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Executive functions after age 5: Changes and correlates

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ABSTRACT

Research and theorizing on executive function (EF) in childhood has been disproportionately focused on preschool age children. This review paper outlines the importance of examining EF throughout childhood, and even across the lifespan. First, examining EF in older children can address the question of whether EF is a unitary construct. The relations among the EF components, particularly as they are recruited for complex tasks, appear to change over the course of development. Second, much of the development of EF, especially working memory, shifting, and planning, occurs after age 5. Third, important applications of EF research concern the role of school-age children's EF in various aspects of school performance, as well as social functioning and emotional control. Future research needs to examine a more complete developmental span, from early childhood through late adulthood, in order to address developmental issues adequately.

For several decades research has reported deficits in the regulation of cognition, emotion, and behavior—but intact sensory processing, movement, speech, and even intelligence—in adult patients with frontal lobe damage (e.g., Stuss & Benson, 1984). As a result of these early neuropsychological studies, researchers (e.g., Luria, 1966) postulated that the prefrontal cortex (PFC) was critical to the planning, organization, and regulation of cognition and behavior. Over the years, primate (e.g., Goldman-Rakic, 1995), lesion (e.g., Stuss et al., 2000), and neuroimaging studies (Konishi et al., 1998) have supported this functional description of the PFC, and recently researchers have attempted to form a concise characterization of those functions.

Executive function (EF) serves as an umbrella term to encompass the goal-oriented control functions of the PFC. Relatively complex neuropsychological instruments such as the Wisconsin Card Sort-

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ing Test (WCST) were first employed to evaluate frontal lobe functioning and later to assess EF (Eling, Derckx, & Maes, 2008). By assessing participants' ability to plan ahead, to reflect on their performance, and to alter that performance if necessary, the WCST is more sensitive to *how* participants complete the task than to *what* factual knowledge can be retrieved to complete the task. However, the WCSTs complexity also makes it difficult to specify exactly what those *how* processes are, and it likely requires a variety of executive processes—a problem of task impurity (Hughes & Graham, 2002; Miyake et al., 2000). Thus, it is difficult to ascertain what specific cognitive deficit underlies poor performance. This problem, along with evidence for modularity of functions within the PFC (e.g., Moscovitch & Winocur, 2002), have spurred the creation and implementation of simpler, more precise assessments to complement or replace the classic neuropsychological tasks.

At the same time, the call for a better understanding of children's development of EF (Hughes, 1998; Hughes & Graham, 2002) has made it necessary to develop simplified EF tasks. Initially, much of the interest focused on the study of atypical development, notably ADHD and autism (Hughes & Graham, 2002). Recently, as attention has shifted toward normal EF development, a disproportionate amount of this research has investigated the age during the preschool years at which specific components of EF emerge, to the neglect of their later developmental course towards complete maturation.

There are good reasons to focus on preschoolers. First, such work identifies the very beginnings of each component of EF. Researchers have modified EF tasks used with adults to make them suitable for young children, who have limited ability to understand and follow instructions, as well as handle complex tasks (see Garon, Bryson, & Smith, 2008, for a review). Moreover, some of these simplified tasks may assess a single EF component, thus avoiding the problem of task impurity, specifically, that the complex tasks used with adults place demands on multiple EF components or on both executive and non-executive processes (Hughes & Graham, 2002; Miyake et al., 2000). Finally, the focus on preschoolers has revealed important relations between EF and theory of mind (e.g., Hughes & Ensor, 2007).

While these are important issues about EF development that require its examination in young children, there are also good reasons to assess EF development in school-age children. Such research allows us to ask questions that cannot be answered in research with preschoolers. First, examining a broader age range may clarify certain issues about EF as a construct, specifically, whether we should view EF as a unitary process or as a set of multiple, distinct component processes. The relations among components may change developmentally, making it critical to include older children. Similarly, children of different ages may coordinate the components in different ways and find different aspects of EF challenging when carrying out goal-oriented behavior. For example, inhibition may be particularly difficult for young children. Research on both of these issues—further changes in the development of each EF component and in the relations among the components during later childhood and adolescence—would not only clarify EF as a construct but also provide insight into processes underlying the development of EF.

Second, significant improvements in EF tasks occur during the school years (Romine & Reynolds, 2005). By excluding school-age children, we miss much of the developmental picture of EF, specifically, the distinct developmental trajectories of each EF component (e.g., working memory, inhibition, shifting) during middle childhood and adolescence. Moreover, there may be sleeper effects, in which experiences or individual differences in early childhood do not show observable effects until middle childhood. This event or change may be very small in early childhood, but eventually lead to large change much later on. For example, small effects of EF on theory of mind during the preschool years might lead to larger effects on social interaction during middle childhood.

To complete this developmental picture, it is necessary to consider the impairments to EF as part of the normal aging process. EF seems to be particularly vulnerable to cognitive aging, and its decline certainly impacts social functioning (von Hippel, 2007). As with studying the developmental trajectories of EF components in childhood and adolescence, the course of typical EF decline should clarify the interaction of EF components to produce goal-oriented behavior and the nature of brain processes supporting EF.

A third reason to study children older than preschool age is that entry into middle childhood means entry into a new set of experiences, and thus new questions can be asked about the uses of EF in everyday life. In particular, we can examine the relations to various aspects of schooling (e.g., academic