Cognitive Development 45 (2018) 48–56

Contents lists available at ScienceDirect

Cognitive Development

journal homepage: www.elsevier.com/locate/cogdev

More than just making it go: Toddlers effectively integrate causal efficacy and intentionality in selecting an appropriate causal intervention☆

Elena Luchkina[a,*], Jessica A. Sommerville[b], David M. Sobel[a]

[a] Department of Cognitive, Linguistic, and Psychological Sciences, Brown University, United States
[b] Department of Psychology, University of Washington, United States

ARTICLE INFO

Keywords:
Intentionality
Efficacy
Causal understanding
Social cues

ABSTRACT

Do children use causal data and social information in conjunction to guide their interventions? We examined whether 2-year-olds (N = 120, 40 in each experiment) were able to appreciate the difference between causally efficacious and inefficacious actions presented intentionally. Toddlers who did appreciate such a difference preferentially used intentionality cues when causal efficacy did not differ between the actions (Experiment 1). When causal efficacy and intentionality were incongruous, toddlers who understood the difference between efficacious and inefficacious actions preferred to produce effective but unintentional actions (Experiment 2) and when both actions weren't intentional, produced effective actions (Experiment 3). These data suggest that as toddlers come to understand the efficacy of action, they successfully integrate social cues to use the most informative combination of cues to guide their causal actions.

Recognizing causal relations between actions and effects is a critical part of learning about the world. Such knowledge enables children to explain and explore phenomena they observe and to use such information to navigate through their physical and social environment (see e.g., Gopnik & Wellman, 2012; Sobel & Legare, 2014). An important research question over the last 15 years has been how to describe the mechanisms by which children learn causal knowledge.

Associative learning accounts (e.g., Dickinson & Shanks, 1995), causal power theories (e.g., Cheng, 1997), constraint-based learning based on correlation matrices (e.g., Gopnik et al., 2004; Pearl, 2000) and rational models (e.g., Tenenbaum & Griffiths, 2001, 2003) have all been proposed to investigate children's causal learning. Notably, each of these accounts focuses primarily on evidence – on whether children observe efficacious or inefficacious events, and the causal inferences that can be made from such data. As the result, much is known about how young children use evidence to make causal inferences, whilst the question of how they evaluate evidence depending on the social context in which evidence is obtained remains less explored. A few investigations, however, demonstrated that preschool-aged children appreciate pedagogical contexts (cf. Csibra & Gergely, 2009) in which information is presented, and are sensitive to pedagogical statements made by teachers. They interpret the same data differently depending on pedagogical statements and such interpretations affect their exploration (e.g., Bonawitz et al., 2011; Butler & Markman, 2012) and learning (e.g., Buchsbaum, Gopnik, Griffiths, & Shafto, 2011; Sobel & Sommerville, 2009).

While preschoolers may have sophisticated causal reasoning abilities and combine statistical evidence with their own and others' knowledge states (see e.g., Kushnir, Wellman, & Gelman, 2008; Sobel & Kushnir, 2013), understanding causal action might be more

☆ This work was supported by the National Science Foundation (1223777 to DMS).
* Corresponding author at: CLPS Department, Box 1821, Brown University, Providence, RI 02912, United States.
E-mail address: Elena_Luchkina@brown.edu (E. Luchkina).

https://doi.org/10.1016/j.cogdev.2017.12.003
Received 19 May 2016; Received in revised form 28 November 2017; Accepted 14 December 2017

difficult for younger children (e.g., Bonawitz et al., 2010; Buchanan & Sobel, 2011; Nazzi & Gopnik, 2000; Sobel, Tenenbaum & Gopnik, 2004). In particular, it might be more challenging for younger children to evaluate causal evidence while simultaneously evaluating the social context in which the evidence is obtained. For example, Bonawitz et al. (2010) presented 2- and 4-year-olds with a sequence of events that suggested a causal relation between the motions of two blocks (one block would move on its own to collide with another; the contact between the blocks made a propeller spin). While both 2- and 4-year-old children made predictions about the regularity of those events when allowed to interact with the blocks, only the older group spontaneously intervened to replicate the causal effect. However, 2-year-olds did produce the same causal effect when an intentional agent made the blocks come into contact.

