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Children's predictions and recognition of fall: The role of object mass

Michael Hast*, Christine Howe

Faculty of Education, University of Cambridge, 184 Hills Road, Cambridge CB2 8PQ, United Kingdom

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ABSTRACT

A small but growing body of evidence suggests that alongside misconceptions in predictions about object motion, adults and children hold relevant underlying conceptions, reflected in recognition, which provide greater understanding of such events. However, the relationship between knowledge retrieved in predictions and in recognition is unclear. One significant element contributing to misconceptions about motion is object mass. This aspect was used to provide further insight into the knowledge relationship. Predictions and recognition of fall in 5–11-year-old children ($N = 121$) were addressed in the present study. The results suggest that children's recognition of object motion is far better than their expressed anticipation of such events, as they normally recognised correct events as correct and rejected incorrect ones yet predictions were typically in error. Response time data provide additional insight. The findings are discussed in relation to different models of knowledge representations, favouring a hybrid model.

1. Introduction

From a young age children hold extensive but largely erroneous beliefs about the physical world, beliefs which they construct on the basis of personal experiences (Klaassen, 2005). A myriad of studies is available (see Duit, 2009 for a comprehensive list), documenting the wide range of misconceptions present in childhood. Among these are beliefs about dynamic events involving objects, a particularly ubiquitous element of the physical world (Planinic, Boone, Krsnik, & Beilfuss, 2006). These beliefs are not isolated ideas but conceptual structures that can be called upon in reasoning and that, despite their limitations, provide a coherent framework for understanding the world. A prominent view is that we hold innate core knowledge about the physical world that is enhanced over time (e.g. Baillargeon & Carey, 2012 but also see e.g. Hood & Santos, 2009, for a wider discussion around the origins of such knowledge).

Accessing relevant conceptual knowledge structures in motion prediction tasks that are coupled with explicit explanations – such as planning motion trajectories or deciding the location of an object following an anticipated path – necessitates deliberation, reflection, and a conscious understanding of rules or decisions (Hogarth, 2001; Plessner & Czenna, 2008): an explicit engagement with the structures is required. At the same time, a small but growing field of research suggests infants (Friedman, 2002; Kannass, Oakes, & Wiese, 1999; Kim & Spelke, 1992), children (Howe, Taylor Tavares, & Devine, 2012; Howe, Taylor Tavares, & Devine, 2014; Kim & Spelke, 1999) and adults (Kaiser & Proffitt, 1984; Kaiser, Proffitt, Whelan, & Hecht, 1992; Naimi, 2011; Shanon, 1976) are able to recognise dynamic trajectories that are physically correct and to reject

* Corresponding author at: St Mary's University Twickenham, Waldegrave Road, Twickenham TW1 4SX, United Kingdom.
E-mail address: michael.hast@stmarys.ac.uk (M. Hast).

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trajectories that appear unnatural to them, even if they are more likely to predict the unnatural events beforehand. Such recognition tasks may merely need to engage underlying tacit knowledge structures (Collins, 2010)—structures set to provide quick responses without conscious awareness, by eliciting feelings of familiarity with events. Although there is some indication that very young children engage in predictive anticipation when evaluating outcomes of dynamic events (e.g. Lee & Kuhlmeier, 2013) it is debatable whether these anticipations can be seen as *explicit* predictions since these children eventually chose an incorrect response – likely through some process of reflection and deliberation – despite very initially displaying accurate looking, which may be accounted for by quick responses without conscious awareness.

Currently, there are at least three divergent views on the relationship between these two manifestations of knowledge. Firstly, explicit understanding is perceived to be a partial version of tacit knowledge whereby the two exist within a single system (Kim, 2012; Kim & Spelke, 1999; Spelke & Hespos, 2001). Specifically, in the process of elevating tacit conceptions to the explicit level, elements are omitted, causing differences in outcomes between tasks relying on different knowledge. According to the second view, on the other hand, explicit and tacit knowledge are two mutually exclusive coexisting systems, seemingly unaffected by each other (Hogarth, 2001; Plessner & Czenna, 2008). Depending on task requirements only one of the systems is accessed. The more recent third view rejects omission and separation, and proposes a hybrid model in which there are two, partially associated knowledge systems wherein explicit knowledge is, in part, an embellishment of knowledge held at the tacit level (Carey, 2009; Howe, 2014; Howe et al., 2012, 2014). There is to date no clear evidence favouring just one of these views—a shortcoming addressed by the present research.

