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Object processing in visual perception and action in children and adults

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ABSTRACT

We investigated whether 6- and 7-year-olds and 9- and 10-year-olds, as well as adults, process object dimensions independent of or in interaction with one another in a perception and action task by adapting Ganel and Goodale's method for testing adults (*Nature*, 2003, Vol. 426, pp. 664–667). In addition, we aimed to confirm Ganel and Goodale's results in adults to reliably compare their processing strategies with those of children. Specifically, we tested the abilities of children and adults to perceptually classify (perception task) or grasp (action task) the width of a rectangular object while ignoring its length. We found that adults process object dimensions in interaction with one another in visual perception but independent of each other in action, thereby replicating Ganel and Goodale's results. Children processed object dimensions interactively in visual perception, and there was also some evidence for interactive processing in action. Possible reasons for these differences in object processing between children and adults are discussed.

Introduction

As soon as children are born, they must deal with the complexity of the visual world. For example, several dimensions such as size, color, texture, and shape typically characterize each object in our daily environment. Children must process this complexity both to visually identify these objects and to interact with them. Therefore, the ways in which children process diverse object dimensions to

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perceive and act on them is a question of interest. A study by Ganel and Goodale (2003) suggested that adults process multidimensional objects differently in visual perception than in action. When acting on an object, adults tend to process object dimensions independent of each other (independent processing strategy). Conversely, when viewing an object, they process an object's dimensions in relationship to each other (interactive processing strategy).

Some studies have suggested that children, in contrast, use an interactive processing strategy in both visual perception and action (Duemmler, Franz, Jovanovic, & Schwarzer, 2008; Gentilucci, Benuzzi, Bertolani, & Gangitano, 2001; Hanisch, Konczak, & Dohle, 2001), although the results of these child studies are ambiguous. Furthermore, these studies did not examine whether different dimensions of the same object are processed interactively as in Ganel and Goodale's (2003) study; rather, they focused on whether context information influences object processing. Accordingly, the question arises as to whether the differing findings in children and adults reflect developmental differences in object processing or whether they result from the use of different stimuli and tasks. Therefore, we adapted Ganel and Goodale's method for a younger age group and examined whether children process object dimensions independently or interactively in both visual perception and action. First, however, we sought to confirm Ganel and Goodale's findings in adults to obtain directly comparable data.

Ganel and Goodale (2003) demonstrated that adults process an object's dimensions in interaction with one another in visual perception but independent of each other in action. They tested adults using Garner's speeded classification task (1974, 1978). This task is frequently used in the literature to measure how efficiently people process one object dimension (i.e., the task-relevant dimension) while ignoring another dimension of the same object (i.e., the task-irrelevant dimension) (e.g., Kunde, Landgraf, Paelecke, & Kiesel, 2007; Lederman, Klatzky, & Reed, 1993). Ganel and Goodale (2003) used four rectangular objects as stimuli. Participants classified (perception task) and grasped (action task) the objects as quickly as possible while attending to the object's width (task-relevant dimension: narrow or wide) and ignoring its length (task-irrelevant dimension: short or long). These authors found that adults' reaction times in the perception task increased during a "filtering" condition in which both the task-relevant and task-irrelevant dimensions varied compared with a "baseline" condition in which only the task-relevant dimension varied. This result indicates that the variation of the task-irrelevant dimension affected the processing of the task-relevant dimension; that is, adults processed both length and width in interaction with each other. Conversely, adults' grasping reaction times (i.e., the time to begin the movement, the time to reach maximum grip aperture [MGA], and the time to complete the movement) and their MGAs (i.e., the maximum opening of the thumb and index finger over the course of the movement) were not influenced when both object dimensions varied in the action task. Ganel and Goodale interpreted these results as evidence that adults processed the task-relevant dimension without being affected by the task-irrelevant dimension in action.

In addition to these measures of perception and action, Ganel and Goodale (2003) conducted another task (i.e., manual estimation task) in which participants estimated the object widths using their index finger and thumb. Ganel and Goodale assumed that the manual estimation task also measures object perception and implemented it to reduce the memory demands of the above-mentioned perception task. They found that participants processed both length and width in interaction with each other like in the perception task.

Besides Ganel and Goodale (2003), other studies on the effects of visual illusions suggest that adults process only task-relevant object information in action but process all available information in visual perception (Aglioti, DeSouza, & Goodale, 1995; Bridgeman, Peery, & Anand, 1997; Dyde & Milner, 2002; Ganel, Tanzer, & Goodale, 2008; Haffenden, Schiff, & Goodale, 2001; Jackson & Shaw, 2000). Goodale and Milner (1992, Milner and Goodale, 1995, 2008) interpret these findings as evidence for a two visual systems model that assumes that the visual brain is divided into two anatomically and functionally distinct pathways for object processing; a ventral pathway for object processing in visual perception and a dorsal pathway for object processing in action. However, additional visual illusion research with adults (Dassonville, Bridgeman, Bala, Thiem, & Sampanes, 2004; Franz, 2001; Franz, Bülthoff, & Fahle, 2003; Franz & Gegenfurtner, 2008; Franz, Gegenfurtner, Bülthoff, & Fahle, 2000; Glover, 2002, 2004; Glover & Dixon, 2001), studies on neurological patients (Schenk, 2006), and even studies using the Ganel and Goodale paradigm (Janczyk, Franz, & Kunde, 2010) suggest that the degree to which these results can be interpreted as supporting a functional division of labor in dorsal and