The effects reported by Bonawitz and colleagues suggest that children's capacity to translate the inferences they make from observing causal evidence into actions that replicate the demonstrated effects might be influenced by their ability to appreciate the intentionality of the demonstrated actions. It is also possible that because children to appreciate intentionality from toddlerhood (e.g., Carpenter, Akhtar & Tomasello, 1998; Meltzoff, 1995; Olineck & Poulin-Dubois, 2005), such cues might highlight the relevance of causal evidence for younger children.

The present study examines whether toddlers evaluate evidence differently, based on whether it was generated intentionally or accidentally. The effects of pedagogy, in which children recognize causal efficacy from certain types of actions over others, potentially require an understanding of efficacy to bootstrap the role of intention. Across three experiments, we examined how children integrated intentional cues with cues to object efficacy. Children observed the efficacy of objects in a novel causal system (a blicket detector, adapted from Gopnik & Sobel, 2000). In each experiment, on one trial, children were asked to activate the machine after seeing two objects placed on it (one made it activate and the other one did not). This allowed us to separate children into a group who appreciated the causal efficacy of others' intentional actions from a group who might not have appreciated this information. Our question was whether children in the first group would integrate the intentionality of the actions into account, specifically whether these children were more likely to generate intentional efficacious actions than those that were accidentally generated (Experiment 1), efficacious actions presented accidentally as opposed to intentional inefficacious actions (Experiment 2), or efficacious and inefficacious actions presented accidentally (Experiment 3).

1. Experiment 1

1.1. Method

1.1.1. Participants

Forty children between the ages of 24–35 months (24 girls, 16 boys, $M = 31.05$ months, $SD = 3.49$) were recruited at the local children's museum. Seven other children were tested, but not included in the final sample because they refused to follow the procedure ($n = 4$), became impatient and left to explore exhibits at the museum ($n = 1$), their parent answered one of the test questions for them ($n = 1$), or due to experimenter's error ($n = 1$). Most children were Caucasian and from middle to upper-middle class families; however, no indicators of SES were obtained.

1.1.2. Materials

The machine was 13cm × 20cm × 8 cm, made of black plastic with a green Lucite top. It activated green and played *Let Me Call You Sweetheart* continuously when certain blocks were placed on top of it. The machine worked via a remote control hidden from the child, which the experimenter used to control whether an object activated it. When a block was effective, the experimenter activated the machine as soon as the block made contact with it and turned it off as soon as the block was removed. This provided a strong impression that something about the block caused the machine to activate.

Four foam blocks from Verdes Textured Foam Blocks set – a blue/purple cylinder, a green/pink parallelepiped with an arch, a red/blue parallelepiped, and a green/pink half-cylinder (Fig. 2) – were used as stimuli, grouped into two pairs.

1.1.3. Procedure

All children were tested at a quiet room at the museum by a female experimenter with a parent/caregiver present. The child was seated at a table across from the experimenter. In some cases, a parent/caregiver sat at the table with their child in order to overcome the child's shyness. Adults were instructed to not interfere with the experimental procedure and not interact with their child during the experiment.

The experimenter first introduced the child to the blicket machine and explained that some toys make the machine light up and play music and some do not. Children were then given two trials in which they were asked to activate the machine based on observing the efficacy of novel objects. The first trial (the *efficacy* trial; see Fig. 1) involved two new objects – Blocks E and N (for efficacious and not efficacious). The experimenter place block E on the machine, which activated. After that, Block E was removed from the machine and placed into a transparent plastic container. Block N then was placed on top of the machine and had no effect. It was also removed from the machine and placed in the same location as block E. Both blocks were demonstrated on the machine intentionally. At test, children were given Blocks E and N and the machine and were asked to "make the machine go." The order in which Blocks E and N were demonstrated, their colors, and the spatial position of the two blocks on the table at test were counterbalanced. The machine only activated when children placed block E on top of it. The purpose of efficacy trial was to test children's understanding of causal efficacy and to separate the group that preferred to replicate the causal effect from the group that did not.

In the second trial (the *intentionality* trial; see Fig. 1), the experimenter showed the child two blocks, which we will label Blocks I