



Best practice guidelines

## Executive function outcome in preterm adolescents

Alice Claudia Burnett <sup>a,1</sup>, Shannon Elizabeth Scratch <sup>a,2</sup>, Peter John Anderson <sup>b,\*</sup>

<sup>a</sup> Murdoch Childrens Research Institute, Royal Children's Hospital, Flemington Rd, Parkville, VIC 3052, Australia

<sup>b</sup> Murdoch Childrens Research Institute & The University of Melbourne, Royal Children's Hospital, Flemington Rd, Parkville, VIC 3052, Australia

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### ABSTRACT

Preterm birth (PT) and low birthweight (LBW) are risk factors for cognitive, academic, and behavioral difficulties. Executive functioning, which is an umbrella term encompassing higher-order problem-solving and goal-oriented abilities, may help to understand these impairments. This review article examines executive functioning in PT and LBW children, with a specific focus on adolescence and the functional consequences of executive dysfunction in this age group. We have focused on adolescence as it is a critical period for brain, cognitive and social-emotional development, and a period of increased autonomy, independence and reliance on executive functioning. While more longitudinal research is required, there is evidence demonstrating that the PT/LBW population is at increased risk for impairments across all executive domains. Emerging evidence also suggests that executive dysfunction may partly explain poorer academic and social-emotional competence in PT/LBW adolescents. In conclusion, PT/LBW adolescents exhibit poorer executive functioning, and close surveillance is recommended for high-risk individuals.

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Prematurity at birth confers risk for a range of adverse outcomes, which are often evident even into adolescence and beyond. Cognitive-ly, the preterm (PT; <37 weeks' gestation) and low birthweight (LBW;

<2500 g) populations typically perform below their term-born peers across all cognitive domains, including lower general intelligence (IQ) [1,2]. Executive function difficulties are particularly prominent [3–5], and can persist despite accounting for IQ [6,7]. The cognitive deficits observed in the preterm population are likely to have broad implications and affect academic and social-behavioral functioning. This review paper explores executive functioning following preterm birth, and how executive dysfunction may influence everyday behavior and other functional outcomes. We have adopted a developmental approach, with a specific focus on adolescence, as this is a critical

\* Corresponding author. Tel.: +61 3 99366704; fax: +61 3 93481391.  
E-mail addresses: [alice.burnett@mcri.edu.au](mailto:alice.burnett@mcri.edu.au) (A.C. Burnett),  
[shannon.scratch@mcri.edu.au](mailto:shannon.scratch@mcri.edu.au) (S.E. Scratch), [peter.anderson@mcri.edu.au](mailto:peter.anderson@mcri.edu.au) (P.J. Anderson).

<sup>1</sup> Tel.: +61 3 9936 6679; fax: +61 3 9348 1391.

<sup>2</sup> Tel.: +61 3 9345 4833; fax: +61 3 93481391.

period for brain maturation as well as cognitive and social–emotional development. Furthermore, adolescence is a period of increasing autonomy in the academic and social spheres, which brings a greater reliance on executive functioning skills. Adolescence is generally agreed to commence with the onset of puberty, although its end lacks a biological cut-point; rather, the transition from adolescence to young adulthood is heralded by the assumption of adult social roles. For the purposes of this review we will focus on the 11 to 20 year age range.