Object mass, being one of the most fundamental concepts of the physical world (Galili, 2001), may help shed light on this matter. It is a concept that appears to be in place early in development; the general ability to distinguish between heavy and light emerges within the first year of life (Hauf & Paulus, 2011; Hauf, Paulus, & Baillargeon, 2012; Molina, Guimpel, & Jouen, 2006; Molina & Jouen, 2003; Paulus & Hauf, 2011). Furthermore, this particular concept plays a key role in the development of commonsense theories of motion, as children rely upon mass to explain their predictions of fall—many children hold the persistent belief that one object will fall faster than another because the first is heavier than the second (Baker, Murray, & Hood, 2009; Chinn & Malhotra, 2002; Hast & Howe, 2012, 2013a; Nachtigall, 1982; Sequeira & Leite, 1991; van Hise, 1988). Given the ubiquity of dynamic events, as well as the early developing understanding of the concept of mass, that inform everyday experiences, these limitations in understanding of object motion might seem surprising.

The importance of object mass in the current context therefore lies with the fact that it has, in actuality, little effect on motion patterns – two balls of same size but different mass will move at almost identical speeds – thereby becoming irrelevant to recognition tasks. An ability to recognise events as correct where objects move at the same speeds would suggest that recognition is not susceptible to interference from object mass concepts. This in turn would imply that predictive beliefs are a result of independently existing structures or of embellishment of underlying conceptions rather than omission. Research with adults suggests that expectations specifically relate to mass – a heavy ball is expected to fall faster than a light ball – but acceptance of such motion patterns as correct is much lower, with a tendency towards a more accurate representation of object motion (Naimi, 2011). Children also expect items to fall faster than others because they are heavier—but can similar mass-based differences between prediction and recognition be observed during childhood?

Three hypotheses can be stated to address each of the three divergent views outlined above. In all three cases, based on the literature, the anticipated outcome is that children will *predict* (P) the heavy ball (H) to be faster, with next to no light-faster (L) or same-speed (S) predictions ($P = \mathrm{H} > \mathrm{L} = \mathrm{S}$). The omission view would envisage a *recognition* (R) task outcome where factors in addition to mass are being taken into account. If other object variables such as size and shape are controlled for this should lead to a similar outcome as in predictions since mass would continue to be a part of the process ($R = \mathrm{H} > \mathrm{L} = \mathrm{S}$). On the other hand, under the proviso that underlying knowledge is highly accurate, the separate systems view would dictate a distinct set of recognition task findings. Same-speed trials would be uniquely recognised as being correct; heavy-faster and light-faster trials would be rejected in equal manner ($R = \mathrm{S} > \mathrm{H} = \mathrm{L}$). Finally, if knowledge representations exist within a hybrid model high success rates on same-speed trial recognition should be anticipated but, in line with predictions, also some heavy-faster trial recognition that significantly exceeds that of light-faster trials ($R = \mathrm{S} > \mathrm{H} > \mathrm{L}$). The study described below was therefore an attempt to assess children's recognition of dynamic events, with motion either adhering to physical laws or contravening them, by placing particular emphasis on the role that object mass plays in such events.

2. Method

2.1. Participants

Participants were recruited from a state primary school located in a suburban area of Cambridge, UK. The sample was drawn from those children whose parents did not object to their participation, and who, when they were non-native speakers of English, were identified by class teachers as capable of understanding the research instructions. This amounted to 121 children (66 girls), including 23 Year 1 children (12 girls; age $M = 6.15$ years, $SD = 0.40$), 31 Year 2 children (18 girls; age $M = 7.12$ years, $SD = 0.34$), 33 Year 4 children (19 girls; age $M = 9.12$ years, $SD = 0.37$) and 34 Year 6 children (17 girls; age $M = 11.17$ years, $SD = 0.44$). An additional nine children participated but were not considered for data analysis due to insufficient completion of practice trials, not completing both tasks, or due to technical errors.