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Infants Attribute Goals to Acts Produced by Human and Object Agents

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Abstract

A debate has been going as to whether infants' ability to represent acts in terms of goals is sensitive to motions performed by people only (the mirror neuron systems theory) or to a variety of cues through which infants apply the principle of rational action to both human and inanimate agents (the teleological stance theory). Solution to the above issue is timely and important (for notable examples, see Sommerville, Woodward and Needham, 2005 ; Biro and Leslie, 2006). Robotic scientists have begun to use such knowledge to design robots that mimic human biomechanical movements, to which infants are likely to attribute goals or intentions (Kamewari, Kato, Kanda, Ishiguro and Hiraki, 2005).

Using an eye tracking technique (Tobii 1750), the study reported here presents an attempt to evaluate the mirror neuron systems theory (Gallese, Fadiga, Fogassi and Rizzolatti, 1996; Gallese, Keysers and Rizzolatti, 2004) and the teleological stance theory (Gergely and Csibra, 2003; Gergely, Nádasdt, Csibra and Bíró, 1995). The key question is whether 12-month-old infants were as likely to predict the goal-state of an action performed by a human agent as by an object agent under contexts of goal selection.

Twelve-month-old infants (n = 13, data collection is still in progress) saw a video that consisted of a familiarization phase and a test phase. During familiarization, the child watched either a chain of beads move self-propelledly, reach one of two containers (one is doll-shaped and the other bear-shaped), and fall into the goal (object agent condition, OA) or a human hand generate the same event (human agent condition, HA). The action was repeated 8 times within each condition. The sequence in which the agent appeared on the left or right side of the screen was randomized and counterbalanced. As a result, the agent travelled along a long or short trajectory to reach the goal on half of the occasions in each condition, respectively. The object of the goal and its position were also counterbalanced (see Figure 1). After familiarization, the containers' positions were switched and infants saw two test events in which the agent selected either the old goal at new location or the new goal at old location (Woodward, 1998).

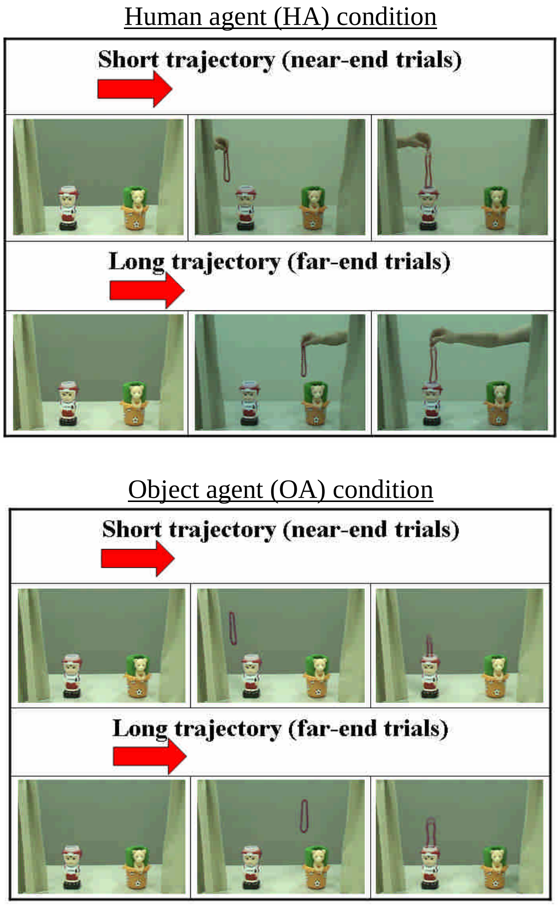

Figure 1. Experimental design : Familiarization

The preliminary results showed that during familiarization infants spent similar proportions of time looking at the goal and non-goal prior to movement initiation (M = 27% and M = 29% in the OA condition, respectively ; M = 25% and M = 28% in the HA condition, respectively). After infants first gave attention to the agent, the proportion of trials where their gaze arrived earlier than the agent at the goal was higher when the agent travelled along the long trajectory to the far-end container than when it travelled along the short trajectory to the near-end container, $F(1, 10) = 20.5$, $p = .001$. Conversely, the proportion of late arrival was higher during near-end trials than during far-end trials, F (1, 10) = 20.5, p = .001. These analyses revealed no condition difference. However, when considering the time lag between the gaze and agent's arrival at the goal, there was a trajectory × agent type interaction, F (1, 11) = 8.36, p = .015. Infants reliably fixated the goal ahead of the beads in the HA condition (p = .028) but not in the OA condition. It is important to note that following attention to the agent, they never first fixated the nongoal on near-end trials. Such an error, by contrast, was frequent on far-end trials (75% of trials, n = 3, and 55% of trials, n = 5, in the HA and OA conditions, respectively), where infants usually redirected their gaze to the goal (80% and 89% of errors in the HA and OA conditions, respectively). They also sometimes shifted their gaze to the agent and then to the goal (33% and 63% of errors in the HA and OA conditions, respectively). The results did not reveal that infants' gaze selection during test events was influenced by goal changes in either condition as contrasted with previous research. Their eye movement patterns were overall similar to those observed during familiarization.

The pattern of infants' gaze selection during familiarization appears to support the teleological stance view that goal attribution in infancy originates from a broad-based psychological framework relating to both people and objects, and that infants apply this framework to any agent that acts purposefully. However, the pattern of lag time was not entirely consistent with the above point of view. Instead, it showed that infants are quick to fixate the goal when observed acts are produced by a human hand. Whereas acts generated by both human and object agents induce infants' proactive eye movements, it seems that extrinsic cues such as the agent's initial position relative to the goal, end-point trajectory and relative size of the agent's area detract their eye movements in a goal-selection context. It is possible, for example, that the angle between the paths to each of two containers provides direction cues about agent motion that immediately directs infants' attention to the end point of the motion at the outset of the action. The end-point trajectory could explain why they did not look longer at the old goal in the new goal / old location event. Thus, while proactive eye movements have been interpreted as indication of an ability to predict action goals (Falck-Ytter, Gredebäck and Hofsten, 2006), we need to consider the operation of general attentional and perceptual processes in guiding eye movements in a complex context involving goal selection.

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