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Relations among prospective memory, cognitive abilities, and brain structure in adolescents who vary in prenatal drug exposure

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ABSTRACT

This investigation examined how prospective memory (PM) relates to cognitive abilities (i.e., executive function, attention, working memory, and retrospective memory) and brain structure in adolescents who vary in prenatal drug exposure (PDE). The sample consisted of 105 (55 female and 50 male) urban, primarily African American adolescents (mean age = 15.5 years) from low socioeconomic status (SES) families. Approximately 56% ($n = 59$) were prenatally exposed to drugs (heroin and/or cocaine) and 44% ($n = 46$) were not prenatally exposed, but the adolescents were similar in age, gender, race, and SES. Executive functioning, attentional control, working memory, retrospective memory, and overall cognitive ability were assessed by validated performance measures. Executive functioning was also measured by caregiver report. A subset of 52 adolescents completed MRI (magnetic resonance imaging) scans, which provided measures of subcortical gray matter volumes and thickness of prefrontal, parietal, and temporal cortices. Results revealed no differences in PM performance by PDE status, even after adjusting for age and IQ. Executive function, retrospective memory, cortical thickness in frontal and parietal regions, and volume of subcortical regions (i.e., putamen and hippocampus) were related to PM performance in the sample overall, even after adjusting for age, IQ, and total gray matter volume. Findings suggest that variations in PM ability during adolescence are robustly

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related to individual differences in cognitive abilities, in particular executive function and retrospective memory, and brain structure, but do not vary by PDE status.

Introduction

Prospective memory (PM) is the ability to complete an intended action at a specified future point in time or, more simply, remembering to remember (e.g., Brandimonte, Einstein, & McDaniel, 1996). PM is a multi-phase, complex cognitive ability that includes (a) planning a future activity (intention formation), (b) keeping the intended future event activity in mind (intention retention), (c) initiating the activity (intention initiation), and (d) carrying out the activity according to the previously formed plan (intention execution) (Kliegel, Martin, McDaniel, & Einstein, 2002). An everyday example of PM is remembering to take food out of the oven amid completing other tasks (e.g., making a salad, setting the table, talking on the phone). PM is important for successful daily functioning across the lifespan (Crovitz & Daniel, 1984; Kliegel & Martin, 2003; Terry, 1988).

Although young children are able to complete simple PM tasks (e.g., Ceci & Bronfenbrenner, 1985), age-related improvements have been documented between childhood and adulthood (e.g., Kliegel, Mackinlay, & Jäger, 2008; Wang, Kliegel, Yang, & Liu, 2006; Ward, Shum, McKinlay, Baker-Tweney, & Wallace, 2005; Zimmermann & Meier, 2006; Zöllig et al., 2007). These age-related differences are thought to arise due to environmental and maturational factors, including increased demands placed on individuals (at home, school, and work), increased ability to complete complex cognitive tasks in general, and prolonged development of brain regions supporting PM (Dumontheil, Burgess, & Blakemore, 2008; Kvavilashvili, Messer, & Messer, 2008). The adolescent years may be particularly important in PM development because this period is characterized by (a) significant increases in autonomy (e.g., Osipoff, Dixon, Wilson, & Preston, 2012), (b) improvements in higher order cognitive functions (for a review, see Steinberg, 2005), and (c) continued brain development (particularly of frontal regions; e.g., Gogtay et al., 2004). Indeed, previous research has documented age-related improvements in PM ability during adolescence (e.g., Meacham & Colombo, 1980; Mäntylä, Carelli, & Forman, 2007; Wang et al., 2006, 2011; Zöllig et al., 2007), although exceptions exist (Ward et al., 2005; Zimmermann & Meier, 2006). The current study examined PM during adolescence.

Relations between development of PM and other cognitive abilities

Previous developmental research has shown that age-related improvements in the ability to successfully complete PM tasks are related to the development of at least four different aspects of cognitive functioning: executive functions (e.g., inhibition, cognitive flexibility, planning), controlled attention, working memory, and retrospective memory.

Executive functioning

One study examining PM in 7- to 12-year-old children showed that a large portion of age-related variance in PM task performance could be explained by performance on measures of planning (mapping out a trip to the zoo) and task switching (alternating between two sets of instructions) (Mackinlay, Kliegel, & Mäntylä, 2009; see also Kerns, 2000; Mahy & Moses, 2011; Wang et al., 2006). Similarly, in a study of children (7–10 years), adolescents (13–16 years), and adults (18–21 years), performance on two executive function tasks (self-ordered pointing and Stroop Color Word Interference) predicted PM performance when cognitive demands were high, with better performance on the executive function tasks related to better PM (Ward et al., 2005). These findings suggest that development in executive functioning relates to age-related increases in PM ability.