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Developmental changes in fact and source recall: Contributions from executive function and brain electrical activity

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ABSTRACT

Source memory involves recollecting the contextual details surrounding a memory episode. When source information is bound together, it makes a memory episodic in nature. Unfortunately, very little is known about the factors that contribute to its formation in early development. This study examined the development of source memory in middle childhood. Measures of executive function were examined as potential sources of variation in fact and source recall. Continuous electroencephalogram (EEG) measures were collected during baseline and fact and source retrieval in order to examine memory-related changes in EEG power. Six and 8-year-old children were taught 10 novel facts from two different sources and recall for fact and source information was later tested. Older children were better on fact recall, but both ages were comparable on source recall. However, source recall performance was poor at both ages, suggesting that this ability continues to develop beyond middle childhood. Regression analyses revealed that executive function uniquely predicted variance in source recall performance. Task-related increases in theta power were observed at frontal, temporal and parietal electrode sites during fact and source retrieval. This investigation contributes to our understanding of age-related differences in source memory processing in middle childhood.

1. Introduction

Episodic memory involves recollection of the central content of information (e.g., fact memory) and its surrounding contextual details, known as source memory (SM). Source monitoring refers to the cognitive processes involved in making judgments about the origin of information and may serve as an important framework in explaining episodic memory development (Johnson, 2005; Johnson et al., 1993). Unfortunately, very little is known about the factors that contribute to SM formation. We investigated (1) age-related differences in fact and source recall in middle childhood, (2) the contribution of higher order executive functions to variation in fact and source recall, and (3) patterns of brain electrical activity exhibited during fact and source recall. In the following sections, we discuss what is known about source memory development and its associations with executive function skills and then review related psychophysiological investigations examining the neural correlates of SM.

1.1. Developmental investigations of source memory

Children have difficulty recollecting the contextual details associated with an event (Drummey and

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Newcombe, 2002; Lindsay et al., 1991). Drummey and Newcombe (2002) taught 4-, 6-, and 8-year-olds novel facts from one of two sources (experimenter or puppet) and tested children on fact and source recall after a 1-week delay. Fact recall steadily improved from 4 to 8 years. Source recall improved between 4 and 6 years and was equivalent among 6- and 8-year-olds. Four-year-olds committed more extraexperimental errors (i.e., incorrectly attributing a source to outside the experimental setting) than intraexperimental errors (i.e., attributing the wrong source within the experimental setting). The finding that 6-year-olds performed equivalently to 8-year-olds on source recall led the authors to conclude that SM skills are relatively intact by age 8. However, the proportion correct for source recall ranged from .40 to .46, which suggests that SM skills develop beyond early childhood. Indeed, other research has found age-related improvement on source discrimination tasks from childhood to adulthood (Billingsley et al., 2002; Chastelaine et al., 2007; Ghetti et al., 2010; Ofen et al., 2007). It is unclear what accounts for age-related improvement in SM processing. We propose that developmental improvement in SM is linked to individual differences in higher order executive processes.

1.2. Associations with executive function

Executive functions (EF) refer to cognitive processes that organize and coordinate goal-directed actions, and consist of working memory, inhibitory control and set-shifting dimensions (Mikaye et al., 2000). In the aging literature, frontal lobe factor scores on EF tasks are associated with better SM performance (Glisky et al., 1995) and lower error rates (Rubin et al., 1999). Only a few studies have examined the relation between EF and SM in childhood. Ruffman et al. (2001) found that the EF component of working memory was related to children's SM accuracy, whereas inhibitory control negatively predicted false alarm errors (i.e., incorrectly attributing a new item as old). Using a global EF composite, Rajan et al. (2014) found that EF uniquely predicted fact and source recall in 4- and 6-year-olds. In terms of specific contextual features, EF predicted episodic memory for spatial and temporal context in participants aged 4–16 years (Picard et al., 2012). Thus, successful SM may require working memory-dependent strategies for linking content to context and the ability to inhibit feelings of familiarity in favor of relevant information (Raj and Bell, 2010). Given that SM skills continue to develop beyond early childhood, we examined whether EF ability would explain variation in fact and source recall in middle childhood.

1.3. Brain electrical activity during fact and source recall

Improvement in SM has been linked to maturation of prefrontal, medial temporal, and parietal brain regions (Ghetti et al., 2010; Ofen et al., 2007; Raj and Bell, 2010). In adults, the prefrontal cortex is involved in SM retrieval (Nolde et al., 1998), hippocampal activation is increased during SM encoding and retrieval (Davachi et al., 2003), and parietal cortex activation is involved in directing attention toward relevant source features (Vilberg and Rugg, 2008). From childhood to adolescence, age-related increases in dorsolateral prefrontal cortex activation (Ofen, 2012; Ofen et al., 2007) and medial temporal lobe activation (Chai et al., 2010; Ghetti et al., 2010) contribute to age-related improvement in episodic recollection.

Event-related potential (ERP) studies reveal that children display different scalp topographies than adults during source retrieval (Cycowicz et al., 2003; Riggins et al., 2013). In addition, the ERP correlates of strategic recollection during source monitoring have been observed for adolescents and adults, but not young children (Sprondel et al., 2011). We examined the neural correlates of fact and source recall by collecting EEG, which provides a continuous measurement of electrophysiological activity during the course of recall and is advantageous to use in developmental populations (Casey and de Haan, 2002).

Memory-related changes in EEG power, which is thought to reflect the excitability of groups of neurons, have been observed in adults. Specifically, neural activity in the theta frequency range (4–7 Hz) is correlated with episodic memory and likely involves the hippocampal-cortical network (Nyhus and Curran, 2010; Klimesch et al., 2001). For example, theta synchronization (reflected by task-related increases in theta power) is associated with episodic encoding and retrieval (Klimesch et al., 1997). Little is known about the functional role of theta activation in episodic memory during childhood. In two-year-olds, task-related increases in theta band power were observed during memory encoding and retrieval and differentiated high and low memory performance (Cuevas et al., 2012). The present investigation addressed this gap in the literature by examining whether memory-related changes in theta activation would be observed in middle childhood.

1.4. Goal and hypotheses

The purpose of our investigation was to assess age-related differences in fact and source recall in 6- and 8-year-olds. We examined whether age-related variability in fact and source recall could be attributable to individual differences in executive function and whether memory-related changes in theta EEG activation would be evident in middle childhood. The following hypotheses were made:

1. *Age-related improvement on fact and source recall will be observed.* Given that recall of contextual information continues to improve from childhood to adulthood (Billingsley et al., 2002), we hypothesized that fact and source recall would continue to improve between 6 and 8 years of age.
2. *Fact and source recall will depend on EF.* We predicted that EF would be associated with fact recall, SM accuracy, and lower rates of false alarms errors. In addition, EF would explain variation in fact and source recall. The SM task was highly dependent on word retrieval and recruited the use of free verbal recall. Rajan et al. (2014) found that fact and source recall were positively correlated with expressive vocabulary. Thus, it was necessary to control for language ability. We predicted that EF would