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Sustained attention in infancy as a longitudinal predictor of self-regulatory functions

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ABSTRACT

Previous literature suggests that attention processes such as sustained attention would constitute a developmental foundation for the self-regulatory functions executive functioning and effortful control (e.g., Garon, Bryson, & Smith, 2008; Rothbart, Derryberry, & Posner, 1994). Our main aim was to test this hypothesis by studying whether sustained attention at age 1 year can predict individual differences in self-regulatory functions at age 2 years. Longitudinal data from 66 infants and their parents were included in the study. Sustained attention was assessed during free play at age 1 year; executive functioning, measured using an eye-tracking version of the A-not-B task, and effortful control, measured using parental ratings, were assessed at both age 1 and age 2 years. The results did support a longitudinal prediction of individual differences in 2-year-olds' self-regulatory functions as a function of sustained attention at age 1 year. We also found significant improvement in both executive functioning and effortful control over time, and the two self-regulatory constructs were related in toddlerhood but not in infancy. The study helps increase our understanding of the early development of self-regulatory functions necessary for identifying developmental risks and, in the future, for developing new interventions.

1. Introduction

Self-regulatory constructs, such as executive functioning and effortful control, refer to higher-order cognitive and temperamental processes that are crucial to performing goal-directed behaviors, planning ahead and being organized. Although originating from two different theoretical perspectives on self-regulation, the concepts of executive functioning and effortful control clearly overlap (Bridgett, Oddi, Laake, Murdock, & Bachmann, 2013; Zhou, Chen, & Main, 2012). The ability to resolve an internal conflict by inhibiting a dominant response and instead act on a subdominant response is at the core of the definitions of both constructs (e.g., Diamond, 1990, 2006; Rothbart & Bates, 2006). Also, Allan and Lonigan (2011) argued that effortful control and executive functions are linked to the same neural substrates and require the same response capacities. However, whereas executive functioning could be viewed as a primarily cognitive construct, often defined as consisting of working memory, inhibition and shifting (e.g., Miyake et al., 2000), effortful control may be seen to reflect a somewhat broader self-regulatory ability (Rothbart & Bates, 2006).

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1.1. Early development of self-regulation

The development of self-regulation is closely linked to the prolonged development of the prefrontal areas of the brain (e.g., Diamond & Goldman-Rakic, 1989; Lezak, Howieson, Bigler, & Tranel, 2012) and in particular the areas sometimes referred to as the anterior attention network (see Posner & Rothbart, 2009; Rothbart, Derryberry, & Posner, 1994 for reviews). The anterior attention network is believed to regulate other brain areas and networks, and thereby play an important role in conflict resolution. Overcoming internal conflict is, as mentioned above, at the core of the definitions of both executive functioning and effortful control. In fact, the anterior attention network is often referred to as the "executive attention network". These brain areas, and consequently the self-regulatory functions executive functioning and effortful control, undergo rapid developmental changes during the first years of life (Posner & Rothbart, 2000; Rothbart, Sheese, Rueda, & Posner, 2011).

To exemplify the developmental changes occurring in self-regulation early in life, we can turn to the temperament literature. Effortful control is there described as self-regulation at a behavior level, with different mechanisms driving this regulation at different points in early development. Already during the first few months of life, individual differences in basic regulatory behaviors, such as hesitating before approaching novel stimuli or expressing distress, are observed and can be assessed using temperamental scales (Gartstein & Rothbart, 2003; Rothbart, Sheese, & Posner, 2007). However, more advanced and complex regulatory skills, believed mainly to rely on the anterior attention network, are not sufficiently mature until several months later; in their review of developing mechanisms of self-regulation Rothbart, Sheese, et al. (2011) concluded that evidence for regulation by the anterior attention network does not begin to appear until the age of 18–20 months. They further proposed that prior to this, regulatory behavior is often reflected by the ability to turn away from distressing stimuli or to shift the focus of attention. These abilities are mainly dependent on the brain's orienting network rather than on the anterior attention network.

Similar developmental changes can be seen in executive functioning. Diamond (1990) proposed that rudimentary forms of executive functions exist already during the first year of life; for example, infants are able to keep simple information in mind over short delays. Although the first years of life seem to constitute such an important period of developmental change (e.g., Diamond, 2006; Posner & Rothbart, 2000; Rothbart, Sheese, et al. (2011)), the knowledge about the very early forms of executive functions is scarce. Encouragingly, the number of studies exploring the very early development of these functions has recently started to increase (e.g., Bell, 2012; Bernier, Carlson, & Whipple, 2010; Friedman, Miyake, Robinson, & Hewitt, 2011; Garon, Smith, & Bryson, 2013; Hughes & Ensor, 2005, 2007) but studies investigating the longitudinal development of executive functioning already in the first and second year are still lacking. Most knowledge of executive functioning still concerns preschool and school-aged children. At these ages, the more complex and higher order forms of executive functioning have emerged, and they continue to develop well into adolescence (see Best & Miller, 2010; Garon, Bryson, & Smith, 2008 for reviews).

The importance of studying the early development of self-regulatory functions could be justified by the extensive literature on preschool and school-aged children which has revealed links between poor self-regulation and several negative developmental outcomes (see Diamond, 2013 for a review). For example, both poor executive functioning and low effortful control have been linked to externalizing behavior (Bohlin, Eninger, Brocki, & Thorell, 2012; Eisenberg et al., 2005; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005) and lower academic achievement (Blair & Peters Razza, 2007; Bull, Espy, & Wiebe, 2008; Valiente, Lemery-Chalfant, Swanson, & Reiser, 2008). Considering the importance of these self-regulatory functions in child development, we should strive to better understand what drives individual differences in executive functioning and effortful control already in the early development.

1.2. Attention as the foundation of self-regulation

The development of self-regulatory functions has been suggested to rely on more basic or lower-level cognitive functions, such as attention (e.g., Colombo & Cheatham, 2006; Garon et al., 2008; Rueda, Posner, & Rothbart, 2011; Ruff & Rothbart, 1996). As mentioned above, self-regulatory functions are believed to rely on frontal brain areas referred to as the anterior attention network. As the name suggests, these are areas important to attention processes, and according to the theory proposed by Rothbart, Posner and colleagues, there is a very close relation between attention and self-regulatory functions such as effortful control (e.g., Posner & Rothbart, 2000, 2009; Rothbart et al., 1994, 2007; Rothbart, Sheese, et al., 2011; Rueda et al., 2011).

In their review of executive functioning in preschool children, Garon et al. (2008) emphasized that attention processes are not only related to executive functioning, but that attention in infancy seems to constitute a developmental foundation for these functions. Among other attention processes, such as orienting, they point to the importance of the ability to attend to a stimulus over a period of time without being distracted, which is referred to as focused or sustained attention. Better sustained attention should promote the development of goal-directed and self-regulatory behavior, by allowing the child to be in control over what information is being processed (Garon et al., 2008). Similar arguments have also been put forward by Colombo and Cheatham (2006), suggesting the emergence of endogenous (that is, internally, or willfully, driven) attention to be a developmental step toward the development of meta-cognitive skills such as executive functioning. Further, the idea that attention is the foundation of more advanced regulatory functions is in line with the suggestion, made in the literature