



# Bidirectionality in preschool children's executive functions and language skills: Is one developing skill the better predictor of the other?



Pauline L. Slot<sup>a,1</sup>, Antje von Suchodoletz<sup>b,\*,1</sup>

<sup>a</sup> Utrecht University, Department of Child, Family, and Education Studies, PO Box 80125, 3508 TC Utrecht, The Netherlands

<sup>b</sup> New York University Abu Dhabi, Department of Psychology, PO Box 129188, Abu Dhabi, United Arab Emirates

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## ABSTRACT

Executive functions and language skills play a critical role for children's school readiness. The present study examined reciprocal relations between these two sets of skills among three-to-four-year-old children attending German preschools ( $N = 227$ ). Multiple tasks assessed executive functions and language skills twice over the one-year study period. Data was analyzed in a cross-lagged model with latent constructs. Findings provided support for bidirectionality between executive functions and language skills with language being a stronger predictor of executive function development than vice versa. Contrary to the hypothesis, no gender differences in executive functions and language skills were detected. Moreover, there were no statistically significant differences in the cross-lagged paths between executive functions and language skills between boys and girls. Together, our findings point to the importance of supporting children's language development for enhancing executive function development for both boys and girls.

## 1. Introduction

Executive functions and language skills play a critical role for children's school readiness, and are important predictors of early academic and social-emotional outcomes (Blair & Razza, 2007; Duff, Reen, Plunkett, & Nation, 2015; Duncan et al., 2007). It is well documented that executive functions and language skills undergo significant developmental changes during the early childhood years (Blair, Protzko, & Ursache, 2012; Farkas & Beron, 2004), suggesting that there might be simultaneous growth and reciprocal relations between the two skill sets (Bohlmann, Maier, & Palacios, 2015). Yet, the theoretical and empirical basis for the bidirectionality between executive functions and language skills is limited and there is an ongoing debate regarding the timing, strength, and direction of relations. Despite a relatively large body of research documenting the impact of executive functions on language acquisition (Blair et al., 2012; Henry, Messer, & Nash, 2012; Verhagen & Leseman, 2016), there is also evidence for the opposite hypothesis, i.e., that language supports executive function development (Kuhn et al., 2014; Petersen et al., 2013; Vallotton & Ayoub, 2011). Conclusions about possible bidirectionality between the development of executive functions and language skills remain limited, largely due to study design and small sample size. To date, only a few longitudinal studies investigated bidirectional relations between executive functions

and language skills in early childhood, but findings were inconsistent (Bohlmann et al., 2015; Fuhs, Nesbitt, Farran, & Dong, 2014; Fuhs & Day, 2011; Weiland, Barata, & Yoshikawa, 2014). In addition, research documents differences between boys' and girls' executive functions and language skills, suggesting a female advantage (Eriksson et al., 2012; Matthews, Cameron Ponitz, & Morrison, 2009; Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009; Sabbagh, Xu, Carlson, Moses, & Lee, 2006). However, it remains unclear whether bidirectional associations between executive functions and language skills are similar or different for boys and girls. The present study aimed to add to prior literature by examining reciprocal associations between boys' and girls' executive functions and language skills. By using multiple tasks to assess executive functions and language skills twice over the one-year study period, we aimed to contribute to a better understanding of the bidirectionality between these skills among preschool children.

Children with strong executive functions and language skills are more likely to adapt to and succeed in early education settings (Blair et al., 2012; Wanless et al., 2011; Weiland et al., 2014). Understanding the processes that may explain early disparities in these two important school readiness skills is therefore of utmost importance to reduce early risks for school failure, especially given the importance of the first years in life in laying the foundation for the development of these skills (e.g.,

\* Corresponding author.

E-mail addresses: [P.L.Slot@uu.nl](mailto:P.L.Slot@uu.nl) (P.L. Slot), [avs5@nyu.edu](mailto:avs5@nyu.edu) (A. von Suchodoletz).

<sup>1</sup> Equal contribution; co-first authors.

Diamond & Lee, 2011; Rose, Feldman, Jankowski, & van Rossem, 2008; Shonkoff, 2010; Shonkoff & Philips, 2000). Importantly, this line of research also has implications for practice in early childhood education (ECE). Over the past decade, the effects of ECE programs on children's development and learning have been of interest globally (e.g., *Education for All*, 2014; Evans & Popova, 2016; Ganimian, & Murnane, 2016; Pianta, Barnett, Burchinal, & Thornburg, 2009). The benefits of developmentally appropriate practices are documented for all children's outcomes, but may be especially strong for children who may be at risk for poor executive functions or language skills (e.g., Bowne, Yoshikawa, & Snow, 2016; Guo, Piasta, Justice, & Kaderavek, 2010; Hatfield, Burchinal, Pianta, & Sideris, 2016; Weiland, Ulvestad, Sachs, & Yoshikawa, 2013). Consequently, it is essential to provide all children with high quality ECE, which may help to ensure that they enter first grade with the skills necessary to succeed in school. Gaining more information on preschoolers' development of executive functions and language skills and their interrelatedness can help to inform and improve ECE practice and support the development of appropriate interventions.

