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Episodic Memory in Middle Childhood: Age, Brain Electrical Activity, and Self-Reported Attention

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Abstract

Middle childhood is a transitional period for episodic memory (EM) performance, as a result of improvements in strategies that are used to encode and retrieve memories. EM is also a skill continually assessed for testing in the school setting. The purpose of this study was to examine EM performance during middle childhood and its relation to individual differences in attentional abilities and in neurophysiological functioning. We examined self-reports of attention at 6, 7 and 8-years of age as well as parietal EEG recorded during baseline, memory task encoding, and memory task retrieval. Results indicate that child self-reports of attention predicted EM performance. Additionally, the difference from baseline to retrieval-related EEG activation contributed variance to EM performance. Results replicate other middle childhood studies showing a positive association between EM performance and attention while also suggesting that parietal EEG yields critical information regarding memory performance.

Keywords

episodic memory; attention; EEG; middle childhood

Episodic memory (EM) involves conscious awareness of detailed memory creation (encoding) and retrieval, and undergoes rapid development throughout early to middle childhood (Ghetti & Bunge, 2012). EM is often measured using visual recognition tasks (e.g., Ritchey, Montchal, Yonelinas, & Ranganath, 2015). A typical recognition memory task involves the presentation of a set of visual stimuli followed by a test of the ability to accurately classify items in the next group of stimuli as "old" when seen in the earlier set or

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"new" when not previously seen (e.g., Marshall, Drummey, Fox & Newcombe, 2002). Performance on these types of tasks shows steady improvement with development, as adolescents and adults exhibit better accuracy and faster reaction times than children (Cycowicz, Friedman, Snodgrass, & Duff, 2001). Given that EM is associated with academic abilities, it is critical to understand potential contributors to individual differences in EM performance in school-age children (Blankenship, O'Neill, Ross, & Bell, 2015; Mirandola, Del Prete, Ghetti & Cornoldi, 2011). In our study we focused on two potential sources of individual differences in EM performance: attention and brain electrical activity.

Middle childhood is a transitional period for EM performance, with increases observed throughout (Ghetti & Bunge, 2012). These developmental changes are assumed to be a result of improvements in strategies that are used to encode and retrieve memories. The use of effective strategies requires attentional processes (Riggins, 2014). Sophisticated attentional processes begin to develop in early childhood and continue to improve as children enter middle childhood. Specifically, attentional skills allow children to engage in planning, establish goals, and monitor progress on simple and complex tasks (e.g., Ridderinkhof, van der Molen, Band, & Bashore, 1997). With development, children show increasing flexibility and focus of attention allowing them to concentrate for longer durations on a wider variety of targets (Archibald, Levee, & Olino, 2015) and to adapt attention to contextual demands and goals (Pezzica, Pinto, Bigozzi, & Vezzani, 2015).

Object recognition involves the ability to selectively deploy attentional processes and correctly parse an object from its environmental context (Coldren & Haaf, 1999; Haaf, Lundy, & Coldren, 1996). Memory processes require a certain amount of attentional resources. Indeed, without attention, memory would not exist (Chun & Turk-Browne, 2007). The very process of encoding relevant information into long-term memory requires attentional resources (Chun & Turk-Browne, 2007), which later impact retrieval of such memories (Warrington & Ackroyd, 1975). For example, when visual cues are added to memory tasks, performance significantly improves (Makovsik & Jiang, 2007; Makovsik, Sussman, & Jiang, 2008). This suggests that visual cues allow focused attention to be allocated to relevant information and irrelevant information to be ignored. Given the well-established relation between attention and memory, we expected associations between attention and EM performance in our study.

