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Prospective memory in adults with high-functioning autism spectrum disorders: Exploring effects of implementation intentions and retrospective memory load

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ABSTRACT

This study examined, for the first time, the impact of implementation intentions on prospective memory (PM) performance in adults with autism spectrum disorders (ASD) and further explored the role of retrospective memory for PM in ASD. PM was assessed with Virtual Week, a computerized game simulating upcoming everyday-life tasks. Twenty-seven adults with ASD and 27 age- and ability-matched controls were included. Half of the participants were instructed to form implementation intentions (i.e., encoding PM tasks in form of if-then statements), while the rest received simple PM instructions. Results provide first tentative evidence for beneficial effects of implementation intentions and PM tasks with low demands on retrospective memory for adults with ASD's PM. Overall, results point to the importance of planning and retrospective memory for successful prospective remembering in ASD.

1. Introduction

Individuals with autism spectrum disorders (ASD) exhibit difficulties to organize everyday life and to cope with daily demands such as planning and coordinating activities. These difficulties have been related to impairments in prospective memory (PM) and underlying executive function and retrospective memory deficits (Mackinlay, Charman, & Karmiloff-Smith, 2006). PM refers to the ability to remember to initiate intended actions in the future. Everyday life examples for PM tasks are remembering to take medication on time, to attend meetings or to post a letter on the way back home (Kliegel, Jäger, Altgassen, & Shum, 2008). PM is crucial for meeting social and occupational demands of everyday life, maintaining one's health and developing and maintaining autonomy (Terry, 1988).

Prospective remembering comprises multiple phases and processes (Kliegel, Martin, McDaniel, & Einstein, 2002). First, the intention has to be planned (intention formation). This plan has then to be kept in memory while the individual is engaged in other ongoing activities (intention retention, Einstein, Holland, McDaniel, & Guynn, 1992). When the appropriate

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moment to initiate the intention arises, the planned activity has to be retrieved, initiated (intention re-instantiation) and performed in accord with the previously formed plan while other ongoing activities have to be interrupted (intention execution, Kliegel, McDaniel, & Einstein, 2000). Thus, executive functions and retrospective memory are involved in prospective remembering (Einstein et al., 1992; Fortin, Godbout, & Braun, 2003; Mäntylä & Nilsson, 1997); though the extent of their involvement depends on characteristics of the respective task and the individual (McDaniel & Einstein, 2000).

In PM research several types of PM tasks are differentiated based on the type of cue that indicates the appropriate moment to initiate the intention as well as on the regularity with which they need to be performed (Brandimonte, Einstein, & McDaniel, 1996; Foster, Rose, McDaniel, & Rendell, 2013; Rendell & Craik, 2000). In *time-based* PM tasks the intended action has to be performed at a certain time-point in the future (e.g., remember to visit the dentist the following day at 9 a.m.), while in *event-based* PM tasks a specific (situational) cue indicates the appropriate moment to initiate the intention (Brandimonte et al., 1996). Previous studies on event- and time-based PM have consistently reported lower performance in time- compared to event-based tasks in different populations such as older adults (e.g., Bastin & Meulemans, 2002), traumatic brain injuries (Mioni, Rendell, Henry, Cantagallo, & Stablum, 2013) and Parkinson's disease (Raskin et al., 2011). This pattern of results has been explained by higher executive control demands of time- than event-based PM tasks given that no external cue prompts retrieval of the intention, but the individual has to monitor the time in order not to miss the critical time window. In light of the concurrent evidence for executive function deficits in ASD, especially in planning (e.g., Hughes, Russell, & Robbins, 1994; Ozonoff & McEvoy, 1994; Zinke et al., 2010) and cognitive flexibility/switching (e.g., Bennetto, Pennington, & Rogers, 1996; Ozonoff, Pennington, & Rogers, 1991; Prior & Hoffmann, 1990), exploring possible performance differences of ASD individuals with respect to these two tasks types and their varying demands on executive functions is of high interest.

