Journal of Experimental Child Psychology 152 (2016) 264–277

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Poor executive functioning in children born very preterm: Using dual-task methodology to untangle alternative theoretical interpretations

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ARTICLE INFO

Article history:
Received 7 March 2016
Revised 4 August 2016

Keywords:
Very preterm children
Executive function
Dual-task
Attention
Cascade model
Cognition
Development

ABSTRACT

Two alternative theoretical explanations have been proposed for the difficulties with executive functioning observed in children born very preterm (VP; ⩽32 weeks): a general vulnerability (i.e., in attentional and processing capacities), which has a cascading impact on increasingly complex cognitive functions, and a selective vulnerability in executive-level cognitive processes. It is difficult to tease apart this important theoretical distinction because executive functioning tasks are, by default, complex tasks. In the current study, an experimental dual-task design was employed to control for differences in task difficulty in order to isolate executive control. Participants included 50 VP children (mean age = 7.29 years) and 39 term peer controls (mean age = 7.28 years). The VP group exhibited a greater dual-task cost relative to controls despite experimental control for individual differences in baseline ability on the component single tasks. This group difference also remained under a condition of reduced task difficulty. These results suggest a selective vulnerability in executive-level processes that can be separated from any general vulnerability.

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http://dx.doi.org/10.1016/j.jecp.2016.08.002
0022-0965/

Introduction

Children born very preterm (VP; ⩽32 weeks) typically show poorer performance on tasks designed to measure high-level cognitive control processes (i.e., executive functioning), which suggests a selective executive-level vulnerability (Aarnoudse-Moens, Weisglas-Kuperus, van Goudoever, & Oosterlaan, 2009; Mulder, Pitchford, Hagger, & Marlow, 2009). Given that intact executive functioning is essential for academic achievement and behavioral regulation, an executive-level vulnerability may help to explain why children born very preterm experience difficulties in these functional domains (Aarnoudse-Moens, Smidts, Oosterlaan, Duivenvoorden, & Weisglas-Kuperus, 2009). However, by contrast, consistent findings of poorer performance across diverse cognitive domains following preterm birth have also led to the conclusion of a general cognitive vulnerability (P. Anderson, 2014). It has been proposed that it may be this general vulnerability (i.e., in attentional and processing capacities) that results in greater difficulty with complex cognitive tasks such as those measuring executive functioning, via a cognitive cascade (Rose, Feldman, & Jankowski, 2011; Rose, Feldman, Jankowski, & Van Rossem, 2008, 2011). The aim of this study was to tease apart this confounded question of whether difficulties associated with prematurity are the result of a general cognitive vulnerability or a selective problem with executive functioning by using a novel methodological approach (i.e., dual-task cost).

Cascade models of cognitive development propose that high-level cognitive functioning hinges on more general information processing abilities. Theoretically, age-related improvements in general information processing lead to an increase in the functional capacity of working memory, which in turn allows for improved high-level reasoning and problem solving (Fry & Hale, 1996, 2000; Kail, 2007). Faster processing speed means that more information can be represented and manipulated in working memory simultaneously, which allows more complex concepts and relations to be constructed (Demetriou et al., 2013). Alternatively, slow processing speed results in the slowed or delayed completion of required cognitive operations (Salthouse, 1996). As a result, the outcome of previous operations may decay in memory either before they are able to be completed or before they are required for subsequent action (Barrouillet, Gavens, Vergauwe, Gaillard, & Camos, 2009).

Rose and colleagues have proposed a cascade model to explain cognitive vulnerability following preterm birth. This cascade model proposes that limitations in general information processing (e.g., speed of processing) lead to difficulties with any complex cognitive function. In other words, executive functioning difficulties are the result of vulnerability in general cognitive processes rather than selective executive-level vulnerability. Rose and colleagues have supported this model with empirical findings (Rose, Feldman, Jankowski, & Van Rossem, 2005; Rose et al., 2008). For instance, one study supported a cognitive cascade from processing speed, through executive functioning (inhibition, working memory, and shifting), to poorer math and reading ability in 11-year-old children (Rose, Feldman, Jankowski, 2011). Longitudinal studies have shown that group differences in core cognitive capacities (e.g., processing speed, attention) during infancy explain the effect of prematurity on general mental development at 2 and 3 years of age (Rose et al., 2005, 2008). These studies support the view that vulnerability on complex cognitive tasks, such as executive functioning, is caused by the cascading impact of lower-level vulnerabilities.

Another class of theories that emphasizes general factors in determining complex cognitive functioning comprises resource-sharing models. Resource-sharing models predict that performance on complex cognitive tasks will be constrained when task demands exceed, or task operations are delayed by, some limited central processing resource (Barrouillet, Bernardin, Portrat, Vergauwe, & Camos, 2007; Chuderski, Taraday, Nęcka, & Smoleń, 2012; Lépine, Barrouillet, & Camos, 2005; McLeod, 1977; Tombu et al., 2011). Traditionally, resource-sharing models have proposed that each individual has a limited capacity of domain-general processing resources that can be allocated according to task demands (Kahneman, 1973; Wickens, 1980). Resource sharing is also often discussed in terms of a limited focus of attention (Barrouillet et al., 2007, 2009; Cowan, 2000, 2011; Tombu et al., 2011). Importantly, diverse cognitive operations are subject to the same central attentional limitation (Tombu et al., 2011). Therefore, to the extent that current cognitive processes occupy attention,