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Using language to get ready: Familiar labels help children to engage proactive control

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ABSTRACT

A key developmental transition is the ability to engage executive functions proactively in advance of needing them. We tested the potential role of linguistic processes in proactive control. Children completed a task in which they could proactively track a novel (target) shape on a screen as it moved unpredictably amid novel distractors and needed to identify where it disappeared. Children almost always remembered which shape to track, but those who learned familiar labels for the target shapes before the task had nearly twice the odds of tracking the target compared with those who received experience with the targets but no labels. Children who learned labels were also more likely to spontaneously vocalize labels when the target appeared. These findings provide the first evidence of a causal role for linguistic processes in proactive control and suggest new ideas about how proactive control develops, why language supports a variety of executive functions, and how interventions might best be targeted.

Introduction

How do we exercise control to achieve the goals we set out to achieve? Every day we use goals to support flexible behavior, whether we are sticking to a diet, inhibiting emotional outbursts, or switching between tasks to meet looming deadlines. Several decades of research have greatly advanced our

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understanding of the cognitive processes supporting goal-directed behavior, termed *executive functions,* and indicate they predict success in life across a range of outcomes such as academics, health, and wealth (Mischel, Shoda, & Rodriguez, 1989; Moffitt et al., 2011). As a result, there has been great interest in improving executive functions through interventions; however, so far such efforts have met with limited success (Diamond, 2012; Melby-Lervåg & Hulme, 2013; Shipstead, Redick, & Engle, 2012). A potential reason for the mixed findings is that interventions have not effectively targeted mechanisms and transitions linked to the development of executive functions, in part because there is still much to learn about how executive functions develop. Gaining further insight into processes supporting these developments may be critical to understanding executive functions and improving interventions.

Recent findings point to a developmental transition in the temporal dynamics of how individuals engage executive functions. Across development, children shift from engaging executive functions *reactively,* in the moment they are needed, to increasingly engaging them *proactively,* in anticipation of needing them (Andrews-Hanna et al., 2011; Chatham, Frank, & Munakata, 2009; Chevalier, Martis, Curran, & Munakata, 2015; Lucenet & Blaye, 2013; Waxer & Morton, 2011). For example, on a rainy day, a 5-year-old child may run inside to get a raincoat only after getting wet, whereas a 6-year-old may anticipate the need for a raincoat and prepare by going to the closet to get it before heading outside. Adults flexibly engage executive functions reactively or proactively in response to situational demands, but as they age they increasingly engage executive functions reactively (Braver et al., 2001; Paxton, Barch, Racine, & Braver, 2008). Successful proactive control may depend on abstract goal representations that are supported by sustained activation of the lateral prefrontal cortex, which may be key to efficiently engaging in goal-directed behavior in the context of cognitively demanding events (Braver, 2012; Munakata, Snyder, & Chatham, 2012; Rougier, Noelle, Braver, Cohen, & O'Reilly, 2005).

Language may play a role in the development and engagement of such abstract goal representations (Clark, 2006; Colunga & Smith, 2003). Behavioral studies with children and adults demonstrate that linguistic input plays a key role in the formation of various kinds of abstract representations (e.g., categories, analogical relations) (Loewenstein & Gentner, 2005; Lupyan, Rakison, & McClelland, 2007; Waxman & Markow, 1995; Yoshida & Smith, 2005). Modeling work shows how abstract goal representations that can be maintained in working memory can emerge through experience, including linguistic experience (Rougier, Noelle, Braver, Cohen, & O'Reilly, 2005). Labels are more effective than nonverbal or nonspecific cues in activating abstract representations (Edmiston & Lupyan, 2015). Moreover, consistent with theorizing that language plays a key role in the emergence of higher cognitive functions (Luria, 1961; Vygotsky, 1934/2012), a large body of empirical findings indicates that linguistic processes support executive functions. For example, instructing children and adults to label information relevant to an upcoming task improves task-switching performance (e.g., Kirkham, Cruess, & Diamond, 2003; Kray, Eber, & Karbach, 2008) and action control (Karbach, Kray, & Hommel, 2011). Children also use self-directed speech (overt or covert nonsocial speech) to support performance on planning, delayed recall, and switching tasks (e.g., Fernyhough & Fradley, 2005; Flavell, Beach, & Chinsky, 1966; Karbach & Kray, 2007; Lidstone, Meins, & Fernyhough, 2010). Interfering with such speech (via articulatory suppression) impairs planning and recall in children (Fatzer & Roebers, 2012; Lidstone et al., 2010) and impairs switching in children and adults (Emerson & Miyake, 2003; Fatzer & Roebers, 2012; Kray et al., 2008).

Language may support executive functions by providing information that can be used to engage control proactively (e.g., by preparing for an upcoming task, by verbalizing possible moves in a planning task). Children may use their own speech to maintain task rules or stimulus representations. For example, they may resolve conflict on the Stroop task by verbally representing the goal of responding to the color of a word instead of its meaning in advance of seeing the word. Yet little work has examined linguistic processes in proactive control specifically. One study found that labels designed to encourage proactive control failed to do so in 7- to 10-year-olds (Kray, Schmitt, Heintz, & Blaye, 2015), but children of this age may have already been sufficiently proactive to use their own inner speech without needing labels.

Thus, the current study tested whether linguistic processes play a role in proactive control by manipulating the availability of labels that could be used to support it in 4- and 5-year-old children, who are just developing the ability to engage proactive control on their own (Chevalier et al., 2015;