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Executive function predicts school readiness in autistic and typical preschool children

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ABSTRACT

Children's emerging executive functions (EF) have been shown to be critical for a whole range of other functions, including school readiness and later academic success. Here we examine for the first time whether individual differences in EF are uniquely associated with autistic children's readiness to learn in school, beyond general and developmental influences in age and ability. Thirty autistic and 30 typical preschool children, matched on age and ability, were assessed on EF (working memory, inhibition, set-shifting) and school readiness measures. Autistic children performed significantly worse on school readiness measures and EF measures relative to typical children. Furthermore, individual differences in children's EF skills, especially in inhibitory control and working memory, were uniquely related to variation in their school readiness for both autistic and non-autistic children. The findings from this cross-sectional study provide further support for the potential role of EF in explaining the variability in autistic children's functional outcomes.

1. Introduction

Entering school for the first time is an important transition for any child. The age at which this takes place varies in countries across the world but in England, the context of the current study, children begin formal education at age 5. Unlike home, childcare and most early learning environments, schools place increasing demands and expectations on children, not least the need to engage in formal, structured learning activities. Children will vary considerably in how ready they are to learn in these environments, including understanding key concepts like colours, letters, numbers and shape, and their social and emotional competence, which collectively have been termed "school readiness" (High, 2008). The extent to which children are prepared for this transition has a significant impact on their social and academic trajectories (Duncan et al., 2007; Friedman et al., 2007; Mashburn & Pianta, 2006; Moffitt et al., 2011; Snow, 2006). Understanding the potential sources of this variability across the full spectrum of typical and atypical development (Graham & Madigan, 2016) is therefore critical, particularly for children who are at risk of poor developmental outcomes.

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Although ecological factors, including parenting, home-school partnership, teacher/peer-child relationships, are widely acknowledged to play a role in children's readiness to learn in school (Pianta & Rimm-Kaufman, 2006), much attention in both policy (e.g., Allen, 2011; Bennett & Tayler, 2006) and research (Blair & Raver, 2015) contexts has been paid to child-level factors. One key factor highlighted by researchers is children's emerging executive functions (EF), a set of higher-order processes that underpin goal-directed activity and enable individuals to respond flexibly to change, including inhibiting prepotent but maladaptive responses, cognitive flexibility and future-oriented (or 'working') memory (see Garon, Bryson, & Smith, 2008; Hughes, 2011; Müller & Kerns, 2015, for reviews). This attention is unsurprising. It is well known that the prefrontal cortex, which partly mediates EF, shows a protracted developmental trajectory, with a particular boost precisely during the preschool period (Diamond, 2013). Furthermore, the transition to school itself relies on mastery of basic EF skills, including remembering and following instructions and representing the goal of the lesson (working memory), completing tasks independently and smoothly transitioning between tasks (cognitive flexibility), and staying on task (inhibitory control). EF, therefore, is held to play an important role in the acquisition of knowledge; the better children are at focusing and re-focusing their attention, holding information in mind and manipulating it and resisting distraction, the better placed children should be to acquire knowledge and skills in the classroom (Blair, 2002).

Several lines of evidence point towards the important role of EF in children's early school success. First, in one large survey of a national sample of teachers in the United States, 46% reported that more than half of the children in their classes showed problems adjusting with transition to kindergarten (Rimm-Kaufman, Pianta, & Cox, 2000). Teachers attributed children's difficulties not to limited knowledge of basic concepts, but to difficulties with following directions and controlling attention (see also, Heaviside, 1993) – thus endorsing a model of school readiness as executive control (Blair & Raver, 2015). Second, there is growing evidence for a substantial link both concurrently (Blair & Razza, 2007; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Bull, Espy, Wiebe, Sheffield, & Nelson, 2011) and longitudinally (Clark, Pritchard, & Woodward, 2010; McClelland et al., 2007; Neuenschwander, Röthlisberger, Cimeli, & Roebers, 2012; Riggs, Blair, & Greenberg, 2004) between typical preschoolers' early EF and their school readiness, over and above general intellectual ability (though see Blair & Willoughby, 2013 and Müller & Kerns, 2015, who call for more research to determine definitively the causal nature of this relationship). Third, several intervention studies have sought to foster learning in early childhood by "exercising" children's early-emerging EF skills (Bierman et al., 2008; Diamond, Barnett, Thomas, & Munro, 2007; Duncan et al., 2007). This research has demonstrated both that EF is malleable and can have significant positive effects on children's early academic success. Furthermore, studies focusing particularly on socially disadvantaged children, often with the weakest EFs, have consistently shown that they appear to benefit the most from intervention (Blair & Raver, 2014; Raver et al., 2011). Together, this evidence provides substantial support for the foundational role of EF in children's adjustment to, and readiness for, school (Blair & Raver, 2015; Ursache, Blair, & Raver, 2012).

Research on the EF-school readiness link has focused almost exclusively on the nature of this link in typically developing samples. Yet there is a substantial minority of children who follow atypical trajectories, some more pronounced than others. Knowledge of such links – either continuities *or* discontinuities – within atypically developing samples should serve to advance our understanding of typical development and indeed the fundamental variability that exists in capacities like EF and school readiness (see Jaswal, Akhtar, & Burack, 2016). The current study therefore examined the relationship between EF and school readiness in a group of children who are at increased likelihood for poor developmental outcomes, namely children on the autism spectrum.

Anecdotally, parents and teachers report that becoming accustomed to the new physical (built and sensory), social and academic environments can be particularly challenging and anxiety-provoking for their autistic[1] youngsters, especially given their core difficulties in social communication and social interaction and their preference for sameness (American Psychiatric Association, 2013). Despite these apparent problems in adjusting to school, there is strikingly little research either on autistic preschoolers' transition to formal education (see Forest, Horner, Lewis-Palmer, & Todd, 2004, for an exception) or on their school readiness. What we know from the also-limited literature on autistic children's academic achievement is that such achievement varies widely (e.g., Mayes & Calhoun, 2003; see Wong et al., 2014, for a review) with many children showing peaks and troughs on aspects of academic performance (reading, mathematics) that are incommensurate with their age and intellectual functioning (Estes, Rivera, Bryan, Cali, & Dawson, 2011; Jones et al., 2009). In a recent review, Keen, Webster, and Ridley (2016) found that, across 19 studies examining potential predictors of variation in autistic children's academic achievement, the majority focused on intellectual functioning and language ability as predictor variables. Remarkably, no study examined children's EF as a possible source of the variation in their academic outcomes, nor was it highlighted by Keen et al. (2016) as a potential avenue for future research.

The absence of research examining the potential role of EF in autistic children's academic outcomes is surprising, especially given that executive difficulties are well established in autism. Such difficulties, which typically manifest as perseverative responses (i.e., getting "stuck" performing the same action) and difficulties switching flexibly between response sets (Hill, 2004; Kenworthy, Yerys, Anthony, & Wallace, 2008; Leung & Zakzanis, 2014), were once thought to play a primary role in the development of autistic features (Damasio & Maurer, 1978; Ozonoff, Pennington, & Rogers, 1991; Pennington & Ozonoff, 1996), but this causal hypothesis is now controversial (Geurts, Corbett, & Solomon, 2009; Happé, Ronald, & Plomin, 2006;

[1] Identity-first language is the preferred language of many people on the autism spectrum (see Sinclair, 1999) and their parents (Kenny, Hattersley et al., 2016). In this article, we use this term as well as person-first language to respect the wishes of all individuals on the spectrum.