Similarly, based on the regularity of PM cue appearance, two types of tasks are differentiated. *Regular* PM tasks are recurrent and need to be executed whenever the prospective cue occurs (e.g., taking medication with breakfast every morning). These tasks typically include only few events that occur regularly. Thus, retrospective memory demands are assumed to be rather low. In contrast, *irregular* PM tasks typically represent single episodes or intentions that are non-recurring, and hence assumed to rely more on retrospective memory compared to regular PM tasks (Foster et al., 2013; Mioni et al., 2013). Differentiating these two task types allows for a systematic investigation of retrospective memory contributions to PM in ASD. Previous research on retrospective memory in ASD points to deficits in free recall tasks that highly depend on self-initiated processing, while performance in recognition and cued recall tasks seems to be spared (for a review see Boucher, Mayes, & Bigham, 2012). Compared to retrospective memory tasks, prospective remembering requires more self-initiated processing, because the individual is not directly requested to execute the PM task (Einstein & McDaniel, 2005). Hence, more deficits can be expected in prospective than in retrospective remembering. Despite its importance for everyday life and evidence for deficits in its underlying processes, research on PM performance in ASD is still rather scarce. To date, there are eight published studies available that investigated PM in ASD (Altgassen, Koban, & Kliegel, 2012; Altgassen, Schmitz-Hübsch, & Kliegel, 2010; Altgassen, Williams, Bölte, & Kliegel, 2009; Brandimonte, Filippello, Coluccia, Altgassen, & Kliegel, 2011; Henry et al., 2014; Jones et al., 2011; Williams, Boucher, Lind, & Jarrold, 2013; Williams, Jarrold, Grainger, & Lind, 2014). To directly compare time- and event-based PM performance, four studies investigated both task types within one and the same paradigm. Whereas Altgassen et al. (2012) found event- and time-based deficits in adults with ASD, Williams and colleagues (2013, 2014) reported impaired time- but spared event-based PM in children and adults with ASD. Similar findings were reported by Henry et al. (2014). Also here, children with ASD performed poorer on time- but similarly on event-based PM tasks compared to controls. No performance differences were found between regular and irregular PM tasks in ASD despite their possible differences in retrospective memory demands. Jones et al. (2011) explored everyday memory in ASD, which included a measure for event-based PM. Results showed higher PM performance scores for control individuals compared to participants with ASD. However, after excluding participants that did not recall the PM task, event-based PM differences between participants with ASD and controls were no longer significant (see also Williams et al., 2013). Inconsistent results were reported by two other studies that only focused on event-based PM. Whereas Altgassen et al. (2010) found preserved PM in children and adolescents with ASD, Brandimonte et al. (2011) observed deficits in event-based PM in children with ASD.

Taken together, studies on time-based PM consistently revealed deficits in individuals with ASD (see also Altgassen et al., 2009 for a study exclusively focusing on time-based PM), whereas results on event-based PM are more inconclusive. Hence, the first aim of the present study was to further investigate time- and event-based PM in ASD compared to controls within one paradigm. To this end, Virtual Week (Rendell & Craik, 2000; Rendell & Henry, 2009) a computer-based task simulating typical everyday-like tasks in the course of a week was applied. This task allows a reliable and valid assessment of event- and time-based PM performance (e.g., Henry et al., 2014) and is supposed to have a higher ecological validity compared to standard laboratory PM tasks (e.g., Mioni et al., 2013).

Similar to the vast majority of PM studies in general, studies on PM in ASD have mainly focused on the phases of intention initiation and execution and investigated how different types of PM cues (event, time) may affect performance. Results were interpreted in terms of lower or higher involvement of executive functions. However, McDaniel and Einstein (2000) proposed that thorough intention formation (i.e., planning) may decrease the need for executive control processes during the delayed performance interval, which should be especially beneficial for groups with executive function deficits. Consistently, previous research showed that planning relates to PM performance (Kliegel, Eschen, & Thöne-Otto, 2004; Kliegel et al., 2000; Martin, Kliegel, & McDaniel, 2003). Altgassen et al. (2012) not only asked individuals to perform the PM task, but also to plan