In addition to attentional skills, research on brain activity during EM may provide insight on the existence of individual differences in EM. One common method used to examine neural activity during EM encoding and retrieval, especially during childhood, is the electroencephalogram (EEG; Riggins et al., 2009). Specifically, event-related potential (ERP) studies associate correct identification of items (i.e., as "old" or "new" stimuli) with an old/new effect that typically comprises of an early mid-frontal and a later parietal component in adults (Rugg, Schloerscheidt, & Mark, 1998). However, children's ERPs during recognition demonstrate a parietal old/new effect but with longer latencies compared to young adults (Mecklinger et al., 2011). These findings suggest children may rely partially on parietal regions during recognition, due to underdeveloped mechanisms of prefrontal control (Czernochowski et al., 2004).

Recently studies also suggest that in addition to ERP, the ongoing electrical activity of the EEG may be used to distinguish correct from incorrect EM responses and to assess developmental changes in relation to EM performance in children (Blankenship & Bell, 2015; Rajan & Bell, 2015). In a sample of 9–12-year-olds, differential EEG connectivity during encoding and retrieval contributed to EM performance. Moreover, event-related increases in EEG power values at parietal scalp locations during recall was associated with memory performance in an EM task with 6- and 8-year-old children (Rajan et al., 2014). This coincides with neuroimaging studies in adults that report the involvement of the posterior parietal cortex (PPC; Wagner, Shannon, Kahn, & Buckner, 2005; Cabeza, Ciaramelli, Olson, & Moscovitch, 2008; Vilberg & Rugg, 2008) during tasks requiring memory retrieval, suggesting a role for PPC in forming and maintaining a bound representation of the recognized item and task-relevant contextual elements (Johansson & Mecklinger, 2003). Evidence also suggests that parietal cortex activation is involved in directing attention toward relevant source features (Vilberg & Rugg, 2008). This effect is thought to be less consistently present and/or to exhibit a different topography in early development as a result of refinements of networks underlying the PPC (Cycowicz, Friedman & Duff, 2003). To our knowledge, only one study investigated and found evidence for a relation between recognition memory and the parietal area in school age children (Cycowicz et. al., 2003). Because limited empirical evidence exists supporting the reliance on the parietal region during middle childhood, we examined EEG activity during middle childhood in an attempt to validate reliance on parietal regions during a recognition memory task.

We used ongoing EEG in our study because of its ability to yield different types of information relative to ERP. For example, task-related EEG have been associated with performance on both working memory and source recall tasks during early and middle childhood (Rajan & Bell, 2015; Wolfe & Bell, 2007). Previous research has also shown an association between task performance and changes in EEG activation from a resting state to a cognitively demanding state (Wolfe & Bell, 2004). Although individual scalp locations reveal critical information regarding neural networks in various regions (Bell & Cuevas, 2012), EEG is context-related; thus, the EEG generated during baseline or rest is believed to be quantitatively different than that generated during cognitive processing (Deater-Deckard & Bell, 2017). Recent research has provided evidence that greater change in EEG power from baseline-to-task is associated with more attention and cognitive processing in both infancy and early childhood (Perry, Swingler, Calkins, & Bell, 2016; Watson & Bell 2013). However, EEG research on brain activity associated with middle childhood memory development and performance is limited. Nevertheless, we know that during adulthood, individual differences in memory encoding and recall are associated with the ongoing EEG (Klimesch, 1999). The lack of EEG studies during middle childhood is surprising as theories of memory allow specific hypotheses to be made about changes in EEG activity (Burgess & Gruzelier, 2000).

We analyzed EEG power within the lower alpha power band (8–10 Hz). Alpha is thought to reflect top-down widespread cortical control of lower level internal processing of information (Benedek, Bergner, Könen, Fink, & Neubauer, 2011). Lower alpha was used in our analyses due to the established relation between this frequency band and attentional processes and memory in both adults and children (Burgess & Gruzelier, 2000; Klimesch, 1996; 2012). In this study, we were interested in whether the EEG recorded during baseline, familiarization (encoding), or recognition (retrieval) proved to be similar predictors of recognition task performance during middle childhood. Specifically, we examined changes in EEG reactivity (operationalized as the power difference from baseline resting state to effortful task performance state) to investigate whether EEG was associated with variance in EM performance. If baseline-to-familiarization EEG predicted EM, then the change in brain activity associated with encoding would be critical for individual differences in task performance. Likewise, if baseline-to-recognition EEG predicted EM, then the change in brain activity associated with retrieval would be critical. These are not mutually exclusive processes; thus, it may be that EEG recorded during all conditions is critical for identifying individual differences in EM performance.

