Cognitive Development 39 (2016) 189–196

Contents lists available at ScienceDirect

Cognitive Development

The role of subvocal rehearsal in preschool children's prospective memory

Caitlin E.V. Mahy[a,*], Hannah Mohun[b], Ulrich Müller[b], Louis J. Moses[c]

[a] Department of Psychology, Brock University, Canada
[b] Department of Psychology, University of Victoria, Canada
[c] Department of Psychology, University of Oregon, Eugene, OR, United States

ARTICLE INFO

Article history:
Received 6 October 2015
Received in revised form 6 June 2016
Accepted 8 July 2016

Keywords:
Prospective memory
Subvocal rehearsal
Verbal ability
Verbal working memory
Preschool children

ABSTRACT

The current study examined the impact of a verbal interference manipulation on 4- and 5-year olds' prospective memory (PM). Children were randomly assigned to either complete a quiet delay activity (standard condition) or answer questions aloud during the delay activity (verbal interference condition). Children then completed a PM task followed by several individual differences measures (verbal working memory, inhibitory control, and receptive vocabulary). Four-year-olds showed worse PM than 5-year-olds, children in the verbal interference condition showed worse PM compared to the standard condition, and there was a marginal interaction between age and condition driven by poor performance of 4-year-olds in the verbal interference condition. PM performance was positively correlated with verbal working memory and receptive vocabulary (but not inhibitory control) in the verbal interference condition only suggesting that children with better verbal abilities were more able to cope with verbal interference to the benefit of their PM.

Remembering to carry out a future intention, prospective memory (PM), has received increasing attention as an important aspect of young children's cognitive development (e.g., Kliegel & Jäger, 2007; Kvavilashvili, Messer, & Ebdon, 2001; Mahy & Munakata, 2015). Age-related improvements in event-based PM during the preschool years have now been clearly established (Kliegel & Jäger, 2007; Mahy & Moses, 2011), and factors such as motivation, length of delay, and difficulty of the ongoing task have been found to affect young children's PM performance (for a recent review see Mahy, Moses, & Kliegel, 2014).

A standard PM task involves two concurrent components: first, the prospective memory task itself—what children must do when a particular cue appears in the environment (e.g., a picture of an animal), and second, the ongoing task which acts as a distractor task in which the PM cues are embedded (e.g., a card sorting task). Prior to the onset of these two tasks, however, there is typically a delay period between the assignment of a PM intention and the start of the ongoing task. Despite the presence of a delay interval in virtually all PM tasks, little attention has been paid to processes occurring during this period that might affect later PM performance.

In one of the few studies examining characteristics of the delay period, Mahy and Moses (2011) found that the length of the delay interval has a significant impact on preschoolers' PM performance such that 4-year-olds' PM was not affected by delay length, but 5-year-olds' PM actually increased after a long delay (5 min) compared to a short delay (1 min). The interpretation of these findings was that 5-year-olds may be refreshing their intentions during the delay and hence might benefit from a longer delay period due to increased opportunities to think and reflect on their future intentions. Further,

* Corresponding author at: Department of Psychology, Brock University, 1812 Sir Isaac Brock Way, St Catharines, ON L2S 3A1, Canada.
E-mail address: caitlin.mahy@brocku.ca (C.E.V. Mahy).

http://dx.doi.org/10.1016/j.cogdev.2016.07.001
0885-2014/

Mahy and Moses (2015) found that filling the delay interval with a difficult visual working memory task resulted in worse later PM performance than when the delay was filled with an easy visual working memory task. They also found that children's executive abilities, including planning and working memory, were related to PM performance for children who received the difficult filler task but not for those who received the easy filler task. Taken together, these studies suggest that important cognitive processes operate during the delay interval that have a significant impact on later PM, and that individual differences in executive control have an impact on children's PM under different experimental conditions.

Mahy and Moses (2011, 2015) have argued that children might take advantage of the delay period to refresh or monitor their intentions (hence, why longer intervals are helpful for older children's PM and why difficult delay tasks might disrupt these processes resulting in worse PM performance). One way in which this refreshing process could be affected is by disrupting subvocal rehearsal during the delay.