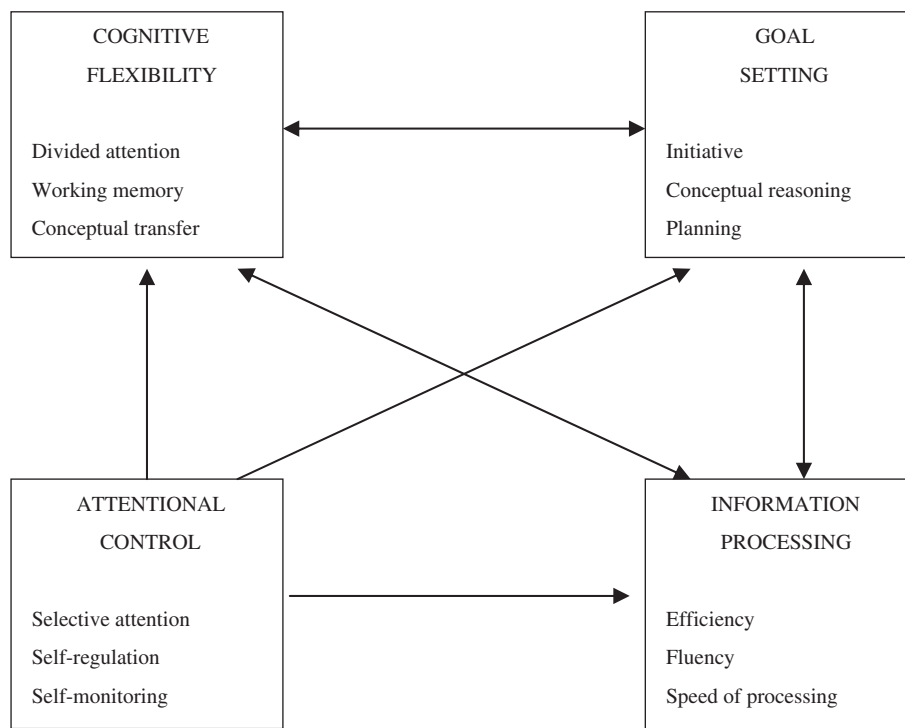
## 1. Executive function

Executive function is an umbrella term used to describe a set of high-level, interrelated cognitive abilities which are essential for goal-oriented behavior [8]. Importantly, executive functioning relies upon lower-level cognitive functions and cannot be assessed in isolation from these. Consensus is lacking as to the precise components of executive function, and a range of theoretical approaches has been proposed; none of which has been universally accepted. Nonetheless, it is generally agreed that executive functioning is important for adaptive outcomes such as everyday behavior [8]. For the purposes of this review on executive function and everyday behavior, we will adopt a conceptual framework called the Executive Control System [9,10], which categorizes the various elements of executive functioning into four broad interdependent domains. As shown in Fig. 1, this framework encompasses information processing, attentional control, cognitive flexibility, and goal setting.

In this model, *information processing* is characterized by sufficient speed, efficiency, and fluency. Importantly, these facets may be aided by other aspects of executive control, such as systematic organization and strategy generation. Behavioral manifestations of poor information processing may include slowing and dysfluency of responses. *Attentional control* forms a foundation upon which other executive domains rely, and includes the ability to direct and maintain the spotlight of attention on goal-relevant information, the ability to monitor

and regulate one's actions, inhibiting actions as necessary. Deficient attentional control may appear behaviorally as impulsivity, distractibility, and poor task persistence. *Cognitive flexibility* incorporates working memory (manipulation of information held temporarily “online”), the capacity to shift or transition to new settings and activities, generalize conceptual knowledge to novel situations, learn from previous experiences, and multi-task. Behaviorally, deficits in this domain may appear as difficulty adapting to changing demands or environments, becoming overloaded by incoming information, difficulty multi-tasking, or perseverative behavior. The final domain within this framework is *goal setting*. These processes include the ability to initiate an activity with adynamia, or an impairment of volition, a feature of a number of dysexecutive syndromes. Goal setting also requires the ability to plan a sequential and efficient course of action towards the desired goal, including organization of relevant steps and anticipation of potential disruptions to the plan. Behavioral signs of impaired goal setting may include difficulties in planning and strategy generation, as well as disorganized learning and/or retrieval of information.

Although assessing executive functioning is complicated by its multi-faceted nature, a range of measures is available to enable these skills to be reliably evaluated from preschool age through to adulthood [10]. Developmentally, the different executive domains are thought to mature at slightly different rates. While the most rapid development for all executive domains occurs between 3 and 7 years of age [10], executive processes continue to mature into late adolescence and early adulthood. For instance, the maturation of working memory has received much attention, and appears to have a particularly protracted development that continues to improve across the teenage years [11,12]. Working memory capacity has been linked with improvements in other aspects of executive function, such as strategy generation [13], which is consistent with the bidirectional relationships described in the above framework. Similarly, performance on less demanding strategic planning tasks tend to plateau in the late teens, while performance on more demanding tasks continue to demonstrate increments into the



**Fig. 1.** The executive control system.

Adapted from “Assessment and development of executive function (EF) during childhood,” by P. Anderson, 2002, *Child Neuropsychology*, 8(2), p. 71.

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