Current Study

We focused on individual differences in EM in middle childhood. We chose to study 6-, 7-, and 8-year-old children because of our overarching interests in cognitive processes associated with successful school performance. Recognition memory processes are typically assessed for testing in the school setting (Nouwens, Groen, & Verhoeven, 2016). We predicted that child age, attention, and changes in brain electrophysiology (measured via EEG) would each contribute unique variance to EM performance.

We administered a questionnaire in order to get a sense of day-to-day attentional behaviors exhibited in many different contexts by children. We asked children to report on their own attentional processes because children are able to do so by age six (Simonds & Rothbart, 2004). Additionally, we used ongoing electroencephalogram (EEG) as our measure of brain activity associated with EM, rather than measures of ERP traditionally used in EM research. We focused on EEG because it provides a continuous measurement of electrophysiological activity during the course of recognition memory processes (encoding and retrieval). Moreover, baseline-to-task change scores were utilized to measure individual differences in EEG change during cognitive processing relative to a resting state. We focused on EEG activity at parietal locations and hypothesized that both familiarization and recognition EEG would predict EM performance.

Method

Participants

Participants included 105 six (*M* = 73.4 months, *SD* = 3.16; 12 boys, 22 girls), seven (*M* = age 85 months, *SD* 2.24; 14 boys, 21 girls), and eight (*M* = 96.6 months, *SD* =4.31; 20 boys, 16 girls) year olds (97 Caucasian, 4 African American, 2 Asian American, 2 Hispanic). All children were born to parents with a high school diploma; college degrees or higher were held by 90% of the mothers and 82% of the fathers. Children were full term, experienced no prenatal or birth complications, had no developmental delays or cognitive disabilities, and were healthy at the time of the lab visit. Children were seen in the research lab within four months after their birth date.

Procedures

Mother and child were greeted by a research assistant who explained the study procedures and obtained signed consent from the mother and assent from the child. After a brief warm-up period, an EEG Electro-cap was situated on the child's head. Electrodes remained on the scalp during the entire procedure. Children sat in front of a table where a baseline movie clip showing slowly turning circles and colors played on a television screen 1.5m away from the child for 1 minute (Diaz & Bell, 2012; Rajan & Bell, 2015). After the baseline video, a rollaway desk with a touch screen computer replaced the table. The child sat at the desk while familiarization and test phases of the EM task were administered. EEG recordings were event marked (baseline, familiarization, test) by a research assistant in an adjacent room. At the end of the EM task, children were asked to self-report on their attention.

Episodic Memory Task

Based on an old/new recognition task designed by Marshall and colleagues (2002), children viewed color photographs of common objects on a touch screen monitor; objects were perceptually simple and easy to label. Prior to the task, children were told that they were about to see several pictures on the screen and that each picture would go by rather quickly. They were asked to sit quietly and pay attention to each picture. The children were also told to try to remember the pictures as they would later be asked whether they had been shown a particular picture or whether it was a new picture. The pictures belonged to familiar categories such as furniture (e.g., sofa, chair), kitchen objects (e.g., frying pan, can opener), and musical instruments (e.g., piano, guitar). The familiarization phase (i.e., memory encoding) consisted of 37 pictures. Each image was displayed for 2-seconds with an interstimulus interval of 2-seconds. After a 5 minute delay, the test phase (i.e., memory retrieval) began.

