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Development of between-trial response strategy adjustments in a continuous action control task: A cross-sectional study

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ABSTRACT

Response strategies are constantly adjusted in ever-changing environments. According to many researchers, this involves executive control. This study examined how children (aged 4–11 years) and young adults (aged 18–21 years) adjusted response strategies in a continuous action control task. Participants needed to move a stimulus to a target location, but on a minority of the trials (change trials) the target location changed. When this happened, participants needed to change their movement. We examined how performance was influenced by the properties of the previous trial. We found that no-change performance was impaired, but change performance was improved, when a change signal was presented on the previous trial. Extra analyses revealed that the between-trial effects on no-change trials were not influenced by the repetition of the previous stimulus. Combined, these findings provide support for the idea that response strategies were adjusted on a trial-by-trial basis. Importantly, we observed large age-related differences in overall change and no-change latencies but observed no differences in response strategy adjustments. This is consistent with findings obtained with other paradigms and suggests that adjustment mechanisms mature at a faster rate than other "executive" action control mechanisms.

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Introduction

Psychologists typically attribute adaptive and flexible behavior to "executive control." This is an umbrella term for the functions of the cognitive system that allow people to regulate their behavior according to higher-order goals or plans (Miller & Cohen, 2001; Monsell & Driver, 2000; Norman & Shallice, 1986). This involves organizing, monitoring, and altering the settings of underlying processes involved in stimulus detection, action selection, and motor execution (for a recent review, see Verbruggen, McLaren, & Chambers, 2014). Aspects of executive control have been linked to a wide range of important life outcomes (e.g., physical and mental health, school and job success, personal finances), and impairments of executive control may underlie psychopathological disorders such as attention deficit/hyperactivity disorder, conduct disorder, substance abuse, and behavioral addictions (Snyder, Miyake, & Hankin, 2015). Thus, executive control is critical in everyday life.

One of the main functions of the executivecontrol system is establishing a balance between competing task demands. For example, focusing on the currently relevant task could lead to overly rigid behavior, whereas frequently reorienting attention (e.g., to detect stimuli that might afford a task switch) would lead to constant distraction. Similarly, responding quickly can lead to fast task completion but increases the probability of an error and reduces the likelihood that actions can be altered when needed (e.g., in response to a sudden change in the environment). It is generally assumed that executive control processes are involved in finding the optimal response strategy. A response strategy can be defined as "an optional organization of cognitive resources or abilities that is designed to achieve some goal in some task environment" (Logan, 1985, p. 194). Research indicates that response strategies are dynamic and constantly adjusted. For example, Strayer and Kramer (1994) discussed a two-stage criteria adjustment model; first people would determine a general response strategy at the beginning of a task, and then a tracking mechanism would allow them to further adjust or fine-tune the response settings on a trial-by-trial basis. Such between-trial response strategy adjustments are a fundamental characteristic of flexible, adaptive, and goal-directed behavior.

The current study explored how children and young adults dynamically adjusted response strategies in a continuous action control task in which they needed to monitor for changes in the environment and occasionally adjust ongoing actions. The ability of children to regulate their thought and actions improves remarkably from infancy through adolescence (for reviews, see Bunge, Mackey, & Whitaker, 2009; Diamond, 2013). Here we further tested whether there are also large age-related differences in response strategy adjustments.

Response strategy adjustments in adults

Performance-related adjustments of response strategies are typically studied in decision-making or choice paradigms and in action control tasks such as the flanker task, the go/no-go task, and the stop-signal task. The trigger for response strategy adjustments may differ between tasks or situations, but adjustments themselves are often very similar (e.g., participants increase the response threshold when instructed to be accurate or when they alter the balance between competing task demands in a stop-signal task; Verbruggen & Logan, 2009).

In decision-making, choice, and interference control tasks, people often alter response strategies when they make an error, when conflict is detected, or when outcomes are otherwise less desirable than anticipated (for reviews, see Egner, 2008; Ullsperger, Danielmeier, & Jocham, 2014). For example, they slow down after they make an error ("post-error slowing"; Laming, 1968; Rabbit, 1966; Rabbitt & Phillips, 1967; Rabbitt & Rodgers, 1977). Such sequential effects have been observed in a variety of tasks (but for some exceptions, see, e.g., Verbruggen, Chambers, Lawrence, & McLaren, 2017; Williams, Heathcote, Nesbitt, & Eidels, 2016) and are usually attributed to executive control mechanisms that monitor for negative outcomes. When such events are detected, response strategies would be adjusted in a "top-down" fashion. These adjustments usually increase response latencies (i.e., people become more cautious) but can reduce the likelihood of further negative or suboptimal outcomes