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Supporting cognitive control through competition and cooperation in childhood

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ABSTRACT

Cognitive control is often engaged in social contexts where actions are socially relevant. Yet, little is known about the immediate influence of the social context on childhood cognitive control. To examine whether competition or cooperation can enhance cognitive control, preschool and school-age children completed the AX Continuous Performance Task (AX-CPT) in competitive, cooperative, and neutral contexts. Children made fewer errors, responded faster, and engaged more cognitive effort, as shown by greater pupil dilation, in the competitive and cooperative social contexts relative to the neutral context. Competition and cooperation yielded *greater* cognitive control engagement but did not change *how* control was engaged (reactively or proactively). Manipulating the social context can be a powerful tool to support cognitive control in childhood.

Introduction

Cognitive control, the goal-directed regulation of thoughts and actions, develops rapidly in childhood, supporting greater autonomy and increasingly adaptive behavior with age. It is one of the best predictors of life success, including attention in the classroom and academic achievement in childhood, staying away from drug abuse and criminality in adolescence, and health and income

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(e.g., Daly, Delaney, Egan, & Baumeister, 2015; Moffitt et al., 2011). Therefore, supporting cognitive control early in development has become a priority. Cognitive control training programs have yielded promising results (e.g., Diamond, 2012; Karbach & Unger, 2014), but training regimens are often lengthy, expensive, and difficult to implement. An alternative to training is to modify children's environment to support cognitive control transiently in situations where it is most needed (e.g., school activities). The social context is a salient environmental aspect that can easily be manipulated ecologically to optimize children's performance. Social factors such as socioeconomic status, parenting, and chronic stress have a long-term influence on cognitive control development (Moriguchi, 2014; Roskam, Stievenart, Meunier, & Noël, 2014). However, little is known about the immediate influence of the social context on children's cognitive control even though children's actions are often performed in contexts where they are socially relevant and in interaction with other people. The current study investigated whether cognitive control can be enhanced through cooperation and competition in childhood.

One reason to suspect that cooperative contexts influence children's cognitive control is that, from early on, children show sensitivity (i.e., are not oblivious) to cooperation. Specifically, young children have been argued to have a drive for cooperation and engage in cooperative activities with adults or other children as early as their second year of life (Rekers, Haun, & Tomasello, 2011; Warneken & Tomasello, 2006). For instance, infants and young children understand the basic principles of cooperation such as the principle of reciprocity (Olson & Spelke, 2008), engage more spontaneously in cooperative activities than in nonsocial ones (Warneken, Chen, & Tomasello, 2006), and regularly engage in cooperative play (Barbu, Cabanes, & Le Maner-Idrissi, 2011). They already take into account their partners' intentions and actively attempt to reengage partners who interrupt joint cooperative activities (Tomasello, Warneken, & Gra, 2012; Warneken & Tomasello, 2007; Warneken et al., 2006).

Importantly, beyond mere sensitivity, there is evidence that cooperation can actually influence children's performance on tasks tapping cognitive abilities such as theory of mind, categorization, and problem solving (e.g., Garton & Pratt, 2001; Harris, Yuill, & Luckin, 2008; Rogoff, 1990, 1998). For instance, preschoolers persist longer on challenging tasks (e.g., difficult puzzles) in cooperative contexts than in noncooperative ones (Butler & Walton, 2013). To date, the only study that examined the effect of cooperation on young children's cognitive control reported that the mere presence of a passive partner, who did not communicate with children, enhanced 3- and 4-year-olds' performance on a response inhibition task (Qu, 2011). In adults, cooperation yields better behavioral performance and modulates activity in prefrontal regions that support cognitive control (Cui, Bryant, & Reiss, 2012; de Bruijn, de Lange, von Cramon, & Ullsperger, 2009; Decety, Jackson, Sommerville, Chaminade, & Meltzoff, 2004; Liu, Saito, & Oi, 2015; Sebanz, Knoblich, Prinz, & Wascher, 2006).

As for cooperation, young children also show sensitivity to competition. For instance, they display greater pleasure when winning than when losing against a competitor (Stipek, Recchia, & McClintic, 1992) and engage in less prosocial behaviors in competitive contexts than in nonsocial ones (Pappert, Williams, & Moore, 2017). Competition can also have a direct influence on children's cognitive performance, as illustrated by school-age children's greater arithmetic performance after playing a math computer game against an opponent rather than with a partner or individually (Plass et al., 2013). Similarly, cognitive control training based on exergames (i.e., video games involving physical exertion) induces even more beneficial short-term effects on older children's cognitive control in a competitive condition than in a cooperative or neutral one (Staiano, Abraham, & Calvert, 2012). In adults, competition has similar effects as cooperation on cognitive control performance and related prefrontal cortex activity (Decety et al., 2004; Liu et al., 2015). Interestingly, unlike cooperation, competition seems to differentially affect boys and girls, with competition enhancing boys' performance in creativity and dexterity tasks but yielding either no gain or even worse performance in girls, relative to individual contexts (Conti, Ann, & Picariello, 2001; Samak, 2013). However, it is unknown whether competition differentially affects cognitive control in boys and girls.

The beneficial effects of both competition and cooperation on cognitive control may be driven by enhanced motivation. Specifically, acting toward the same goal as a partner or competing with an opponent may increase awareness of the relevant task goal and willingness to adopt different perspectives and problem-solving methods that help children to regulate their thoughts and actions (see Qu, 2011). Sharing a common goal with a partner may be intrinsically motivating (Decety et al., 2004),