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Executive function in the first three years of life: Precursors, predictors and patterns

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ABSTRACT

Executive function (EF) underpins the ability to set goals and work towards those goals by co-ordinating thought and action. Its emergence during the first 3 years of life is under-studied, largely due to the limitations that early social, motor and language skills place on performance on traditional EF tasks. Nevertheless, across the fields of cognitive psychology, neuroscience, social development and temperament research, evidence is amassing of meaningful precursors and predictors of EF. This review draws together the evidence, highlighting methodological considerations and areas of theoretical debate, and identifies 4 domains critical to the development of EF: control of attention, self-regulation, processing speed and cognitive flexibility. Individual differences within these domains have clinical significance both in terms of the identification of risk markers for later executive dysfunction and for the target or delivery of early intervention to ameliorate this risk. By the end of the third year, typically-developing infants are able to selectively employ impulse control and cognitive flexibility to achieve goal-directed responses to novel situations.

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What is executive function and why is it important?

Executive function (EF) can be described as the cognitive toolkit of success. It underpins the ability to set goals and work towards those goals by co-ordinating thought and action, particularly in new situations. The precise nature of the ‘tools’ in the ‘kit’ is a matter of considerable debate, but they are largely considered to be higher-order self-regulatory processes, including the control of attention and motor responses, resistance to interference, and delay of gratification (Carlson, Mandell, & Williams, 2004; Diamond, 2013; Jurado & Rosselli, 2007), or, as Barkley puts it, “those self-directed actions needed to choose goals and to create, enact, and sustain actions toward those goals” (Barkley, 2012, p. 60).

From its emergence in very early childhood through to its decline in late adulthood, EF supports and constrains an individual’s ability to learn and thrive across their lifespan (Diamond, 2013). Not only does early EF have strong links to children’s later social and academic functioning (Blair & Peters Razza, 2007; Eisenberg et al., 2009), but difficulties with some EFs are implicated in a range of disorders including attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) (Barkley, 1997; Ozonoff, Pennington, & Rogers, 1991; Rommelse, Geurts, Franke, Buitelaar, & Hartman, 2011). However, currently executive dysfunction is primarily detected during a child’s school years. By developing our understanding of the developmental pathway(s) involved in EF, we may be able to monitor and intervene in cases where emergent EF is delayed or disrupted, whilst the brain is most responsive to treatment (Johnson, 2012; Wass, 2015).

Goals and structure of this review

The main aim of this review is to present an account of the current status of understanding of early EF and its components, by drawing together evidence of domains foundational to EF, the related attributes and skills that have predictive validity to EF later in life, and EF skills that emerge in the first 3 years of life. In doing so, this review outlines and critiques key methods used to measure EF and related attributes prior to the age of 3 and highlights gaps in knowledge and areas of theoretical and empirical debate.

The EF-related processes identified in this review can be categorised as relating broadly to one of four domains: control of attention, self-regulation and reactivity, processing speed and cognitive flexibility. These processes are each relevant to EF first as a foundational component – both supporting the development of EF itself and driving individual differences in that development – and then subsequently as a directly-contributing component of EF performance. As shall be demonstrated, these processes are deeply inter-related throughout early development.

In adults, performance on EF tasks has been found to be driven by a Common EF factor and separate ‘Updating-specific’ and ‘Shifting-specific’ factors (Miyake & Friedman, 2012). Common EF is understood to be the ability that allows individuals to maintain task-relevant goals, which in turn influences which other skills are deployed, and is isomorphic to the variable previously labelled in models as Inhibitory Control (the ability to deliberately override dominant or prepotent responses) (Miyake, Emerson, & Friedman, 2000). Thus, in adults, EF has both unity and diversity. In early childhood a dissociable pattern of EF abilities is less clearly evident. Many researchers have found that a single latent EF construct best describes pre-schoolers’ performance on EF batteries (Hughes, Ensor, Wilson, & Graham, 2009; Senn, Espy, & Kaufmann, 2004; Wiebe, Espy, & Charak, 2008; Wiebe et al., 2011; Willoughby, Wirth, Blair & Family Life Project Investigators, 2012), although more recent studies have detected dissociable EF factors in children aged 2 and 3 (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Garon, Smith, & Bryson, 2014; Mulder, Hoofs, Verhagen, van der Veen, & Leseman, 2014; Skogan et al., 2015). In this review, concurrent or predictive relations to probable latent variables are drawn out where supporting evidence is available.

Fig. 1 illustrates a conceptual model of the relationships between the foundational domains identified in infancy, emerging and dissociable EFs observed in toddlerhood, and their predictive relationship to the 3 EF factors observed (by some) from pre-school and beyond. This model has been developed by drawing together the evidence currently available, but remains to be tested with a longitudinal data set comprising all the relevant measures.

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