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# The contribution of children's time-specific and longitudinal expressive language skills on developmental trajectories of executive function

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### ABSTRACT

To investigate whether children's early language skills support the development of executive functions (EFs), the current study used an epidemiological sample ( $N = 1121$ ) to determine whether two key language indicators, vocabulary and language complexity, were predictive of EF abilities over the preschool years. We examined vocabulary and language complexity both as time-varying covariates that predicted time-specific indicators of EF at 36 and 60 months of age and as time-invariant covariates that predicted children's EF at 60 months and change in EF from 36 to 60 months. We found that the rate of change in children's vocabulary between 15 and 36 months was associated with both the trajectory of EF from 36 to 60 months and the resulting abilities at 60 months. In contrast, children's language complexity had a time-specific association with EF only at 60 months. These findings suggest that children's early gains in vocabulary may be particularly relevant for emerging EF abilities.

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## Introduction

Executive functions (EFs) refer to a set of abilities that are used in the service of problem solving and involve self-regulatory skills. This set of abilities typically includes aspects of working memory, attention shifting, and inhibitory control, and there is rapid development (improvement) in these skills during the first 5 years of life (Best & Miller, 2010) that has been linked to brain maturation (Bell & Fox, 1992; Klingberg, Vaidya, Gabrieli, Moseley, & Hedehus, 1999). Recent research has highlighted that EF is a critical aspect of early child development that is associated with academic achievement (Bierman, Torres, Domitrovich, Welsh, & Gest, 2009; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Thorell & Wählstedt, 2006), social-emotional development (Carlson, Mandell, & Williams, 2004; Hughes & Ensor, 2007; Riggs, Jahromi, Razza, Dillworth-Bart, & Mueller, 2006), and other cognitive abilities such as theory of mind (ToM; Carlson, Claxton, & Moses, 2015; Müller, Liebermann-Finestone, Carpendale, Hammond, & Bibok, 2012).

### *Language and EF*

Given its contribution to children's positive outcomes, there is interest in identifying factors that facilitate the early development of EF (Blair & Diamond, 2008). Doing so may create new opportunities for the development of early EF interventions. Zelazo and colleagues have previously developed a concept of EF that identifies language as a precursor (Zelazo & Frye, 1998; Zelazo, Müller, Frye, & Marcovitch, 2003). Specifically, the cognitive complexity and control (CCC) theory contends that children's ability to take specific actions to resolve conflict are dependent on their ability to use labels to create conscious representations of a problem (Zelazo, 1999). Furthermore, language is needed to construct and use the embedded rule structures that denote EF tasks (Marcovitch & Zelazo, 2009; Zelazo & Frye, 1998). The hierarchical competing systems model (HCSM; Marcovitch & Zelazo, 2009), a developmental framework that extends the CCC theory, explains that children's early cognitive processes arise from a habit system based exclusively on infants' previous experiences. During the course of development, this transforms into a representational system, in part through the use of language. In the context of EF development, children have a greater likelihood of overriding a prepotent response (e.g., moving to the representational system) when reflection occurs. This activation of the representational system occurs when children have the ability to verbally label a condition.

Although previous studies have established an association between children's language abilities and EF performance (for reviews, see Carlson, Davis, & Leach, 2005; Müller, Jacques, Brocki, & Zelazo, 2009), much of that research does not inform questions about whether and how early language development may serve as a developmental precursor to EF. Many of the previous studies can be loosely categorized as focusing on contemporaneous associations between language use and EF. For example, there is a persistent positive association between children's receptive language (i.e., the language that children passively comprehend) and their performance on a variety of EF tasks during childhood (Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Lang & Perner, 2002). These studies suggest that language and EF skills reflect some shared indirect measure of children's general cognitive ability. Another line of inquiry has suggested that language use can also act as a facilitator of EF performance. For instance, language aids EF performance through the labeling of conditions during a task (Kirkham, Cruess, & Diamond, 2003; Müller, Zelazo, Hood, Leone, & Rohrer, 2004; Yerys & Munakata, 2006), through the use of self-talk to scaffold performance (Alarcón-Rubio, Sánchez-Medina, & Prieto-García, 2014; Fernyhough & Fradley, 2005; Vygotsky, 1962), and by virtue of advanced cognitive flexibility and inhibitory control achieved through bilingualism (Bialystok, 2010; Carlson & Meltzoff, 2008; Foy & Mann, 2013). Despite their varied emphases, none of these studies has contributed to our understanding of emerging language as a precursor to later EF or how the maturation of language skills may be related to EF. More recent research has focused on the directionality of the relation between children's receptive vocabulary and EF (McClelland et al., 2014; Weiland, Barata, & Yoshikawa, 2014). The important point is that although numerous studies have investigated language and EF, few studies have tested the question of whether emerging language, which occurs over toddlerhood and the preschool period, provides a foundation on which EF skills develop.

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