The retrieval phase was comprised of 74 pictures, including the 37 pictures displayed at the familiarization phase and an additional set of 37 new pictures, randomly mixed. Practice trials were given to teach the child the rules of the game on the touch screen computer monitor. For both practice and test trials, children were told that the object of the game was to indicate whether they had seen the image on the computer monitor (touch the word "old" to the left of the picture on the screen) or whether they had not seen the image on the monitor (touch the word "new" to the right of the picture on the screen) and to do so as quickly as possible. Children began each trial of the test phase with their hands in their lap and then returned their hands to their lap during the intertrial interval. Table 1 provides summary scores for each age. To ensure that the participants would understand the procedure, the practice phase included both study and test blocks images and asked children to demonstrate their response to a presentation of “new” and “old” pictures. Thirteen children did not proceed to the test phase for not demonstrating understanding of instructions or refusal to continue. Additionally, three computer malfunctions occurred during the test phase of the task. Thus, 16 children did not contribute retrieval memory behavioral data. Chi Square and t-tests were performed in order to determine whether there were differences between children who passed and did not passed the test trials on the variables of age, sex, cultural identification, mother-rated and self-rated attention. Results indicated no statistical differences between the two groups on any variable (*p*'s > .08).

Attention Measure

Child report of attention—The Temperament in Middle Childhood Questionnaire Self-Report (TMCQ-Self) was utilized to measure self-reported observations of attention (Simonds & Rothbart, 2004). This 157-item questionnaire measures 17 domains of child temperament. The focus of this study however was on self-rated attentional focusing ($\alpha = .63$) and children responded only to items associated with that scale. Children were told they would be asked a few things about themselves and it was really important that they answer as truthfully as possible. Children used stampers with brightly colored ink to mark their answers on a sheet that contained a 5-point likert scale (none, a little, sometimes, mostly, a lot). The experimenter would read out a statement; for instance, *I like candy*. Then follow with, do you not like candy? Do you like candy a little bit? Do you like candy sometimes? Do you like candy most of the time? Or do you like candy a lot? Then children were told to stamp their answers on the sheet in front of them with whichever stamp they liked. All statements were asked in this matter. Three practice statements were given in order to assess if the child comprehended the instructions. Two children did not demonstrate comprehension of the task and began to draw on the form and thus contributed no self-report attention data. The children reported relatively low levels of self-rated attention ($M = 2.22$, $SE = .09$, *range* = .30 – 4.00). The sample range, however, shows that there was variability in children’s responses to their own attention focusing behaviors (see Table 1).

EEG

The EEG electrodes were placed on the child’s head using an EEG cap (Electro-Cap International, Inc., Eaton, OH). Recordings were made from 24 left and right scalp sites [frontal pole (Fp1, Fp2), medial frontal (F3, F4), lateral frontal (F7, F8), central (C3, C4), central frontal (FC1, FC2, FC5 FC6), temporal (T7, T8), lateral parietal (P7, P8), medial parietal (P3, P4), central parietal (CP1, CP2, CP5, CP6), and occipital (O1, O2)]. All electrode sites were referenced to Cz during recordings.

After the EEG cap was placed on the head, a small amount of abrasive gel was placed into each recording site and the scalp gently rubbed. Next, conductive gel was placed in each site and the scalp gently rubbed. Electrode impedances were measured and accepted if they were below 10K Ohms. The electrical activity from each lead was amplified using separate James Long Company Bioamps (Caroga Lake, NY) and bandpassed from .1 to 100 Hz. Activity for each lead was displayed on the monitor of an acquisition computer. The EEG signal was digitized at 512 Hz for each channel so that the data would not be affected by aliasing. The acquisition software was Snapshot-Snapstream (HEM Data Corp., Southfield, MI) and the raw EEG data were stored for later analyses.

