



RESPONSE

Theories, evidence and intuitions about infants' attributions of goals: a reply to commentaries by Bíró and Kuhlmeier & Robson and Luo & Choi

Mikolaj Hernik¹ and Victoria Southgate²

1. Cognitive Development Center, Central European University, Budapest, Hungary

2. Centre for Brain and Cognitive Development, Birkbeck, University of London, UK

This is a response to the commentaries on Hernik and Southgate (2012) by Biro (2012), Kuhlmeier and Robson (2012) and Luo and Choi (2012).

Both L&C and K&R reject our conclusion that an absence of a Woodward-effect in some single-object versions of the paradigm reflects a lack of goal-attribution. Both argue that, while infants would naturally interpret a direct approach to a solitary object (i.e. an action, which is lacking in cues to the goal, like efficiency and selectivity) as goal-directed, they may need these additional cues in order to generate the further expectation required for the Woodward-effect: that an agent will persevere in acting on the same target. Thus, the point of contention is whether these cues primarily facilitate goal-attribution, or rather the expectation of perseverance.

Neither K&R nor L&C provide any independent evidence that efficiency can serve as a cue to continued action on the same object. L&C propose that the presence of cues like efficiency are interpreted by infants as indicating that the agent is going to a lot of 'trouble' to approach its target, which leads infants to attribute a positive disposition towards the target, which in turn suggests that the agent will approach it again. However L&C do not explain how effort can be extracted from efficiency and why inefficient approaches, with the same timing and path as the efficient ones, are nevertheless not interpreted as effortful. Furthermore, since L&C contend that cues to efficiency were present in Luo and Baillargeon's (2005) one-object condition, it is unclear why that one-object approach did not also lead the infant to attribute a 'positive disposition towards the target that was strong enough to endure the addition of a new choice'. While there is no evidence that efficiency leads to such positive disposition attributions, there is evidence that efficiency serves as a cue to the goal, even when expectation of another action on the same object is *not* required: e.g. infants expect that an efficiently-behaving agent will make contact with a target-object even if they have never seen this outcome (Southgate & Csibra, 2009; Wagner & Carey, 2005). These data suggest that effi-

ciency serves as a cue to the goal, rather than to the agent's perseverance.

L&C further claim that we have failed to appreciate the role of agent identification in goal-attribution. They cite a theoretical paper (Leslie, 1995) in support of their claim that, once an agent has been identified, infants would assume its actions are goal-directed. Contrary to L&C's claim, many studies have shown that agent identification is insufficient for goal-attribution (e.g. Woodward, 1999). Even if the agent is a human, goal-attribution depends on available cues (Kamewari, Kato, Kanda, Ishiguro & Hiraki, 2005; Király, Jovanovic, Prinz, Aschersleben & Gergely, 2003) or on familiarity with the particular action (Southgate, Johnson, Karoui & Csibra, 2010). The fact that human actions are not automatically interpreted as goal-directed in the absence of additional cues should give us reason to question whether infants would represent the goal of a self-propelled box-agent's direct approach to a solitary object (Luo & Baillargeon, 2005) when it is lacking any known cues to goal-directedness.

We agree to a large extent with Bíró's comment, but we find the notion of 'means selection' potentially misleading and believe that its relations to action efficiency, variability and adjustment to change of constraints as well as its role in goal-attribution require further clarification. After all, when an agent is *selectively* engaged in *inefficient* means-actions (e.g. Hernik & Southgate, 2012, Experiment 2), infants do not evidence goal-attribution. Furthermore, adjustment of efficient action to varying situational constraints is not necessary for goal-attribution (Kamewari *et al.*, 2005, Sodian, Schoeppner & Metz, 2004) and when action variability does facilitate goal-attribution, it doesn't necessarily highlight a selection of a particular means-action (Csibra, 2008).

In sum, while as adults we share both K&R's and L&C's commentators' intuition that a direct approach to

a solitary object is likely to be goal-directed, our conclusions about infants are based on empirical data, not intuition. The Woodward-effect in one-object tasks depends on the presence of cues to the goal, rather than on knowledge of the agent's preferences. Insofar as the Woodward-effect *is* what we, as researchers, deem evidence of goal-attribution, our conclusion, however unintuitive, follows. However, K&R are right to raise the issue of whether reliance on one particular paradigm is wise, and we believe it is now time to develop alternative tools to test our conclusions. With the advent of new brain imaging techniques suitable for use with infants, one possible way of doing this might be to ask whether infants recruit brain regions involved in goal-attribution (Hamilton & Grafton, 2006) in the absence of these additional cues.

References

- Csibra, G. (2008). Goal attribution to inanimate agents by 6.5-month-old infants. *Cognition*, **107**, 705–717.
- Hamilton, A., & Grafton, S.T. (2006). Goal representations in human anterior intraparietal sulcus. *Journal of Neuroscience*, **25**, 1133–1137.
- Kamewari, K., Kato, M., Kanda, T., Ishiguro, H., & Hiraki, K. (2005). Six-and-a-half-month-old children positively attribute goals to human action and to humanoid-robot motion. *Cognitive Development*, **20**, 303–320.
- Király, I., Jovanovic, B., Prinz, W., Aschersleben, G., & Gergely, G. (2003). The early origins of goal attribution in infancy. *Consciousness and Cognition*, **12**, 752–769.
- Leslie, A.M. (1995). A theory of agency. In D. Sperber, D. Premack & A.J. Premack (Eds.), *Causal cognition: A multidisciplinary debate* (pp. 121–149). Oxford: Oxford University Press.
- Luo, Y., & Baillargeon, R. (2005). Can a self-propelled box have a goal? Psychological reasoning in 5-month-old infants. *Psychological Science*, **16**, 601–608.
- Sodian, B., Schoeppner, B., & Metz, U. (2004). Do infants apply the principle of rational action to human agents? *Infant Behavior and Development*, **27**, 31–41.
- Southgate, V., & Csibra, G. (2009). Inferring the outcome of an ongoing novel action at 13 months. *Developmental Psychology*, **45**, 1794–1798.
- Southgate, V., Johnson, M.H., Karoui, I.E., & Csibra, G. (2010). Motor system activation reveals infants' on-line prediction of others' goals. *Psychological Science*, **21**, 355–359.
- Wagner, L., & Carey, S. (2005). 12-month-old infants represent probable ending of motion events. *Infancy*, **7**, 73–83.
- Woodward, A.L. (1999). Infants' ability to distinguish between purposeful and non-purposeful behaviors. *Infant Behavior and Development*, **22**, 145–160.