### 1.1. Bidirectional associations between executive functions and language skills

Several lines of research suggest that executive functions, generally described as higher-level cognitive processes involved in the control of goal-directed action that include working memory, inhibitory control, and attentional or cognitive flexibility (Blair & Razza, 2007; Blair & Ursache, 2011; Fuhs & Day, 2011), and language skills are overlapping developmental processes. First, research has demonstrated that early language development relies on executive function processes (Blair et al., 2012; Montgomery, Magimairaj, & Finney, 2010; Rose, Feldman, & Jankowski, 2009; Verhagen & Leseman, 2016; Weiland et al., 2014). Most previous work has focused on the role of working memory for language acquisition and found, for example, that the ability to update information in working memory contributes to young children's vocabulary (Morra & Camba, 2009) and lexical learning and organization (Montgomery et al., 2010). Second, it has been argued that language drives executive function development through the use of self-talk (or private speech; Vygotsky, 1962) to regulate and plan goal-directed action (Fuhs & Day, 2011; Petersen et al., 2013). Deficits in language ability have shown to predict problems in regulating attention and behavior (Petersen et al., 2013; Vallotton & Ayoub, 2011). Particularly, children with specific language impairments (i.e., deficits in expressive or receptive language abilities but normal-range nonverbal intelligence) exhibit significant deficits in executive function tasks relative to same-age peers with normally developed language (Henry et al., 2012; Im-Bolter, Johnson, & Pascual-Leone, 2006). A possible explanation for executive function difficulties in children with specific language impairments might be neural deficits in processing during executive function tasks, as indicated by a different pattern in an event-related potential paradigm in comparison to typically developing children (Stevens, Sanders, & Neville, 2006). Third, there is initial evidence that interventions targeting executive functions may improve preschool children's language-related skills (Rojas-Barahona, Förster, Moreno-Ríos, & McClelland, 2015).

Although the relationship between executive functions and language skills has been established, the use of concurrent data in many studies limits conclusions regarding possible reciprocal associations between the two skills. In terms of longitudinal evidence, findings of previous studies are so far inconsistent regarding the bidirectionality in executive functions and language skills. Bohlmann et al. (2015) found simultaneous growth and reciprocal relations between executive functions and language skills in preschoolers. However, differences depended on children's age indicating that the reciprocal relation only occurred from approximately 56–62 months of age (from wave 2 to wave 3), whereas when children were younger the association between

executive functions and language skills was only unidirectional. Like with most previous research, the study assessed executive functions based on a single measure and focused on one domain of language, i.e., vocabulary, thus limiting the conclusions that can be drawn from the results. Although another study used a multi-method approach to assess executive functions and language skills among preschoolers, the language domain under investigation was also limited to vocabulary (Fuhs & Day, 2011). Results did not support a bidirectional relation but suggested that vocabulary might be driving executive function development. To date, the research base on other language-related skills that develop rapidly during the first few years of life, in particular grammar knowledge and grammar understanding, remains scarce.

### 1.2. Neuropsychological foundations of executive functions and language

Recent neuroscience literature provides empirical and theoretical evidence for overlapping neural processes involved in executive functions and language skills, thus supporting the hypothesis that the two skills are interrelated processes. With regard to executive functions, Duncan (2001) proposed an adaptive coding model of prefrontal cortical function. It assumes that circuitry and the flexible adaptation of neural networks in the prefrontal cortex play a central role in orchestrating neural processes to enable goal-directed action (Blair et al., 2012; Blair & Ursache, 2011; Duncan, 2001). In line with these assumptions, neural imaging studies have shown that performance on executive function tasks is associated with activation of anterior brain regions, primarily frontal cortex (Blair et al., 2012). Recent work also advanced our understanding of the neural organization of language. Despite consensus that language processing is associated with activity in the Broca's area (Sakai, 2005; Rogalsky & Hickok, 2011), the role of this area has been re-evaluated (Poeppel, Emmorey, Hickok, & Pyllkänen, 2012; Rogalsky & Hickok, 2011). There is growing evidence that Broca's area supports both language and non-language processing, which lead to the assumption that the contribution of Broca's area to language might be partly due to its role in executive function processes, particularly in working memory and attentional or cognitive flexibility (Poeppel et al., 2012; Rogalsky & Hickok, 2011).

Executive functions and language acquisition are associated with developmental changes in the brain. For example, the synaptic density in prefrontal cortical regions, a brain area relevant to executive functions, peaks about midway through the second year of life, however, adult levels are not reached until late adolescence (Shonkoff & Phillips, 2000; Welsh, Friedman, & Spieker, 2006). The pattern looks different for the synaptic density in areas involved in language. The peak is earlier, at around age 1 years, followed by a gradual retraction to reach adult levels already by the end of the preschool period (Shonkoff & Phillips, 2000). Neurodevelopmental changes in the developing brain may help to understand variability in the direction of associations between executive functions and language skills. Yet, the empirical base to conclude whether one skill set might be the leading indicator of the other early in development or regarding the onset of reciprocal associations is still limited.

### 1.3. Gender differences in executive functions and language skills

There is growing evidence of considerable gender differences in young children's executive functions and language skills (Eriksson et al., 2012; Matthews et al., 2009; Mulder, Hoofs, Verhagen, van der Veen, & Leseman, 2014; Rimm-Kaufman et al., 2009; Sabbagh et al., 2006; Wanless et al., 2013). Using various measures of executive functions, ample research found that girls outperform their male counterparts. For instance, Mulder et al. (2014) showed in a large-scale study involving Dutch two-year olds that girls performed better on a wide range of executive function tasks than boys. A similar pattern of gender differences is also reported for language skills. For example, one

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