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The Multidimensional Card Selection Task: A new way to measure concurrent cognitive flexibility in preschoolers

Gal Podjarny [a,*], Deepthi Kamawar [a,b], Katherine Andrews [c]

[a] Department of Psychology, Carleton University, Ottawa, Ontario K1S 5B6, Canada
[b] Institute of Cognitive Science, Carleton University, Ottawa, Ontario K1S 5B6, Canada
[c] Department of Educational and Counseling Psychology, McGill University, Montreal, Quebec H3A 1Y2, Canada

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ABSTRACT

Most executive function research examining preschoolers' cognitive flexibility, the ability to think about something in more than one way, has focused on preschoolers' facility for sequentially switching their attention from one dimension to another (e.g., sorting bivalent cards first by color and then by shape). We know very little about preschoolers' ability to coordinate more than one dimension simultaneously (*concurrent* cognitive flexibility). Here we report on a new task, the Multidimensional Card Selection Task, which was designed to measure children's ability to consider two dimensions, and then three dimensions, concurrently (e.g., shape and size, and then shape, size, and color). More than half of the preschoolers in our sample of 107 (50 3-year-olds and 57 4-year-olds) could coordinate three dimensions simultaneously and consistently across three test trials. Furthermore, performance on the Multidimensional Card Selection Task was related, but not identical, to performance on other cognitive tasks, including a widely used measure of switching cognitive flexibility (the Dimensional Change Card Sort). The Multidimensional Card Selection Task provides a new way to measure concurrent cognitive flexibility in preschoolers, and opens another avenue for exploring the emergence of early cognitive flexibility development.

* Corresponding author.
E-mail address: galpod@gmail.com (G. Podjarny).

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Introduction

To fulfill the simple request of retrieving a "red marker from the crafts box," a child needs to search for an item that both is a marker (among markers, crayons, and pencils) and is red (among the various colors). Focusing only on one of these dimensions is likely to lead to retrieving the wrong item (e.g., a red crayon, a green marker). To properly fulfill this request, the child must exercise his or her cognitive flexibility—the ability to think about something in more than one way (Jacques & Zelazo, 2005).

Cognitive flexibility emerges during the preschool years (e.g., Cragg & Chevalier, 2012; Doebel & Zelazo, 2013; Garon, Bryson, & Smith, 2008; Perner, Stummer, Sprung, & Doherty, 2002; Podjarny, Kamawar, & Andrews, in preparation) and relates to skills such as flexible problem solving (Deák, 2004; Siegler & Svetina, 2002), creativity (Diamond, 2006), and reasoning about others' mental states (i.e., theory of mind; Perner, Lang, & Kloo, 2002). Moreover, preschoolers with stronger cognitive flexibility skills perform better when they later enter school (Coldren, 2013; Masten et al., 2012) and tend to experience fewer academic problems (e.g., Bull & Scerif, 2001). Researchers often examine cognitive flexibility in the context of executive functions—processes that enable goal-directed behavior—including working memory (holding and manipulating information in mind) and inhibitory control (suppressing a prepotent response; for reviews of executive functions, see, e.g., Garon et al., 2008; Miyake et al., 2000). More recently, researchers have begun to examine cognitive flexibility in more detail, focusing on different aspects of this skill and how these aspects affect children's performance (e.g., Blakey, Visser, & Carroll, 2016; Cragg & Chevalier, 2012).

The tasks that researchers typically use to measure young children's cognitive flexibility require them to switch from considering one aspect of a stimulus to considering a different aspect of the same stimulus (see, e.g., Cragg & Chevalier, 2012; Deák, 2004; Diamond, 2006; Jacques & Zelazo, 2005; Snyder & Munakata, 2010). For example, the most widely used task to measure cognitive flexibility in preschoolers, the Dimensional Change Card Sort (Zelazo, 2006), requires children to sort bivalent test cards, such as blue rabbits and red boats, first according to one dimension (shape or color) and then according to the other dimension. To succeed in sorting by the second dimension, children need to be able to switch from thinking about the test cards in terms of the first dimension (e.g., think about the blue rabbits as *rabbits*) to thinking about them in terms of the second dimension (e.g., think about the blue rabbits as *blue*; Frye, Zelazo, & Palfai, 1995). Typically, 3-year-olds are unable to make the switch and continue to sort the cards along the first dimension. Most children succeed at this task by the time they are 5 years old (Doebel & Zelazo, 2015).

The development of switching cognitive flexibility has been widely studied (see Cragg & Chevalier, 2012, for a review). Although it is important, thinking about an object in two different ways, *one after the other,* is not the only way to exhibit flexible thinking. In addition to this sequential way, we are sometimes required to coordinate multiple aspects of a single stimulus concurrently—for instance, when we are asked to find a red marker in a box containing markers, crayons, and pencils in different colors. In this situation, we must think about both the color and the shape of the item we are searching for *at the same time.*

Perner, Stummer, et al. (2002) distinguished between sequential and concurrent processes in the context of perspective taking (i.e., thinking about an object or event from someone else's point of view). The authors defined *switching perspectives* as alternating between different perspectives at different times (e.g., using "rabbit" in one situation and "animal" in another situation to refer to the same object) and *confronting perspectives* as representing two different perspectives simultaneously (e.g., understanding that the object is *both* a rabbit and an animal at the same time). Both cognitive flexibility and perspective taking rely on the same basic process: children must represent the same object or situation in two (or more) different ways. Perspective taking necessitates another person (i.e., the second view is always someone else's; see, e.g., Moll, Meltzoff, Merzsch, & Tomasello, 2013), whereas one person can think about an object first in one way and then in another way. Nevertheless, both skills require the understanding that the same thing (object or situation) can be represented in multiple ways.