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Just do it? Investigating the gap between prediction and action in toddlers' causal inferences

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ABSTRACT

Adults' causal representations integrate information about predictive relations and the possibility of effective intervention; if one event reliably predicts another, adults can represent the possibility that acting to bring about the first event might generate the second. Here we show that although toddlers (mean age: 24 months) readily learn predictive relationships between physically connected events, they do not spontaneously initiate one event to try to generate the second (although older children, mean age: 47 months, do; Experiments 1 and 2). Toddlers succeed only when the events are initiated by a dispositional agent (Experiment 3), when the events involve direct contact between objects (Experiment 4), or when the events are described using causal language (Experiment 5). This suggests that causal language may help children extend their initial causal representations beyond agent-initiated and direct contact events.

> ... suppose that an individual ape ... for the first time observes the wind blowing a tree such that the fruit falls to the ground... we believe that most primatologists would be astounded to see the ape, *just on the bases of having observed the wind make fruit fall* ... create the same movement of the limb ... the problem is that the wind is completely independent of the observing individual and so causal analysis would have to proceed without references to the organism's own behavior (Tomasello & Call, 1997; italics theirs)

Tomasello and Call's thought experiment suggests that the ability to recognize predictive relations among events may not entail the ability to recognize that such relations potentially support intervention. Recently, researchers have expressed a similar intuition across a variety of fields. Philosophers have suggested that only a cognitively sophisticated being would recognize "that the very same relationship that he exploits in intervening also can be present both when other agents intervene and in nature even when no other agents are involved" (Woodward, 2007). Similarly, psychologists have suggested that causal knowledge requires understanding causal relations as non-egocentric, stable relations among diverse events, not merely relations "that involve rewards or punishments (as in classical or operant conditioning), not just object movements and collisions (as in the Michottean effects), and not just events that immediately result from (one's own) actions (as in operant conditioning or trial-and-error learning)" (Gopnik et al., 2004). The implication is that human beings may be unique among animals in having a single representation ("causal knowledge") that encodes what

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is common across causal relationships that do not involve the actions of agents and the relationship between agent actions and outcomes.

To our knowledge, Call and Tomasello's thought experiment holds empirically for non-human animals. Non-human animals can generalize behaviors learned only through action to cues learned only through observation (i.e., in Pavlovian to instrumental transfer, Estes, 1948). They can also make systematic predictions about the interaction between cues learned through observation and intervention. For example, if a rat learns to associate a light with both a tone and food, the rat will expect food when it hears the tone; however, if the rat itself pushes a lever and triggers the tone, the rat no longer treats the tone as a cue to the food (Blaisdell, Sawa, Leising, & Waldmann, 2006; though see Dwyer, Starns, and Honey (2009) and Penn and Povinelli (2007) for critique) and Leising, Wong, Waldmann, and Blaisdell (2008) for a reply. However, no study has found that non-human animals spontaneously design appropriate novel interventions after only observing a predictive relationship between events, and one study suggests that dogs do not (Waisman, Cook, Gopnik, & Jacobs, 2009a, 2009b). Lack of evidence of course is not conclusive evidence of a lack. However, the absence of evidence from non-human animals, together with the abundance of evidence from adult humans, raises the question of whether the ability to generalize from observation to intervention arises not only late in phylogeny but also in ontogeny.

We propose that while adults live in a world rife with causal connections, the domain of causal relationships in early childhood is far more circumscribed. In particular, we suggest that although toddlers are sensitive to predictive relations between events, there are substantial constraints on their ability to infer that these relations might support effective manipulation. In better understanding the origins of, and limitations on, children's inferences about causal relations, we may better understand not only the gap between prediction and action in early childhood (and consequent discrepancies between children's performance across paradigms with different task demands; see e.g., Hood, Carey, & Prasada, 2000) but also the contextual and cultural cues that support adult-like causal inference.

The claim that very young children might not readily generalize from observed data to possible actions may seem surprising given the abundant evidence for very early and very sophisticated causal reasoning in young children (e.g., Bullock, Gelman, & Baillargeon, 1982; Gopnik & Sobel, 2000; Gopnik et al., 2004; Kushnir & Gopnik, 2005; Kushnir & Gopnik, 2007; Schulz & Bonawitz, 2007; Schulz, Goodman, Tenenbaum, & Jenkins, 2008; Schulz & Sommerville, 2006; Shultz, 1982; Sobel, 2004; Sobel & Kirkham, 2006; Williamson, Meltzoff, & Markman, 2008. However, three features of previous studies may have masked young children's limitations.

First, studies of causal reasoning in early childhood have almost always investigated causal understanding in the context of an agent's goal-directed actions. Events initiated by agent action characterize for instance, all studies of imitative learning (see e.g., Horner & Whiten 2004; Lyons, Young, & Keil, 2007; Meltzoff, 1995, 2007; Schulz, Hooppell, & Jenkins, 2008). Children might be able to imitate goal-directed actions, or even attribute causal efficacy to goal-directed actions, without extending this inference to predictive relations where no agent is involved.

Second, many studies of causal inference (and in particular infancy studies) have looked at the special case of causal events involving unmediated direct contact between objects (as in Michottean launching events, Michotte (1963)). Children's perception of causality might initially be constrained to such special cases. Indeed, both philosophers and psychologists have suggested that Michottean causality might be a modular process, specific to the visual system, and relatively divorced from causal knowledge more broadly (Scholl & Tremoulet, 2000; Woodward, in press; though see Schlottmann, 2000).

Finally, in most studies of causal reasoning, adults have given children additional information about the relationship between the events by describing the observed events with causal language. Causal language (by which we mean here language accessible to young children: "make go", "turn on") might facilitate children's causal reasoning in at least two respects. First, describing an observed correlation ("The block makes the toy go") with the same verb as the invitation to act ("Can you make the toy go?") might help children recognize the relevance of observational evidence to their own interventions. Second, causal language might facilitate children's causal learning simply by testifying that an observed relation is indeed causal (Harris, 2002; Lutz & Keil, 2002; Vygotsky, 1978).

Here we hypothesize that young children's understanding of causal events critically depends upon such supplemental information. That is, toddlers will not spontaneously intervene on a predictive relation unless the events are initiated by dispositional agents,[1] the events involve unmediated, direct contact between objects, or adults describe the events in causal language. Like Call and Tomasello's hypothetical ape, very young children do not otherwise spontaneously represent predictive relations as causal.

Here we show children a sequence of two events: a block contacts a base, and then a toy connected to the base lights up and spins. We assess whether children generalize from this observation to a potentially effective intervention: moving the block to the base themselves. Absent additional cues, we suggest that toddlers will not spontaneously perceive the possibility that predictive events might be causally related, and thus will fail to generate the target intervention.

Note that of course children may not (and indeed should not) assume that all predictive relations will support effective interventions. That is, in this experiment they need not expect that moving the block to the base will *definitely* cause the toy to activate. However, adults recog-

[1] We use the term "dispositional agent" to distinguish agents capable of goal-directed action from both the more general case of causal agents (which of course include inanimate entities), and the more specific case of agents engaging in intentional actions (versus for instance, accidental actions, a distinction we do not investigate here). There is some evidence that 6-month-old infants might restrict their causal inferences to relations involving specifically intentional rather than accidental agent action (Muentener & Carey, 2006), however, there is no evidence that children as old as the ones tested in this study (24 months) are similarly restricted.