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Executive and theory-of-mind contributions to event-based prospective memory in children: Exploring the self-projection hypothesis

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ABSTRACT

In two studies, 4- to 6-year-olds were asked to name pictures of animals for the benefit of a watching hand puppet (the ongoing task) but to refrain from naming and to remove from view any pictures of dogs (the prospective memory [PM] task). Children also completed assessments of verbal ability, cognitive inhibition, working memory, and false-belief understanding (both studies), empathy (Study 1 only), and performance on false-sign tests that matched the false-belief tests in narrative content and structure (Study 2 only). Both studies found that inhibition and false-belief performance made unique contributions to the variance in PM, although in Study 1 the influence of inhibition was evident only when children needed to withhold naming. Study 2 further demonstrated that false-belief performance was the only reliable predictor of whether children remembered to return to the researcher an object that had been loaned to them prior to the picture-naming game. Both experiments uncovered moderate relations between PM and chronological age, but such relations were rarely significant after taking account of cognitive ability. We consider the implications of the findings for (a) current views regarding frontal/executive contributions to PM development and (b) the suggestion that the same brain network underlies various forms of mental self-projection, including envisioning the future and understanding the minds of other people.

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Introduction

The term *prospective memory* (PM) refers to the act of remembering to carry out planned activities at some appropriate time in the future (Kvavilashvili, 1992). Whereas *time-based* PM involves remembering to perform a task at a prearranged time, *event-based* PM involves remembering to do something in response to a specific external cue whose timing is unpredictable (Einstein & McDaniel, 1990; Kvavilashvili & Fisher, 2007). For example, children might want to remember to watch their favorite television program when they get home from school or to pass on an important message to their mother when they next see her. It has been suggested that PM involves four main phases, namely (a) forming the intention, (b) retaining the intention in memory during the course of intervening activity, (c) initiating the intended action at the appropriate time, and (d) executing the intended action according to the original plan (Ellis, 1996; Kliegel, Martin, McDaniel, & Einstein, 2002).

Compared with an extensive literature detailing the development of children's ability to remember past events (retrospective memory), relatively few studies have focused on PM (see Kvavilashvili, Kyle, & Messer, 2008, for a review). On the whole, research on the latter topic has documented robust gains in PM accuracy as children grow older, particularly when examining broader age ranges (Kerns, 2000; Kliegel & Jäger, 2007; Mackinlay, Kliegel, & Mäntyla, 2009; Passolunghi, Brandimonte, & Cornoldi, 1995; Rendell, Vella, Kliegel, & Terrett, 2009; Wang, Kliegel, Liu, & Yang, 2008). Improvements in PM during early childhood are mirrored by declines in PM during late adulthood (Henry, MacLeod, Phillips, & Crawford, 2004; Smith & Bayen, 2006; West, Jakubek, & Wymbs, 2002; Zeintl, Kliegel, & Hofer, 2007), giving rise to an "inverted U" developmental trajectory in regard to PM capabilities across the lifespan (Zimmermann & Meier, 2006; Zöllig et al., 2007).

PM and executive functions

Given the multistage nature of PM, the task of identifying the causes of its development poses a significant challenge. One suggestion has been that young children's difficulties with PM are due mainly to their forgetting what their intention was (Guajardo & Best, 2000). Given persistent evidence of age effects in PM even after screening out participants with retrospective memory failures, however, it is clear that processes unique to PM are also subject to maturation (Kliegel & Jäger, 2007). In terms of PM itself, a widely held view is that development is driven by age-related improvements in executive functions, including working memory, planning, monitoring, inhibition, and cognitive flexibility, all of which are subserved by the prefrontal cortex (Martin, Kliegel, & McDaniel, 2003). This notion accords with the inverted U developmental trajectory in PM given that the prefrontal cortex does not reach full maturity until late adolescence and, conversely, shows reductions of volume and complexity during old age (West, 1996; Zimmermann & Meier, 2006).

Evidence of an involvement of executive functions in PM comes from studies showing that children's PM performance is impaired by raised cognitive load, for example, when a delay is introduced between the appearance of the PM cue and the opportunity to enact the response (Rendell et al., 2009) or when the ongoing task must be interrupted to execute the PM response (Kliegel, Mackinlay, & Jäger, 2008; Shum, Cross, Ford, & Ownsworth, 2008; Wang et al., 2008). In one of the first studies of this kind, Kvavilashvili, Messer, and Ebdon (2001) asked 4- to 7-year-olds to name line drawings of everyday objects and animals, presented in four stacks of 20 pictures each, while showing the pictures to a toy mole (i.e., the ongoing task). To introduce a PM component, children were advised that the mole was afraid of other animals and that if they came across a picture of an animal, they should *not* show it to the mole but rather should place the picture out of sight on a table placed just behind them. There was one picture of an animal embedded in each stack, either in the 10th position (interruption condition) or in the final position (no-interruption condition). Results showed a reliable (albeit small) age-related improvement in PM accuracy and a significant effect of condition, indicating that accuracy was impaired when the ongoing task needed to be interrupted. In a computer-based experiment structured along similar lines, Kliegel et al. (2008) observed that the adverse effects of interruption were greater for first-grade children, fourth-grade children, and older adults than for young adults. Their results conformed to the predicted inverted U developmental pattern on measures of intention