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Brief Report

It's all relative: The role of object weight in toddlers' gravity bias

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ABSTRACT

Work over the past 20 years has demonstrated a gravity bias in toddlers; when an object is dropped into a curved tube, they will frequently search at a point immediately beneath the entry of the tube rather than in the object's actual location. The current study tested 2- to 3½-year-olds' ($N = 88$) gravity bias under consideration of object weight. They were tested with either a heavy or light ball, and they had information about either one of the balls only or both balls. Evaluating their first search behavior showed that participants generally displayed the same age trends as other studies had demonstrated, with older toddlers passing more advanced task levels by being able to locate objects in the correct location. Object weight appeared to have no particular impact on the direction of these trends. However, where weight was accessible as relative information, toddlers were younger at passing levels and older at failing levels, although significantly so only from around 3 years of age onward. When they failed levels, toddlers made significantly more gravity errors with the heavy ball when they had information about both balls and made more correct choices with the light ball. As a whole, the findings suggest that nonvisual object variables, such as weight, affect young children's search behaviors in the gravity task, but only if these variables are presented in relation to other objects. This relational information has the potential to enhance or diminish the gravity bias.

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Introduction

Between 2 and 4 years of age, toddlers exhibit a so-called gravity bias in their motoric search behaviors (Hood, 1995, 1998; Hood, Carey, & Prasada, 2000; Hood, Wilson, & Dyson, 2006; Jaswal et al., 2014; Lee & Kuhlmeier, 2013). When an object is dropped into a curved tube, toddlers frequently navigate their manual search toward a location directly beneath the point at which the object has been dropped, rather than toward the actual location to which the curved tube has transported the object. In doing so, they demonstrate a tendency to prefer a location aligned with the direction of gravitational attraction. Various other studies have gone on to demonstrate that this gravity bias can be influenced by providing additional information through testimony, music, or specific visualization strategies (Bascandziev & Harris, 2010; Bascandziev, Powell, Harris, & Carey, 2016; Iulianetti, 2016; Joh, Jaswal, & Keen, 2011) or through apparatus manipulations (Bascandziev & Harris, 2011; Huang & Lin, 2015; Joh & Spivey, 2012). However, no studies appear to examine the role of the objects involved and whether manipulations of object variables, such as their shape, size, and weight, have any impact on the gravity bias. The current study aimed to address this.

A number of studies have been able to demonstrate that by the end of their first year, infants are able to use relational information about objects in a range of situations. For example, they are able to draw conclusions about how objects would be affected in different ways due to their relative size. Infants appear to understand when an item is too big for a container even though a smaller item fit (Aguiar & Baillargeon, 2003; Hespos & Baillargeon, 2001; Wang & Baillargeon, 2008). They seem to understand that when a medium-sized ball can cause another ball to roll a certain distance following collision, a bigger ball should cause the same ball to roll farther, but a smaller ball should cause it to roll a shorter distance (Kotovsky & Baillargeon, 1998; Wang, Kaufman, & Baillargeon, 2003). Infants even expect physical size to contribute to events underpinned by social dominance (Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011).

However, object size is a variable that can be perceived through visual means and does not require an explicit manual engagement with the objects. What about nonvisual variables? Young children use a range of visual and nonvisual variables in their reasoning about dynamic events, including size (Hast & Howe, 2012), but weight appears to be a far more prominent one. Repeatedly, studies have demonstrated that during middle childhood children reason about downward motion—either falling or moving down an incline—by directly drawing on the *relative* heaviness or lightness of objects (Chinn & Malhotra, 2002; Hast, 2016; Hast & Howe, 2015, 2017; Nachtigall, 1982; Sequeira & Leite, 1991; van Hise, 1988). So by around 4 or 5 years of age, weight certainly matters. However, it appears to matter in a way that misaligns children's conceptions from accepted scientific views about downward motion, frequently interfering with instruction at the formal education level—a challenge stemming from the deep entrenchment of such ideas (see, e.g., Duit, Treagust, & Widodo, 2013).

But when does this involvement of weight in understanding motion events begin? Even within their first year, infants seem to at least rudimentarily appreciate object weight differences (Gottwald & Gredebäck, 2015; Hauf & Paulus, 2011; Hauf, Paulus, & Baillargeon, 2012; Molina, Guimpel, & Jouen, 2006; Molina & Jouen, 2003; Paulus & Hauf, 2011), so an understanding of weight as a concept appears early in development. Does it interfere with behavior in tasks such as the one typically resulting in a gravity bias? If so, when does it do this, and might this indicate a starting point for the misalignment noted above? To examine this, the current study evaluated children who should already understand relative weight but who are younger than those who are known to show weight-related conceptions that deviate from scientific conceptions. Because this approximate age range of 1–4 years coincides with the gravity bias, it was seen as a useful task to explore this issue by examining at what age different levels of task difficulty are failed or passed and how the proportion of gravity-related search errors changes.

Three hypotheses were formulated around the potential impact of object weight and relational versus nonrelational object information on the age at which toddlers can correctly predict the results of different configurations of the tubes in the gravity task. First, if weight alone matters, then search errors and age would be affected by object weight, regardless of whether objects are presented alone or in relation to one another. Second, if simply having access to two objects matters regardless of any