



Preverbal infants identify emotional reactions that are incongruent with goal outcomes



Amy E. Skerry*, Elizabeth S. Spelke

Department of Psychology, Harvard University, 33 Kirkland Street, Cambridge, MA 02138, United States

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ABSTRACT

Identifying the goal of another agent's action allows an observer to make inferences not only about the outcomes the agent will pursue in the future and the means to be deployed in a given context, but also about the emotional consequences of goal-related outcomes. While numerous studies have characterized the former abilities in infancy, expectations about emotions have gone relatively unexplored. Using a violation of expectation paradigm, we present infants with an agent who attains or fails to attain a demonstrated goal, and reacts with positive or negative affect. Across several studies, we find that infants' attention to a given emotional display differs depending on whether that reaction is congruent with the preceding goal outcome. Specifically, infants look longer at a negative emotional display when it follows a completed goal compared to when it follows a failed goal. The present results suggest that infants' goal representations support expectations not only about future actions but also about emotional reactions, and that infants in the first year of life can relate different emotional reactions to conditions that elicit them.

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1. Introduction

Success in a social environment depends on capacities to understand, anticipate, coordinate with, and learn from the behavior of others. Human adults readily solve these problems by relying on intuitive knowledge of other minds that specifies the causal relationships linking various mental states to each other, to events or conditions in the external environment, and to overt action (Wellman, 1990; Wellman & Gelman, 1992; Carey, 1985; Gopnik & Meltzoff, 1997). On this basis of this knowledge, a perceiver can recover goals and other mental states from observed behavior (Baker et al., 2009, 2011), and recruit these mental state representations for a range of inferences. For example, we rely on goals or intentions to socially evaluate other agents (e.g. Cushman, Young, &

Hauser, 2006; Young & Saxe, 2009), to interpret speech and other communicative acts (e.g. Goodman & Stuhlmüller, 2012; Smith, Goodman, & Frank, 2013), and to reason about an agent's emotional state in different contexts (e.g. Parkinson, 2007; Siemer & Reisenzein, 2007; Zaki, Bolger, & Ochsner, 2009).

The present research probes the development of this last set of inferences, specifically the ability to predict the emotional consequences of goal-related outcomes. Prior studies using verbal vignettes and pictorial scenarios suggest that young children can identify how a target will feel in response to a particular event (Wellman & Wooley, 1990): by 2–3 years of age, children reason about emotions as well as desires and preferences, inferring others' emotional states in the absence of overt reactions (e.g. Russell, 1990; Wellman & Banerjee, 1991; Wellman & Bartsch, 1988; Yuill, 1984; for related findings with younger children, see Chiarella & Poulin-Dubois, 2013; Vaish, Carpenter, & Tomasello, 2009). To investigate the origins of this knowledge, the present research examines whether basic emotion inferences might be evident in preverbal infants.

* Corresponding author. Address: William James Hall, c/o Psychology Department, 33 Kirkland Street, Cambridge, MA 02138, United States. Tel.: +1 508 934 6457.

E-mail addresses: amy.skerry@gmail.com (A.E. Skerry), spelke@wjh.harvard.edu (E.S. Spelke).

By midway through first year of life, humans attend to the intentional movements of others and appear to encode goal-relevant properties of these movements, such as the objects to which they are directed, over more superficial properties, such as their trajectories (Gergely, Nádasdy, Csibra, & Bíró, 1995; Woodward, 1998). On the basis of observed actions, infants form expectations both about the outcome of future actions (Bíró & Leslie, 2007; Csibra, Bíró, Koós, & Gergely, 2003; Jovanovic et al., 2007; Woodward, 1998) and about the means that will be exploited under different physical constraints (Gergely et al., 1995; Kamewari, Kato, Kanda, Ishiguro, & Hiraki, 2005; Phillips & Wellman, 2005). One interpretation of these and other findings (e.g. Kovács, Téglás, & Endress, 2010; Luo & Baillargeon, 2005; Luo & Johnson, 2009) is that infants exploit abstract principles to make sense of the movements of others, integrating several relevant variables (outcomes, paths, physical obstacles and barriers to perception) to identify an agent's goal and anticipate future behavior. On this view, early representations of goal-directed behavior are embedded in a coherent inferential framework for predicting and explaining action (Bíró, Verschoor, & Coenen, 2011; Carey, 2009; Luo & Baillargeon, 2010).