EEG data were examined and analyzed using EEG Analysis System software developed by James Long Company (Caroga Lake, NY). Data were re-referenced via software to an average reference configuration and then artifact scored for eye movements using a peak-to-peak criterion of 100 uV or greater. Artifact associated with gross motor movements over 200 uV peak-to-peak were also scored. These artifact-scored epochs were eliminated from all subsequent analyses. Finally, some children had excessive artifact specific to the electrodes of interest in this study. The data were then analyzed with a discrete Fourier transform (DFT) using a Hanning window of 1-second width and 50% overlap. Power was computed for the 8 to 10 Hz (lower alpha) frequency band and expressed as mean square microvolts. Data were transformed using the natural log (ln) to normalize the distribution. Nine children were missing EEG data (1 refused to wear the EEG cap, 1 removed the cap during the task, 2 had excessive gross motor artifact throughout the protocol, and 5 had excessive artifact at parietal electrode sites). Child EEG data were included if the number of artifact-free DFT windows for each phase of processing (baseline, familiarization, test) exceeded 10 (Watson & Bell, 2013). Two children did not meet this minimum requirement and did not contribute physiological data. Because task-related changes in EEG power (in comparison with baseline) are hypothesized to represent activation of brain areas underlying specific scalp electrodes (Cuevas & Bell, 2011), we derived a measure of neural activity at parietal scalp locations by subtracting baseline EEG power from EEG power during familiarization (i.e., encoding) and by subtracting baseline EEG power from EEG power during recognition (i.e., retrieval) at parietal electrode sites (CP1, CP2, CP5, and CP6).

Results

Age was not correlated with attention ($p > .77$). The correlation between age and EM performance approached significance, with older children performing better than younger children ($r = .19$, $p > .07$). Children's reports of their own attention positively correlated with their EM performance ($r = .23$, $p = .03$). EEG baseline-to-task change scores (i.e., task EEG power - baseline EEG power) were computed for encoding and retrieval trails for CP1, CP2, CP5, and CP6. Decreases in task-related EEG power, relative to baseline, were observed for both encoding and retrieval at electrodes CP1 (encoding, M = −.02, SD = .28; retrieval, M = −.07, SD = .34) and CP2 (encoding, M = −.02, SD = .29; retrieval, M = −.03, SD = .39). Increases in EEG power were observed at CP5 (encoding, M = .03, SD = .28; retrieval, M = −.01, SD = .30) and CP6 (encoding, M = .05, SD = .31; retrieval, M = .06, SD = .44), with the exception of a decrease at CP5 during retrieval. A MANOVA suggested no age-related differences in EEG change scores, ($F(16, 148) = 1.60$, $p = .08$).

Regression analyses were conducted to examine contributions of child age, attention, and EEG power changes from baseline-to-task on EM task performance (i.e., mean number correct). Child age and self-ratings of attention were entered in Step 1. EEG change scores at individual electrode sites were entered in Step 2. Our hypotheses were associated with posterior parietal (we used central parietal for posterior parietal) areas and we performed separate regression analyses to examine baseline-to-familiarization and baseline-to-test EEG change scores. Children's electrophysiology may provide additional variance to children's EM score above and beyond child age and self-reports of attention.

Results of regression analyses using baseline-to-familiarization EEG (i.e., during encoding) are presented in Table 2. Before children's posterior parietal EEG was entered into model, children's attention significantly predicted their performance $F(2, 75) = 4.01$, $p < .03$ However, the model was not significant after accounting for baseline-to-familiarity EEG ($F(6, 75) = 1.81$, $p = .11$).

Results of regression analyses using baseline-to-recognition EEG (i.e., during retrieval) are presented in Table 3. When the final model included age, child reports of attention, and posterior parietal EEG recorded during the test portion of the EM task, posterior parietal changes at CP1 and CP5, as well as self-reported attention, significantly contributed to EM performance accounting for 15% of the variance, $F(6, 73) = 3.09$, $p = .01$.

Discussion

With respect to the regression analyses performed, there were three main findings. First, only the model containing recognition-related (i.e., retrieval) posterior parietal EEG change scores contributed variance to EM scores in middle childhood. Second, child self-reports of attention predicted EM performance. Lastly, child age was not a significant contributor of variance to EM performance.

