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Inhibition and behavioral self-regulation: An inextricably linked couple in preschool years

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ABSTRACT

A modified version of the flanker task was used to investigate how children deal with increasing inhibitory control demands. Additional variables such as age, cue salience and behavioral regulation were also considered in the present research. Preschoolers and first graders alike, showed a performance decline once inhibitory control demands increased. When taking behavioral regulation skills into account, an age-related interaction effect was found: Compared to their peers with high behavioral regulation skills, preschoolers with low to moderate behavioral regulation skills showed a weaker performance when faced with increased inhibitory control demands. No such effects were found for first graders. The results suggest that in particular in preschool years inhibition and behavioral regulation are highly intertwined.

1. Introduction

A day in a child's life is packed with situations that require inhibitory control. Raising the hand before speaking in class or taking turns when playing a game; all these situations involve the ability to suppress a prepotent or spontaneous action. Inhibitory control is defined as the ability to ignore irrelevant information while pursuing the represented goal (Carlson & Moses, 2001; Simpson & Riggs, 2007). Research focusing on individual differences show that inhibitory control develops rapidly in early childhood (Carlson, 2005; Hughes, 1998; Zelazo, Müller, Frye, & Marcovitch, 2003) and continues to develop throughout childhood (Romine & Reynolds, 2005). Despite extensive research on inhibition, the precise mechanisms involved in inhibitory control are not yet fully understood (Best & Miller, 2010; Cragg, 2016). Thus, experimental research on inhibitory control may add to a more comprehensive picture of how distraction can be successfully overcome.

Conflict tasks demand inhibitory control (Ambrosi, Lemaire, & Blaye, 2016; Cragg, 2016; Davidson, Amso, Anderson, & Diamond, 2006). In such tasks, participants are confronted with relevant stimuli but also with irrelevant stimuli. Typical conflict tasks are the Flanker task (Eriksen & Eriksen, 1974), the Simon task (Simon & Berbaum, 1988) or the Stroop task (e.g., MacLeod, 1991). The Flanker task and the Simon task have two particular advantages for examining inhibitory control: Firstly, the tasks are computerized and therefore quantify conflict effects precisely in terms of two different variables (reaction time and accuracy). Secondly, the two tasks do not require a verbal response and thus eliminate confounding language-based influences (Best & Miller, 2010; Mullane, Corkum, Klein, & McLaughlin, 2009).

Various research fields take interest in inhibitory control (Nigg, 2000). For example, research has shown that inhibitory control is critical for cognitive abilities such as attention and memory (Levy & Anderson, 2002; Posner & Rothbart, 2000). Further, it seems to play a key role in academic performance (e.g., Blair & Razza, 2007; St Clair-Thompson & Gathercole, 2006) and social competences (Carlson & Moses, 2001; Cragg, 2016). In addition, inhibitory control is intrinsically involved in self-regulatory skills such as

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behavioral regulation or emotion regulation (Calkins & Fox, 2002; Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003; Williford, Vick Whittaker, Vitiello, & Downer, 2013). For example, an observational study revealed substantial interrelatedness between behavioral regulation and inhibition. Correlations between the behavioral regulation task, the Head-toes-knees-shoulders task (HTKS; McClelland et al., 2014) and two different conflict tasks (i.e., Simon task and Stroop task) ranged from (r = 0.29–0.44) in preschool to (r = 0.37–0.50) in kindergarten. When considering the motor component in inhibitory processes (Nigg, 2000; Ridderinkhof, van der Molen, Band, & Bashore, 1997), the relation between inhibition and behavioral regulation seems obvious. And although the relation between inhibition and behavioral regulation is not being questioned, little is known about the quality of the relation. In other words, research is needed to examine *how* inhibition and behavioral regulation are related.

