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Inhibitory control in childhood stuttering

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ABSTRACT

Purpose: The purpose of this study was to investigate whether previously reported parental questionnaire-based differences in inhibitory control (IC; Eggers, De Nil, & Van den Bergh, 2010) would be supported by direct measurement of IC using a computer task.
Method: Participants were 30 children who stutter (CWS; mean age = 7;05 years) and 30 children who not stutter (CWNS; mean age = 7;05 years). Participants were matched on age and gender (±3 months). IC was assessed by the Go/NoGo task of the Amsterdam Neuropsychological Tasks (De Sonneville, 2009).
Results: Results indicated that CWS, compared to CWNS, (a) exhibited more false alarms and premature responses, (b) showed lower reaction times for false alarms, and (c) were less able to adapt their response style after experiencing response errors.
Conclusions: Our findings provide further support for the hypothesis that CWS and CWNS differ on IC. CWS, as a group, were lower in IC pointing toward a lowered ability to inhibit prepotent response tendencies. The findings were linked to previous IC-related studies and to emerging theoretical frameworks of stuttering development.

Educational objectives: The reader will be able to: (1) describe the concept of inhibitory control, and its functional significance; (2) describe the findings on self-regulatory processes, attentional processes, and inhibitory control in CWS; (3) identify which Go/NoGo task variables differentiated between CWS and CWNS; and (4) summarize the theoretical implications for the development of stuttering and the possible clinical implications.

1. Introduction

Inhibitory control (IC) is the ability to suppress, interrupt or delay an inappropriate response under instructions or in novel or uncertain situations (Clark, 1996; Rothbart, 1989) or to ignore irrelevant information (Dagenbach & Carr, 1994; Dempster & Brainerds, 1995; Rothbart & Posner, 1985). IC is essential for the performance of everyday tasks (Simpson & Riggs, 2009) and has been implicated in cognitive development (Harnishfeger & Bjorklund, 1994), executive functioning (Friedman & Miyake, 2004), and the conscious use of attention or attentional control (Desimone & Duncan, 1995; Kochanska, 1997). It is strongly related to the coordination and integration of mental processes in successful task performance (Dowsett

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& Livesey, 1999) and plays an important role in the self-regulation of emotional states (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Kopp, 1982).

Several authors have alluded to a possible role for self-regulatory processes, attentional control processes, and more specifically inhibitory control in the development of stuttering. Evidence for possible reduced self-regulation has come from observations that children who stutter (CWS) are (a) lower in adaptability (Anderson, Pellowski, Conture, & Kelly, 2003), (b) lower in biological rhythmicity (Anderson et al., 2003) and (c) less efficient in emotional regulation (Karrass et al., 2006), although the latter finding was not confirmed in a recent study from the same research group (Arnold, Conture, Key, & Walden, 2011). With regard to attentional control, studies have reported CWS to be (a) more or less distractible, depending on the measurement method used (Anderson et al., 2003; Embrechts, Ebben, Franke, & van de Poel, 2000; Schwenk, Conture, & Walden, 2007), (b) less efficient in attention regulation (Felsenfeld, van Beijsterveldt, & Boomsma, 2010; Karrass et al., 2006; Schwenk et al., 2007), and (c) less efficient in attentional orienting (Eggers et al., 2010; Eggers, De Nil, & Van den Bergh, 2012); also studies in adults who stutter pointed to a lowered efficiency in allocating attentional resources under dual task conditions (Bosshardt, 1999, 2002, 2006; Bosshardt, Ballmer, & De Nil, 2002; Smits-Banstra & De Nil, 2007; Vasic & Wijnen, 2005). Finally, some studies reported that CWS were lower in inhibitory control (Eggers et al., 2010; Embrechts et al., 2000), while others found no difference (Anderson & Wagovich, 2010).

Further study of IC in stuttering may be particularly interesting because of its role in speech motor planning and production (e.g., Alm, 2004b; Smits-Banstra & De Nil, 2007; Xue, Aron, & Poldrack, 2008); moreover, imaging studies in stuttering (for an overview: see Watkins, Smith, Davis, & Howell, 2008) have revealed aberrant activity in the underlying cortical and subcortical structures of IC, namely the right prefrontal cortex (e.g., Aron, Fletcher, Bullmore, Sahakian, & Robbins, 2003; Casey et al., 1997) and the fronto-basal ganglia circuit (Aron et al., 2007; Chambers, Garavan, & Bellgrove, 2009; Congdon et al., 2010).

