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Knowing minds, controlling actions: The developmental relations between theory of mind and executive function from 2 to 4 years of age

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ABSTRACT

This longitudinal study examined the concurrent and predictive relations between executive function (EF) and theory of mind (ToM) in 82 preschoolers who were assessed when they were 2, 3, and 4 years old. The results showed that the concurrent relation between EF and ToM, after controlling for age, verbal ability, and sex, was significant at 3 and 4 years of age but not at 2 years of age. Hierarchical regression analyses showed that EF at age 2 significantly predicted ToM at age 3 and that EF at age 3 significantly predicted ToM at age 4, over and above the effects of age, verbal ability, and prior performance on ToM tasks. However, ToM at ages 2 and 3 did not explain a significant amount of variance in EF at age 4. Bootstrap procedures revealed that verbal ability at age 3 fully mediated the relation between ToM at age 2 and EF at age 4.

Introduction

During the preschool period, children make significant progress in both their understanding of their own and other people's mental life and perspective (or *theory of mind* [ToM]) and their conscious control of action and thought (or *executive function* [EF]) (see Carpendale & Lewis, 2006). To a large extent, ToM research has focused on the acquisition of false belief understanding. False belief understanding is considered a milestone in development because it indicates that children differentiate be-

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tween mind and world and understand that someone can have a belief that differs from reality (Astington, 1993; Carpendale & Lewis, 2010; Perner, 1991). The development of EF, in turn, is marked by growth in several domains such as working memory, inhibitiory control, and flexibility in rule use (e.g., Carlson, 2005; Garon, Bryson, & Smith, 2008; Zelazo & Müller, 2010).

Interestingly, the acquisition of false belief understanding coincides with significant changes in EF. In a meta-analysis of extant studies, Perner and Lang (1999) reported that the average correlation between false belief understanding and EF amounts to a strong effect size (d = 1.08); a significant correlation persists even after controlling for age, verbal ability, and general cognitive abilities (e.g., Carlson & Moses, 2001; Frye, Zelazo, & Palfai, 1995; Perner, Lang, & Kloo, 2002). Furthermore, false belief understanding and EF have been found to be significantly correlated in different cultures (e.g., Chasiotis, Kiessling, Hofer, & Campos, 2006; Oh & Lewis, 2008; Sabbagh, Xu, Carlson, Moses, & Lee, 2006) and in atypically developing children (e.g., Dennis, Agostino, Roncadin, & Levin, 2009; Pellicano, 2007; Pellicano, 2010). These and other robust findings have led researchers to suggest that the development of ToM and EF is "in some way bound together" (Moses & Tahiroglu, 2010, p. 218).

A variety of explanations have been offered to account for the empirical relation between false belief understanding and EF (Perner & Lang, 1999; Moses, & Tahiroglu, 2010), including that (a) false belief understanding is a prerequisite for EF (Perner & Lang, 1999), (b) EF is a prerequisite for the emergence of false belief understanding (Moses & Carlson, 2004; Sabbagh et al., 2006), (c) false belief tasks have executive components (e.g., they require the ability to inhibit a prepotent response; see Carlson, Moses, & Hix, 1998), and (d) false belief tasks and EF are related because they share a common level of complexity (Frye, Zelazo, & Burack, 1998).

Training and longitudinal studies provide a means to further investigate these explanations. Kloo and Perner (2003) found that training children's false belief understanding improved performance on an EF task; conversely, training EF also promoted false belief understanding, suggesting that EF and false belief understanding reciprocally influence each other. In two microgenetic studies, Flynn and colleagues (Flynn, 2007; Flynn, O'Malley, & Wood, 2004) found that for the majority of children good performance on EF tasks was a prerequisite for good performance on false belief tasks. Similarly, Hughes (1998) reported that EF performance at 4 years of age significantly predicted performance on false belief tasks 1 year later, even when effects of age, verbal ability, and initial false belief understanding were controlled. By contrast, performance on false belief tasks at age 4 did not predict later performance on EF tasks.

More recent longitudinal studies by Carlson, Mandell, and Williams (2004) and by Hughes and Ensor (2007) have examined the relation between ToM and EF in younger children. The study by Carlson and colleagues (2004) showed that performance on EF tasks at 24 months of age predicted performance on ToM tasks (e.g., visual perspective taking, pretend–reality) at 39 months of age even after controlling for age, verbal ability, maternal education, and ToM performance at 24 months. By contrast, ToM performance and mental state language at 24 months did not predict EF at 39 months over and above control variables. In the study by Hughes and Ensor (2007), performance on EF tasks at 2 years of age significantly predicted performance on ToM tasks at 3 and 4 years of age even after controlling for performance on ToM tasks at age 2, verbal ability, social status, age, and sex. The relation between EF at age 3 and ToM at age 4 was also significant but did not remain significant once control variables were entered. Interestingly, performance on ToM tasks at age 2 also predicted performance on EF tasks at age 4, over and above control variables.

The preponderance of empirical evidence from microgenetic and longitudinal studies supports the proposal that advances in EF are a prerequisite for the emergence of ToM in general and false belief understanding in particular; however, there is only limited support (Hughes & Ensor, 2007; Kloo & Perner, 2003) for the proposal that advances in EF depend on advances in ToM, specifically on the emergence of false belief understanding. Information about the relation between EF and ToM is still limited for a number of reasons. First, with the exception of the study by Hughes and Ensor (2007), longitudinal studies extend over a relatively short time interval, ranging from 20 weeks (Flynn, O'Malley, & Wood, 2004) to 1 year (Carlson et al., 2004). For that reason, it is largely unknown whether the relation between ToM and EF extends over a longer developmental time span.

Furthermore, the finding that ToM explained a significant amount of variance in EF only for the 2-year interval (Hughes & Ensor, 2007) suggests that it may be necessary to use a longer interval to de-