Results suggest that the change in EEG activation from baseline to task predicts children's EM performance. We know that EEG continues to develop during middle childhood (see Bell, 1998, for a review of EEG development), and our data show that changes in parietal activation accounted for significant variance in EM task performance. Parietal areas are thought to be associated with the subjective experience of vividness and confidence in memories as well as with helping to hold the qualitative content of memories for retrieval, and thus make them accessible to decision-making processes (Ciaramelli, Grady & Moscovitch, 2008) including EM. That parietal EEG was predictive of EM only when examining the baseline-to-recognition change compared to baseline-to-familiarization EEG change, suggests that the cognitively demanding aspect of retrieving information associated with recognition EEG yields critical information for the subjective nature of memory performance. This is also true in EEG work with adults (Deater-Deckard & Bell 2016). Indeed, the PPC is thought to be involved in allocating attentional resources (Cabeza et al., 2008), specifically item-context associations (Mecklinger, 2010), which in turn may enhance mechanisms involved in EM retrieval.

Our data also captured one specific aspect of EEG activity during retrieval that was associated with individual differences in EM performance, and that was changes in EEG activity at two posterior parietal electrodes (CP1 & CP5) of the left hemisphere. We did not have specific hypotheses regarding differences between encoding and retrieval EEG; however, it is not surprising that parietal EEG activity during retrieval contributed to memory performance, while encoding did not. Indeed, previous research suggests that parietal regions are active during retrieval, but not encoding (Cabeza et al., 1997; Wagner et al., 2005). This activation pattern may be attributed to the need to direct attention to relevant features during retrieval (Vilberg & Rugg, 2008), which would be required when engaging in old/new judgments. Our hypotheses were also not specific to hemisphere; although because our stimuli were photographs of familiar objects, finding effects for only left hemisphere EEG should not be surprising. Perhaps children utilized their left hemisphere to help them discriminate local feature differences between objects during the recognition task as the left hemisphere has been linked with various cognitive abilities including attending to local cues and visual-spatial analyses on local features (Vallortigara & Rogers, 2005).

Alternately, perhaps children were naming the objects as they viewed them and utilized left hemisphere language areas in the process (Lochy, van Reybroeck, & Rossion, 2016).

The mean values of our EEG baseline-to-task change scores suggested that alpha power decreased from baseline to retrieval (desynchronized) at CP1 and increased (synchronized) at CP5. Further, CP5 desynchronization positively and CP1 synchronization negatively predicted memory performance. In adults, alpha synchronization (i.e., increased power) is associated with decreased cortical activity and resting cognition, while desynchronization is associated with increased cortical activity and cognitive control (Pfurtscheller, Stancak, & Neuper, 1996; Sauseng, Klimesch, Doppelmayr, Pecherstorfer, Freunberger, & Hanslmayr, 2005). Our results suggest that children between 6–8 years display EEG patterns that are comparable to adults.

In support of our prediction, attention did significantly predict EM performance. The TMCQ self-report utilized in this study is believed to capture children’s attentional focusing (Simonds & Rothbart, 2004). Results suggest that attentional focusing may be important for recognition ability during middle childhood. These data also suggest that children may contribute critical self-report of cognitive information (Simonds & Rothbart, 2004).

The development of EM has been characterized as a continuous increase in the quantity and quality of memory accuracy (Ofen et al., 2007). Developmental studies of EM have shown consistent improvement across development, with mature performance occurring during adolescence (Cycowicz et al., 2001; Mandler & Robinson, 1978). Age-related changes in EM performance are thought to be due to different memory functions developing at different rates (e.g., Ghetti & Angelini, 2008). Moreover, due to the established relation between attention and memory, we expected attentional skills to contribute unique variance to memory performance. However, this study utilized children’s physiology to further understand individual differences in EM performance in addition to maturation and attentional control abilities in middle childhood. Our results suggest that child age did not contribute unique variance in children’s EM performance when examining baseline-to-task EEG; it may be the case that with older children, child age no longer contributes unique variance when also examining encoding/familiarization or retrieval/test EEG. This would be an intriguing developmental pattern and would inform regarding the effects of age relative to the effects of developing EEG activity. Moreover, although examining individual electrode sites and hemispheric specialization is informative, future studies should also examine EEG composite scores and obtain information about the temporal relationships and functional connectivity of EM in this population.

