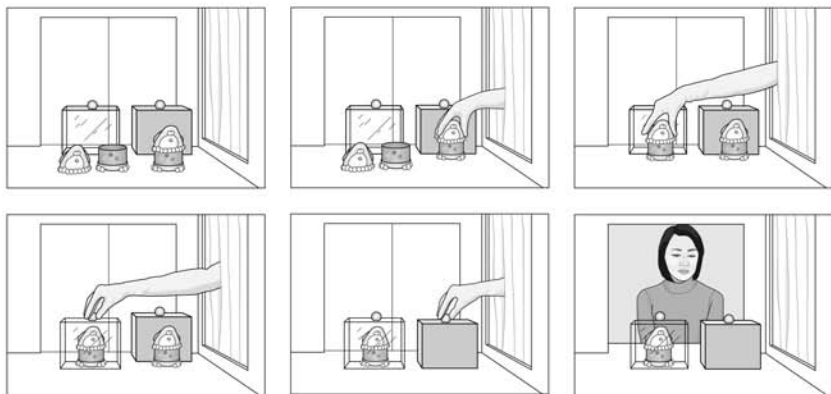
Trials 1 and 2



Trials 3 and 4



Test trials



Transparent-cover event



Opaque-cover event