Despite mixed findings concerning inhibition development beyond the age of six (e.g., Klenberg, Korkman, & Lahti-Nuuttila, 2001; Lee, Bull, & Ho, 2013; Romine & Reynolds, 2005), there seems to be more evidence in favour of a continuous but less pronounced improvement during middle childhood (for a review see Best & Miller, 2010). One reason for these partially contradictive results is a methodical one: There are many different tasks to assess inhibition. And even for one type of inhibition such as inhibitory control there are a variety of tasks (e.g., Stroop task, Flanker task, Simon task). Generally, it is difficult to compare performance of various tasks. But it is even more difficult with regard to detecting developmental change. Because different tasks detect developmental change with varying sensitivity (Nigg, 2000). To overcome such methodological issues, Best and Miller (2010) call for a more systematic research approach to address developmental questions regarding inhibition. One of these questions concerns the processes involved in inhibition development (Best & Miller, 2010) which could be addressed by means of within task manipulations. Such systematic within task manipulations are beneficial to analyze the relation between factors involved in inhibitory control (Garon, Bryson, & Smith, 2008).

Experimental research has mainly focused on the inhibitory process itself. For example, response-cueing studies have shown how cues interact with inhibitory processes. In such studies, brief cues precede the target stimuli. Results consistently show that reliable cues (i.e., only valid cues) decrease reaction times and/or increase accuracy whereas unreliable cues (i.e., valid cues and invalid cues mixed) increase reaction times and/or decrease accuracy (Adam, Hommel, & Umiltà, 2003; Wühr, 2006). Benefits for reliable cues and costs for unreliable cues are consistently found, for both adults and children (Olivier, Audiffren, & Ripoll, 1998; Wühr, 2006). Aside from other processes such as motor inhibition (Ridderinkhof et al., 1997) and attention (Rueda et al., 2004), unreliable cues demand inhibitory control. Because information provided by the cues cannot be relied on, subjects have to ignore the cues and inhibit the prepotent responses (Band, van der Molen, Overtoom, & Verbaten, 2000; Wühr, 2006). To sum up, while correlational research has shown (a) the importance of inhibitory skills for a child's cognitive and social functioning and (b) revealed a high interrelatedness between behavioral regulation and inhibition, experimental research provides evidence how cue reliability affects inhibitory control. However, what remains less clear is to which extent factors such as age or behavioral regulation affect inhibitory control.

1.1. The current study

The aim of the present research was to gain a more comprehensive picture of the processes involved in inhibitory control. Therefore, we varied inhibitory control demands through within task manipulations. That is, visual cues as previously applied in cueing tasks (Adam et al., 2003; Wühr, 2006) were coupled with the flanker task. More precisely, before presenting the target stimulus, a visual cue appeared briefly in some of the trials. Cues triggered prepotent responses, which subjects had to inhibit. To increase inhibitory control demands, we used unreliable cues (with equal amounts of valid and invalid cues; Band et al., 2000; Rueda et al., 2004; Wühr, 2006).

To gain further insights on inhibitory control, we varied two factors, namely age and cue format. There were two age groups, preschool children and first graders. We expected that regardless of the cue format, younger participants' performance would be affected more severely by the cues than the performance of older children. Cue format was a between subject factor. That is, half of the participants received a salient cue, whereas the other half received a neutral cue. For both cue formats, we expected inhibitory control demands to increase and–as a result–performance to decrease. More specifically, we expected the additional demands to prolong response latencies and decrease accuracy performance. In addition, we aimed to explore if the salient cue would evoke stronger prepotent responses compared to the neutral cue. To sum up, in the present research, we combined an experimental design with an individual differences approach. By varying inhibitory control demands, we were not only able to examine performance difference across different conditions but also able to relate inhibitory control skills to individual differences in behavioral regulation.

2. Methods

2.1. Participants

The sample (N = 125) consisted of 59 preschoolers (mean age: 5 years, 10 months, SD = 7.0) and 66 first graders, (mean age 7 years, 5 months, SD = 4.8). In both age groups, gender was approximately equally distributed with 47.5% females in the younger age group and 51.5% females in the older age group. The children were predominately Caucasian from middle-class families, reflecting the characteristics of the local community. Written consent from the children's parents as well as verbal consent from the child was obtained before testing. Five additional children had to be excluded due to missing data.