Others have avoided appeal to abstract inferential principles, explaining these phenomena in terms of domain-general associative or statistical learning mechanisms operating over sensory or motoric representations (e.g. Paulus, 2012; Paulus et al., 2011; Rakison, Cicchino, & Hahn, 2007). In fact, some have argued that infants could exhibit expectations about the path of an action in these experiments without having any representation of the action as goal-directed (Paulus et al., 2011). Moreover, even among theories that grant abstract goal knowledge to infants, early accounts posited a relatively limited inferential mechanism; Gergely, Csibra and colleagues, for example, proposed that infants represent actions by assuming a *teleological stance*, analyzing the path an entity takes, the outcomes it achieves, and the physical constraints of the environment, in accord with an assumption that actions are efficient with respect to goals (Gergely & Csibra, 2003; Gergely et al., 1995). This mechanism, at least as initially described, would operate over observable variables to form an abstract action representation, but would not posit subjective epistemic states, or other internal psychological states such as emotions.

One way to distinguish between these possibilities is to examine the range of inferences supported by early goal-representations. Upon observing a goal-directed action, are infants' predictions limited to the path a subsequent action will take and the end state it will achieve, or do infants form a broader set of expectations? In particular, the present research explores whether preverbal infants have expectations about the affective states that are likely to result from different goal outcomes. Despite decades of research on infants' abilities to process and interpret emotional displays (e.g. Field et al., 1983; Grossmann, 2010; Moses, Baldwin, Rosicky, & Tidball, 2001; Nelson, 1987; Walker-Andrews, 1997), there is little evidence to date that infants have knowledge of the eliciting conditions for different emotions. In fact, several findings

suggest that young infants might fail to understand the relations between goals and emotions.

First, Repacholi and Gopnik (1997) found that whereas 18-month-old toddlers could use an agent's positive emotional expression towards a food item to guide their sharing behavior (see also Egyed, Király, & Gergely, 2013), 14-month-olds ignored the target's expressed emotion and provided her with the item they themselves preferred. However, this failure could have resulted from conflict between the partner's preference and the child's own preference, which must be suppressed in order to help according to the partner's desire. To eliminate these demands, Vaish and Woodward (2010) used a looking time paradigm investigating whether infants this age could use an agent's emotional expression to predict her subsequent action. Specifically, infants viewed an agent direct attention and emotion towards one of two objects, and then reach either towards the attended or unattended object. Fourteen-month-old infants looked longer when the agent reached towards the unattended object, regardless of whether her expressed emotion had been positive or negative. The authors interpret this pattern as evidence that infants did not understand the relation between emotion and goal-directed action. Because emotion cues conflicted with attentional cues, however, it is possible that infants failed to use emotional information because another salient and relevant cue was provided. Infants might nevertheless represent the relations between emotions and goals by this age, and exhibit such understanding in contexts that eliminate these competing demands.

Thus, despite the abundance of research on action understanding in infancy, additional research is needed to characterize the full scope of early goal knowledge, and the trajectory of developmental change in these abilities. In the present studies, we begin to fill this gap by investigating whether preverbal infants form expectations about emotional reactions to goal-relevant outcomes. If infants can represent the affective consequences of achieving or failing to achieve a goal, they should be sensitive to whether an agent's emotional reaction is consistent with an observed outcome. We were particularly interested in infants between 8 and 10 months of age, given conflicting reports of change and continuity in social cognitive abilities through this range (see Beier & Spelke, 2012; Luo, 2010; Senju & Csibra, 2008; Tomasello, Carpenter, Call, Behne, & Moll, 2005; Woodward, 2003).

2. Experiment 1

In Experiment 1, we familiarized infants with events in which an agent pursued a goal (reaching a mat in a particular location) by repeatedly moving to that location, modifying its path based on the constraints of the environment. We then presented events in which the agent either successfully completed or failed to complete this goal, and exhibited an emotional response that was congruent or incongruent with the outcome. If infants link goal outcomes to emotional reactions, they should exhibit heightened attention to events in which there is a mismatch between the outcome and the target's affective response.

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