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The benefits of adding a brief measure of simple reaction time to the assessment of executive function skills in early childhood

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ABSTRACT

Early childhood represents a period of rapid cognitive developmental change in executive function (EF) skills along with a variety of related cognitive processes, including processing speed. This leads to interpretational challenges in that children's performance on EF tasks reflects more than EF skills per se. We tested whether the inclusion of a brief measure of simple reaction time (SRT) during EF assessments could help to partially address this challenge. Data were drawn from a cross-sectional convenience sample of 830 preschool-aged children. Individual differences in SRT were significantly associated with performance on all tasks (R^2s = .09–.26); slower performance on the SRT task was associated with poorer performance on each EF task. Age-related differences in individual EF tasks were reduced by approximately one half after accounting for age-related differences in SRT, and EF task scores were less coherent (i.e., less strongly intercorrelated with each other) after the removal of SRT. Age-related differences in EF were smaller (Cohen *d*s = 1.36 vs. 0.78), and poverty-related differences in EF were larger (Cohen *d*s = 0.30 vs. 0.46) after accounting for SRT-related variation. Finally, consistent with previous studies, SRT-related differences in fluid reasoning were mediated by EF skills. Results are discussed with respect to using a brief measure of SRT to partially address the problem of measurement impurity at the level of individual EF tasks.

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Introduction

Executive function (EF) skills are important for organizing information, planning and problem solving, and orchestrating thought and action in support of goal-directed behavior (Diamond, 2013). EF skills develop gradually from early childhood through early adulthood (De Luca & Leventer, 2008) and make unique contributions to children's social, behavioral, emotional, and academic development (Ursache, Blair, & Raver, 2012). There is strong interest among researchers, educators, and clinicians in measuring EF for purposes of basic and applied research as well as intervention-focused efforts.

One of the challenges in the early childhood literature on EF is that children's performance on tasks that purportedly measure EF skills reflects a wide range of cognitive processes, not just EF skills. For example, a variety of perceptual, receptive language, speed of processing, and fine motor skills likely contribute to children's performance on EF tasks. Many of these cognitive processes, which have been collectively referred to as foundational cognitive abilities (FCAs), develop rapidly in early childhood (see Espy, 2017). Moreover, individual differences in basic information processing abilities that emerge in infancy, including processing speed, contribute to children's performance on EF tasks in early childhood (Hendry, Jones, & Charman, 2016). Hence, young children's performance on EF tasks likely represents a confluence of EF and non-EF cognitive processes that are developing across the first 5 years of life.

It has become increasingly common for researchers to administer multiple EF tasks to young children and to use confirmatory factor analytic (CFA) models to represent EF ability as that variation that is shared across tasks (Hughes, Ensor, Wilson, & Graham, 2010; Miller, Giesbrecht, Muller, McInerney, & Kerns, 2012; Monette, Bigras, & Lafreniere, 2015; Wiebe et al., 2011). However, to the extent that non-EF processes contribute to performance across multiple EF tasks, latent variable representations of EF skills continue to suffer from the problem of conflating EF and non-EF sources of variation. Espy and colleagues recently drew attention to this problem and advised researchers to include measures of FCAs when assessing EF skills (Clark et al., 2014; Espy, 2017). They also advocated for the use of bifactor (an extension of CFA) models to explicitly remove FCA-related variation from the latent variable that represented EF. Removing FCA-related variation affected the associations between the construct of EF and criterion variables, including attention-deficit/hyperactivity disorder behaviors and socioeconomic status. A similar approach was used by van der Sluis and colleagues. In their study, the removal of rapid naming speed-related variation from EF tasks attenuated the association between the construct of EF and criterion measures of academic achievement (van der Sluis, de Jong, & van der Leij, 2007). Both studies underscore the value of incorporating measures of non-EF skills as a part of EF assessments.

As elaborated elsewhere, we have concerns about the use of CFA models, including bifactor models, as an approach for representing children's performance across a battery of EF tasks (Willoughby, 2014; Willoughby, Holochwost, Blanton, & Blair, 2014). The crux of our concern stems from the repeated observation that children's performance across a battery of EF tasks is often weakly correlated (*r*s $\approx$ .30). When CFA methods are used to represent individual differences in latent EF skills, most of the observed variation in each task is attributed to the residual error term, which includes systematic variation specific to each task and measurement error, and the resulting estimate of true score ability has uncertain meaning and implausibly strong temporal stability (Willoughby, Blair, & The Family Life Project Investigators, 2016; Willoughby, Kuhn, Blair, Samek, & List, 2017). Hence, although we agree with the suggestion that non-EF-related cognitive processes should be included as part of routine assessments of EF, we question whether the application of a CFA or bifactor modeling approach to a battery of tasks is the preferred or necessary solution (Willoughby, 2017). The current study considered a simple alternative approach that adjusts individual EF task scores.

One of the practical challenges of administering both EF and non-EF (e.g., FCAs, rapid naming speed) tasks is that it increases overall assessment time. Although issues of test burden are important for children of all ages, they are particularly salient when working with preschool-aged children, for whom assessment time is typically constrained to 30–45 min per testing occasion. In many contexts,

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