There are important theoretical reasons to examine the role of subvocal rehearsal in how children maintain a prospective intention. In his classic model of working memory, Baddeley (1992) suggested that working memory is composed of a central executive, a visuospatial sketchpad, an episodic buffer, and the phonological loop. For our purposes, an important aspect of working memory is the phonological loop, which allows for storage and rehearsal of speech based information and directly supports subvocal rehearsal of the contents of working memory. Importantly, the central executive does not have storage capacity so relies on the episodic buffer to maintain information over time. According to this model, information such as intentions can be stored in working memory via the episodic buffer but also can be refreshed or rehearsed directly through subvocal rehearsal in the phonological loop. It is probable, however, that an intention is not held in the focus of working memory consistently (as this would index a vigilance process rather than PM, see Brandimonte, Ferrante, Feresin, and Delbello, 2001) but rather that it fades in and out of the focus of attention during the delay period (Cowan, 1995, 2005). It would be unlikely that children would use a vigilance strategy during a PM task given that they are engaged in an ongoing task that is occupying their attentional resources.

Similarly, Vygotsky (1934/1986) emphasized the important role of children's inner speech for guiding their actions. He hypothesized that children first use speech interpersonally for communication but as development progresses speech is internalized and used to direct children's behavior (in the form of inner speech). This self-directed speech supports higher cognitive functions and allows children to plan ahead and think about solutions in advance. Taken together, there are important theoretical reasons to examine the role of subvocal rehearsal and private speech in children's maintenance of their prospective intentions over time, as this may be one process through which prospective intentions are refreshed and maintained over a delay period. Importantly, Vygotsky's work has not been explored in relation to children's PM and thus is an important as well as novel aspect of the current study.

Several lines of empirical work support the idea that subvocal rehearsal plays an increasingly important role in problem solving in early childhood (see Müller & Kerns, 2015). First, consistent with Vygotsky's theory, the use of covert (private) task-relevant speech is positively associated with performance on planning tasks in 4–8-year-old (Al-Namlah, Fernyhough, & Meins, 2006; Fernyhough & Fradley, 2005). Second, during the preschool period children are more likely to label stimuli or use private speech when task demands increase (e.g., Fernyhough and Fradley, 2005; Müller, Zelazo, Hood, Leone, & Rohrer, 2004) suggesting that private speech is particularly useful under higher cognitive demand. Finally, the function of verbal labels changes during the preschool period from being attention-directing to stimulating a richer conceptualization of the task at hand (Jacques & Marcovitch, 2010). Consistent with Vygotsky's suggestion that overt (audible) private speech is gradually replaced by covert (inaudible) private speech, it has been found that the use of covert private speech linearly increases between 4- and 8-years of age, and that the use of overt private speech decreases during the same period (e.g., Al-Namlah et al., 2006; Winsler & Naglieri, 2003). Further, important changes in children's private speech between 3 and 5 years of age seem to indicate a progressive internalization of private speech (Winsler, de Leon, Wallace, Carlton, & Willson-Quayle, 2003).

More directly relevant to the role of subvocal rehearsal in prospective memory, recent research has documented that children's capacity for private speech is linked to their performance on memory and planning tasks. For example, Al-Namlah, Meins, and Fernyhough (2012) showed that 4–7-year-olds' use of self-regulatory private speech was positively related to longer autobiographical narratives that included more specific memories and demonstrated greater narrative cohesion. Further, Lidstone and colleagues showed that articulatory suppression (i.e., disruption of subvocal rehearsal by constant repetition of the word "Monday") negatively affected 7–10-year-old children's performance on the Tower of London task (Lidstone, Meins, & Fernyhough, 2010). Individual differences in private speech production in 8–10-year-olds also positively predicted performance on the Tower of London, digit span task, and two measures of spatial intelligence (Lidstone, Meins, & Fernyhough, 2011). In sum, this literature suggests private speech is positively associated with memory performance and planning in early to middle childhood.

Given that subvocal rehearsal seems a likely candidate mechanism by which children refresh their prospective intentions, we set out to design an experiment that would disrupt subvocal rehearsal during the delay period. Thus, we designed a delay task that would interrupt any rehearsal or refreshing of intentions at regular intervals: Children were asked to draw pictures but every 20 s they were interrupted with a question they had to answer (e.g., what's your favorite color? how many brothers or sisters do you have? etc.). In contrast, in the standard condition, children were simply asked to draw pictures quietly so their subvocal rehearsal was not interrupted in any way by the experimenter.

In addition to this manipulation, children's verbal working memory (backward word span), inhibitory control (Grass/Snow and Head-Shoulders-Knees-Toes), and receptive vocabulary (Peabody Picture Vocabulary Test) were measured. We predicted