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Everyday conceptions of object fall: Explicit and tacit understanding during middle childhood

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ABSTRACT

Adults make erroneous predictions about object fall despite recognizing when observed displays are correct or incorrect. Prediction requires explicit engagement with conceptual knowledge, whereas recognition can be achieved through tacit processing. Therefore, it has been suggested that the greater challenge imposed by explicit engagement leads to elements of conceptual understanding being omitted from prediction that are included in recognition. Acknowledging that research with children provides a significant context for exploring this "omission hypothesis" further, this article reports two studies with 6- to 10-year-olds, each of which used prediction and recognition tasks. Study 1 ($N = 137$) focused on understanding of direction of fall, and Study 2 ($N = 133$) addressed speed. Although performance on the recognition tasks was generally superior to performance on the prediction tasks, qualitative differences also emerged. These differences argue against interpreting explicit level understanding purely in terms of omission of tacit constructs, and the article outlines alternative models that may account for the data.

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Introduction

Although philosophers and natural scientists have discussed the physics of object fall for centuries, psychological work on the topic only began during the 1980s, when research with undergraduates produced two important sets of results. The first set (e.g., McCloskey, 1983; Whitaker, 1983) covers the direction in which objects are predicted to travel when they fall after moving horizontally, as when balls roll over cliffs or litter is dropped from moving vehicles. The main message is that moving objects are predicted to fall vertically, travel backward, fall diagonally forward, or continue

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horizontally in space (due to an impetus-like force) before making a 90° turn and falling. However, they are seldom predicted to trace the parabolic paths in a forward direction that they actually follow. The second set of results relates to the speed with which objects are expected to fall, emphasizing fall from rest (e.g., Champagne, Klopfer, & Anderson, 1980; Gunstone & White, 1981) but occasionally considering fall after horizontal motion (e.g., Maloney, 1988; Whitaker, 1983). One message is that when objects vary only in mass, heavy items are typically predicted to fall faster than light items, not travel at speeds that, even taking air resistance into account, are actually almost identical. Another is that, regardless of mass, objects are expected to reach maximum velocity quickly and then fall with constant velocity.

Nevertheless, in marked contrast to these prediction errors, undergraduates have proved successful at differentiating anomalous fall from veridical fall. For example, Kaiser, Proffitt, Whelan, and Hecht (1992) found that when undergraduates viewed computer-simulated kegs falling from aircraft, they consistently judged forward parabolas as correct and other trajectories as incorrect. Yet the trajectories they drew in prediction displayed all of the errors listed above. When Shanon (1976) presented videotapes of balls falling with constant or accelerating velocity, he found constant velocity to be consistently judged as incorrect, whereas acceleration was regarded as correct. Yet on a prediction task, many students anticipated constant velocity. This gap between recognition and prediction has been widely construed in terms of relative explicitness (e.g., Karmiloff-Smith, 1992; Kim & Spelke, 1999). Prediction requires explicit engagement with conceptual knowledge; that is, scenarios must be related to underlying conceptions and relations must be considered and used to draw inferences. In other words, there is "deliberation" (Hogarth, 2001) and "reflection" (Plessner & Czenna, 2008). By contrast, recognition of veridicality demands only that scenarios be matched with conceptions. Matching does not necessitate consideration and inference, so in principle nonreflective, perhaps unconscious, processing suffices. Kim and Spelke (1999) and Hogarth (2001) referred to this form of processing as "tacit."

Noting the additional steps (and hence greater challenge) associated with explicit engagement, Kim and Spelke (1999) proposed that the gap between prediction and recognition may result from omission at the explicit level of elements that are tacitly appreciated. This "omission hypothesis" concurs with much of the above research given that much could be interpreted as discounting forward velocity when predicting direction or considering one moment (rather than comparing across time) when predicting speed. Moreover, in addition to providing a straightforward account of task performance, the hypothesis also suggests a plausible model of conceptual development: Notions of object fall that initially are only grasped tacitly gradually become accessible at the explicit level (see also Karmiloff-Smith, 1992). Yet despite these appealing features, the omission hypothesis can be questioned. Addressing number (not motion), Carey (2009) identified conceptions that are accessed at the explicit level that cannot be partial versions of tacit knowledge. Moreover, when students recognize forward parabolas as correct after horizontal motion, it is difficult to regard the impetus-like forces and backward trajectories (which, as noted, they sometimes predict) as explicit-level omissions of what is tacitly understood. On the face of it, they introduce something new rather than omit what exists. Yet their status is unclear given that they could, in principle, reflect tacit conceptions from some earlier stage. Just because undergraduates recognize the veridicality of forward parabolas does not necessarily mean that children do this as well. Perhaps there is a period when children judge impetus-laden or backward trajectories as correct, and this exerts residual influence when they engage explicitly.

Acknowledging the omission hypothesis's attractive yet uncertain status, we report two studies that compare performance on tasks that require and do not require explicit engagement with conceptions about object fall. The studies' primary aim was to establish whether errors on the former tasks could be interpreted as omission at the explicit level of what is tacitly understood. In the interest of obtaining comprehensive information about object fall, one study addressed direction and the other addressed speed. Noting the developmental significance of the issue together with potential ambiguities in research with adults, the studies were conducted with children.

Children's understanding of object fall

Although research into children's understanding of object fall has been conducted, it focuses on tasks that require reflection and inference and, therefore, explicit engagement with conceptual

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