Our study was not without challenges. We had more children with unusable EEG data than is typical for EEG research studies during middle childhood (e.g., Rajan & Bell, 2015); nine children had excessive artifact in their EEG recordings and two did not tolerate the EEG electrodes. Additionally, thirteen children did not pass the practice trials for our EM task and two children were not able to complete the self-report attention measure. Larger sample sizes and longitudinal research is critically needed to further elucidate these relations.

In sum, the findings from our study provide evidence for an association between EM and children's neurophysiology. Parietal baseline-to-retrieval EEG and self-reports of attention were linked to EM performance, where baseline-to-familiarization EEG and child age was not. These findings suggest that more developmental studies combining psychological and neurophysiological measures are required to reveal critical information regarding normative EM development during middle childhood.

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Highlights

- Examined children’s episodic memory (EM), attention, & neurophysiological functioning.
- Parietal baseline-to-task changes in EEG and attention linked to EM performance.
- Parietal EEG may yield critical information about EM in middle childhood.

Table 1

Episodic Memory and Attention Summary Scores by Age

	M	SD	Range
		6-year-olds	
VRM Number Correct	46.90	6.62	35–62
Child Reported Attention	2.22	.74	.57–4.00
		7-year-olds	
VRM Number Correct	48.74	6.28	36–61
Child Reported Attention	2.30	.82	.57–3.71
		8-year-olds	
VRM Number Correct	50.30	6.49	37–62
Child Reported Attention	2.25	.88	.29–3.86

Table 2

Summary of Regression Analysis Predicting Episodic Memory (EM) Performance by Age, Attention, and Baseline-to-Familiarization EEG

EM Number Correct (N= 76)	**b**	**SE b**	**β**	**t**	**p**	**sR^2**
Step 1						
Age	.002	.001	.17	1.53	.13	.03
Child Reported Attention	.3	.01	.27	2.42	.02	.07
Step 2						
Age	.001	.001	.14	1.17	.25	.02
Child Reported Attention	.03	.01	.26	2.27	.03	.06
Baseline-to-task change CP1	.07	.06	.19	1.19	.24	.02
Baseline-to-task change CP2	−.07	.05	−.20	−1.30	.20	.02
Baseline-to-task change CP5	−.05	.05	−.16	−1.02	.31	.01
Baseline-to-task change CP6	.05	.05	.15	.95	.35	.01

Note. Step 1 $R^2 < .10$, $p > .02$; Step 2 $\Delta R^2 < .04$, $p > .57$

Table 3

Summary of Regression Analysis Predicting Episodic Memory (EM) Performance by Age, Attention, and Baseline-to-Test EEG

EM Number Correct (N= 75)	**b**	**SE b**	**β**	**t**	**p**	**sR^2**
Step 1						
Age	.002	.001	.17	1.49	.14	.03
Child Reported Attention	.03	.01	.27	2.36	.02	.07
Step 2						
Age	.002	.001	.17	1.10	.17	.02
Child Reported Attention	.03	.01	.24	2.20	.03	.06
Baseline-to-task change CP1	.10	.05	.37	2.20	.03	.06
Baseline-to-task change CP2	−.06	.05	−.20	−1.17	.25	.02
Baseline-to-task change CP5	−.14	.05	−.45	−2.81	.007	.09
Baseline-to-task change CP6	.08	.05	.24	1.52	.13	.03

Note. Step 1 $R^2 < .10$, $p > .03$; Step 2 $\Delta R^2 < .12$, $p < .05$