In a number of recent studies, we have found evidence for a possible role of IC in developmental stuttering (Eggers, De Nil, & Van den Bergh, 2009; Eggers et al., 2010). These studies were done using the Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001), a parent-report temperament questionnaire for young children based on Rothbart's temperament model. Rothbart defines temperament as constitutionally based individual differences in reactivity and self-regulation (Rothbart, 1989, 2011; Rothbart & Derryberry, 1981). Reactivity refers to motor, emotional, and attentional responses to internal and external stimuli and is operationalized in CBQ-scales such as Approach and Anger/Frustration. Self-regulation are those processes serving to modulate – i.e., facilitate or inhibit – the aforementioned reactivity, and is measured in the CBQ by scales such as Inhibitory Control and Attentional Focusing/Shifting. In a recent study of 3–8 year-old children (Eggers et al., 2010) we found that CWS scored significantly lower on the self-regulation-related scales of IC and Attentional Shifting and their overarching superfactor of Effortful Control, a finding that was consistent with other questionnaire-based studies in CWS (Embrechts et al., 2000; Karrass et al., 2006).

In a subsequent study (Eggers et al., 2012), we examined whether the parent-reported lower self-regulation and inhibitory control in CWS could be corroborated experimentally using measures of attentional processes, which are central to these self-regulatory behaviors (Rothbart, Ellis, Rueda, & Posner, 2003). Using the child version of the Attention Network Test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002; Rueda et al., 2004), a computer task measuring the efficiency of the 3 attentional networks, we found CWS to be significantly lower in the efficiency of their orienting network, which is linked to the Attentional Shifting scale of the CBQ. However, for the executive control network, the network underlying IC, only a non-significant trend ($p = .066$) toward a lower efficiency for CWS was found. This led us to propose that our earlier reported CBQ-based IC findings were either not associated with a lower efficiency of the executive control network or, that the paradigm used to test the executive attentional network in the previous study lacked the necessary power to detect significant between-group differences. One reason for the need of more specific measures is the fact that executive attention consists of three integrated, measurable mechanisms, namely error detection and correction, conflict resolution, and inhibition of automatic responses (e.g., Norman & Shallice, 1986; Posner & Raichle, 1994; Rothbart & Posner, 2001). As such, attempts to measure a complex network such as executive attention using one global measure may be less likely to be successful. Some indirect support for this comes from the observation that in similar studies with ADHD children, differences in IC emerged by using a stop-signal paradigm (Pliszka, Liotti, & Woldorff, 2000), while no differences were found for the broader underlying executive attentional network (Adolfsdottir, Sorensen, & Lundervold, 2008; Booth, 2003). Therefore, the current study was designed to examine specifically IC in CWS by using a more targeted experimental measurement.

There is a considerable variability in the paradigms used to measure IC and several experimental measures have been developed to assess IC across different age-ranges, e.g., Go/NoGo or stop-signal tasks, Stroop-like or card sorting paradigms, and Mistaken Gift or Gift Delay Tasks (Baron, 2004; Carlson & Moses, 2001; Christ, White, Mandernach, & Keys, 2001). According to Barkley's model of response inhibition (1997), these measures are directed at evaluating three interrelated processes: (a) inhibition of an initial prepotent response, which can be measured using a Go/NoGo task (Casey et al., 1997) or a gift delay task (Kochanska et al., 1996); (b) stopping of an ongoing response, as measured for instance using a stop-signal task (Aron & Poldrack, 2005; Pliszka, Borcherding, Spratley, Leon, & Irick, 1997); and (c) protection of self-initiated responses from disruption by conflicting events or interference, for instance as measured by a Stroop-like task (Gerstadt, Hong, & Diamond, 1994).

The purpose of this study was to test experimentally previous findings of parent-reported (CBQ) differences in IC between CWS and children who not stutter (CWNS), in particular the inhibition of prepotent responses, using a Go/NoGo task. Based on these previous findings, we hypothesized that CWS, as a group, would be lower in IC compared to CWNS.