



# Event-based prospective memory in children with autism spectrum disorder: The role of executive function



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## ABSTRACT

The present study investigated event-based prospective memory (PM) and its cognitive correlates in children with autism spectrum disorder (ASD) compared to age- and ability-matched typically developing (TD) peers. Participants included 25 children with ASD, 25 age-matched TD peers, and 28 ability-matched TD peers. Participants completed one PM task, and several executive functioning tasks assessing working memory (Block Recall Task), inhibitory control (Stroop Task), and cognitive flexibility (Dimensional Change Card Sorting Task). Results indicated that children with ASD had significantly lower scores on the PM task than children in the TD groups. Additionally, PM performance of children with ASD was significantly predicted by their nonverbal IQ, whereas PM performance of TD children was significantly predicted by their inhibitory control. These results provide evidence for the PM deficit in children with ASD and the effect of cognitive functioning, rather than a specific aspect of executive function, on the development of PM.

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## 1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by socio-communication impairments, and restricted and repetitive behaviors. Many individuals with ASD also have impairments in executive functioning skills (see Hill, 2004 for review), and thus have difficulty with tasks that require planning, organizing, inhibiting behavior, keeping track of multiple things simultaneously, and keeping track of time. Day to day living skills, as well as some types of memory functions requires implementation of executive functioning skills.

One type of memory that requires executive functioning skills is prospective memory (PM). PM is the type of memory required to conduct future actions (e.g., McDaniel & Einstein, 2007; Williams, Boucher, Lind, & Jarrold, 2013). PM plays an important role in daily cognition and activities of daily living, ranging from relatively simple tasks (e.g., remembering to buy groceries) to more fundamental tasks (e.g., remembering to take necessary medication). There are two ways in which PM retrieval can occur, by an event, event-based PM, for example remembering to call a friend for their birthday; or by a specific time

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point, time-based PM, for example remembering to make a phone call in 20 minutes. Due to the presence of an external cue, event-based PM tasks are relatively simpler than time-based PM tasks, which require more self-initiation (Williams et al., 2013).

PM requires the integration of several complex processes. First, one has to plan the future action, and maintain the intention to complete the action while processing other information. Second, when either an event-based or a time-based cue is presented, one has to retrieve the PM, inhibit, and flexibly switch from an on-going task to the planned action (Kliegel, Martin, McDaniel, & Einstein, 2002). Therefore, successful PM requires a certain level of executive functioning ability, which typically involves three functional domains: working memory, cognitive flexibility, and inhibitory control (Altgassen, Williams, Bölte, & Kliegel, 2009; Mackinlay, Charman, & Karmiloff-Smith, 2006; Miyake et al., 2000). Impairments in these aspects of executive functioning have been highlighted in several studies of children with ASD (e.g., Cui, Gao, Chen, Zou, & Wang, 2010; Dichter et al., 2010; Ozonoff & Jensen, 1999; Prior & Hoffman, 1990; Yi et al., 2012). In light of these executive functioning deficits, it is reasonable to postulate that individuals with ASD would also have associated deficits in PM.

The few studies that have examined PM in individuals with ASD have had contradictory findings. While several studies have repeatedly demonstrated impaired time-based PM in individuals with ASD (Altgassen et al., 2009; Altgassen, Koban, & Kliegel, 2012; Williams et al., 2013), studies examining event-based PM have been less conclusive. Some studies have reported intact event-based PM skills in ASD (Altgassen, Schmitz-Hübsch, & Kliegel, 2010; Williams et al., 2013), while other studies have reported impairments (Altgassen et al., 2012; Brandimonte, Filippello, Coluccia, Altgassen, & Kliegel, 2011; Jones et al., 2011). Two factors may be contributing to this discrepancy—heterogeneity of the sample and heterogeneity of the types of PM tasks used. Participants in the Altgassen et al. study (2012) were adults, while participants in other studies were primarily children and adolescents (Altgassen et al., 2010; Williams et al., 2013). In terms of task heterogeneity, tasks used in previous studies included standard PM tasks, such as the Red Pencil test, the Dresden Breakfast task (Altgassen et al., 2012), the Rivermead Behavioral Memory test (Jones et al., 2011), and several computer-based games (Altgassen et al., 2009; Williams et al., 2013). These tasks are varied in their nature and complexity, as such the performance of PM in individuals with ASD varied dependent on task difficulty. For example, in the Dresden Breakfast task, a naturalistic prospective memory task which has high demands on inhibition and switching, adult participants with ASD demonstrated more impaired event- and time-based PM performance than typical controls (Altgassen et al., 2012).

Despite its theorized relationship with PM, the exact role that executive functioning plays in PM in individuals with ASD has been difficult to establish. It has been postulated that event-based PM tasks have less of a demand for executive functioning than time-based PM tasks (Altgassen et al., 2012); as such, these skills may not be as affected when an individual has executive functioning deficits. In school-aged children with ASD, Williams et al. (2013) did not find a relationship between executive functioning and PM; and in adults with ASD, only time-based PM tasks were related to executive functioning skills (Altgassen et al., 2012).

An important aspect to consider however is the effect of age on executive functioning skills. These skills develop with age, and studies have found significant age effects on executive functioning in typically developing children (e.g., Kvavilashvili, Messer, & Ebdon, 2001; Somerville, Wellman, & Cultice, 1983). In a longitudinal study examining the development of executive functioning in typically developing children, Lee, Bull, and Ho (2013) demonstrated that the organization of these skills change from early childhood to adolescence, with older children having better developed inhibitory control. In ASD, while some executive functioning skills improve over time, it is at a slower rate, and it generally remains impaired compared to typically developing children (O’Hearn, Asato, Ordaz, & Luna, 2008). Thus, some of the differences observed across studies may in fact be related to the age difference of the participants, as executive functioning may play a more important role in the PM development in younger children. An alternative explanation is the possible effect of intellectual functioning on executive functioning skills.

Executive functioning skills are difficult to disentangle from cognitive skills. Many of the cognitive processes that are associated with intellectual functioning, for example working memory and processing speed also involve executive functioning skills. Studies have found that some aspects of executive functioning are associated with IQ. However, the previous studies that have examined the PM abilities of individuals with ASD have primarily included a homogeneous group of participants with average to above average cognitive skills (Altgassen et al., 2009, 2010, 2012; Brandimonte et al., 2011; Jones et al., 2011; Williams et al., 2013).

The current study has three aims: (a) to compare the performance of event-based PM in young children with ASD to their typically developing age- and ability-matched peers; (b) to investigate the role of executive functioning on event-based PM in young children with ASD with below average nonverbal IQ (NVIQ); and (c) to examine the role of age and cognitive functioning in the development of event-based PM in young children with ASD with below average NVIQ compared to age- or ability-matched typically developing peers. Based on the few studies examining PM in children with ASD, we expected that this young group of children with ASD would demonstrate poorer performance on the event-based PM task than their typically developing peers. Additionally, we expected that the PM performance in children with ASD would be related to cognitive functioning and to some aspects of executive functioning.

## 2. Method

### 2.1. Participants

Participants included 25 preschool or school-aged children diagnosed with ASD (range = 4–10 years,  $M_{age} = 7.66$  years,  $SD = 1.56$ ; 6 female), 25 age-matched typically developing children (TD; range = 4–11 years,  $M_{age} = 7.68$  years,  $SD = 1.72$ ;

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