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Infants use contextual contingency to guide their interpretation of others' goal-directed behavior

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ABSTRACT

To examine the extent to which infants encode the context of a goal-directed action, nine-month-old infants were tested in three separate experiments using a visual habituation paradigm similar to that used by Woodward (1998). Experiment 1, necessary to support methodology used in subsequent experiments, demonstrated that infants can track the goals of others in a visual habituation paradigm even when a goal object changes position. Experiment 2 examined the capacity of infants to make context-dependant judgments regarding an actor's two goal-directed actions (i.e., that object A would be grasped when paired with B, and B would be grasped when paired with C). Experiment 3 examined whether infants encode these contextually contingent goals in a linear order (e.g., A > B > C). Infants are able to use contextual information to correctly encode the actions of others, yet no evidence was found for encoding this information in a linear order.

Perceiving the goals underlying a stream of action is a social cognitive skill that appears to develop within the first year of life (Gergely, Nádasdy, Csibra, & Biró, 1995; Woodward, 1998, 2005). Recognizing that the actions of others are in the service of specific goals is crucial to early word learning

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(Baldwin & Moses, 2001; Baldwin et al., 1996; Buresh & Woodward, 2007) and the social learning of tool use (Gerson & Woodward, 2012), and is likely a foundation of mature theory of mind (Aschersleben, Hofer, & Jovanovic, 2008; Wellman, Lopez-Duran, LaBounty, & Hamilton, 2008; Yamaguchi, Kuhlmeier, Wynn, & vanMarle, 2009). Indeed, recognizing the goal motivating another's actions provides a powerful aid for making predictions regarding future actions in similar contexts (Cannon & Woodward, 2012).

Infants' attribution of goals to others has been shown to survive slight changes in context, such as the movement of a goal object from one location to another. For instance, in Woodward's (1998) seminal study, infants viewed a stage on which two objects rested. On each trial, a hand reached from the side of the stage to grasp the same object from the pair. After the infant habituated to this event, the positions of the two objects were switched. Six-month-old infants looked reliably longer at test trials in which the hand reached to the new object in the same spatial location as it had reached previously than at trials in which the old object was grasped in its new location, indicating that they had formed a goal-related, rather than spatially-related, expectation regarding the hand's movements (Woodward, 1998).

In Woodward's study, both objects were available to the experimenter's grasp such that, even when the locations were switched, it was possible to make predictions about the experimenter's likely actions. Contexts can also change in terms of the availability of goal objects. Indeed, our goal-directed actions are often guided by the availability of options. For example, we might buy vanilla ice cream only when strawberry is sold out, thus flexibly changing our goals in a context-contingent fashion depending on which options are available to us.

Changes in availability of options can influence how infants encode the target of a goal-directed movement. If no alternative is available (i.e., only one object is present), infants tend not to show differences in looking time to a novel or familiar selection at test when two objects are present (Biro, Verschoor, & Coenen, 2011; Luo, 2011; Luo & Baillargeon, 2005). This may be so because a reach to a single object is lacking the cues that prompt infants to see it as a goal- directed action at all (Biro et al., 2011; Hernik & Southgate, 2012). Alternatively, infants see the action as goal directed but do not encode the features of the solitary target object (Kuhlmeier & Robson, 2012) or do not have a basis for reasoning about the actor's preference between test objects (Luo & Baillargeon, 2005). In either case, the availability of options appears to have an impact on how infants encode goal-directed reaching.

The present study examined whether infants can recognize and encode the contextual contingency influencing a person's goal-directed actions. Woodward's (1998) methodology was adapted for this purpose through the presentation of two object pairs (A&B and B&C) to infants on alternating trials during a habituation phase. Infants saw an experimenter make selections from these pairings (A chosen over B, B chosen over C), with the experimenter's selection of object B dependent on the identity of the accompanying object. In order to succeed at tracking the experimenter's goal within each pair, the infant would have to encode both the goal and the context in which the goal existed.

Of secondary interest is whether infants come to represent this contextually contingent selections in a linear fashion, such that A > B > C, a logical interpretation of the pairwise information provided them. To do this, we examined whether infants show evidence of transitive inference after observing the contextually contingent actions. In other words, after observing that A is grasped when A and B are paired (A > B), and that B is grasped when B and C are paired (B > C), will infants infer that A > C? Some form of transitive inference is thought to develop between four and five years, becoming more adult-like around the age of eight years (Breslow, 1981; Bryant & Trabasso, 1971; Goodwin & Johnson-Laird, 2008; Markovits, Dumas, & Malfait, 1995; Pears & Bryant, 1990; Sodian & Wimmer, 1987; Wright, 2001).

Past experiments have relied not only on an understanding of transitivity, but also on the ability to understand the problems posed verbally by the experimenter (Breslow, 1981; Markovits et al., 1995). Yet, it is clear that language is not a prerequisite for transitive inference, as this ability is observed in a variety of non-human animal species including mammals (Davis, 1992; Gillan, 1981; McGonigle & Chalmers, 1977; Treichler & Van Tilburg, 1996), birds (Bond, Kamil, & Balda, 2003; Von Fersen, Wynne, Delius, & Staddon, 1991; Weib, Kehmeier, & Schoegl, 2010), and fish (Grosenick, Clement, & Fernald, 2007). Infants have also been shown to possess some understanding of ordinality, the unchanging position of items in ordered sets (Brannon, 2002). Recently, Mou, Province, and Luo (2014)