Predicting Recollection: Electrophysiological Indices of Recollection at Encoding Using Objective and Subjective Measures in Children and Adults

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Introduction

• Only one study to date has examined ERP responses at encoding in developmental populations (Riggins & Rollins, in press). We found age-related differences in the timing, duration, and topography of the subsequent memory effect (i.e., ERP differences between later recognized and missed items).

• In adults, ERPs show not only subsequent memory effects but also subsequent recollection effects (i.e., ERP differences between items that are later given given "remember" responses versus "know" responses) using subjective recollection paradigms (Duarte et al., 2004; Friedman & Trott, 2000; Mangels, et al., 2001; Yovel & Paller, 2004). However, subsequent recollection effects are not typically observed when objective recollection paradigms (i.e., when recollection is indexed by accuracy for a contextual detail, e.g., color) are used (Friedman & Trott, 2000; Guo, et al., 2006; Smith, 1993).

•Behavioral studies show that age-related changes are present in subjective and objective recollection (Ghetti, et al., 2011).

•The goals of the current study are to determine if ERP correlates of recollection can be detected in children during encoding and if effects differ from adults using subjective and objective measures.

Behavioral Methods

Participants

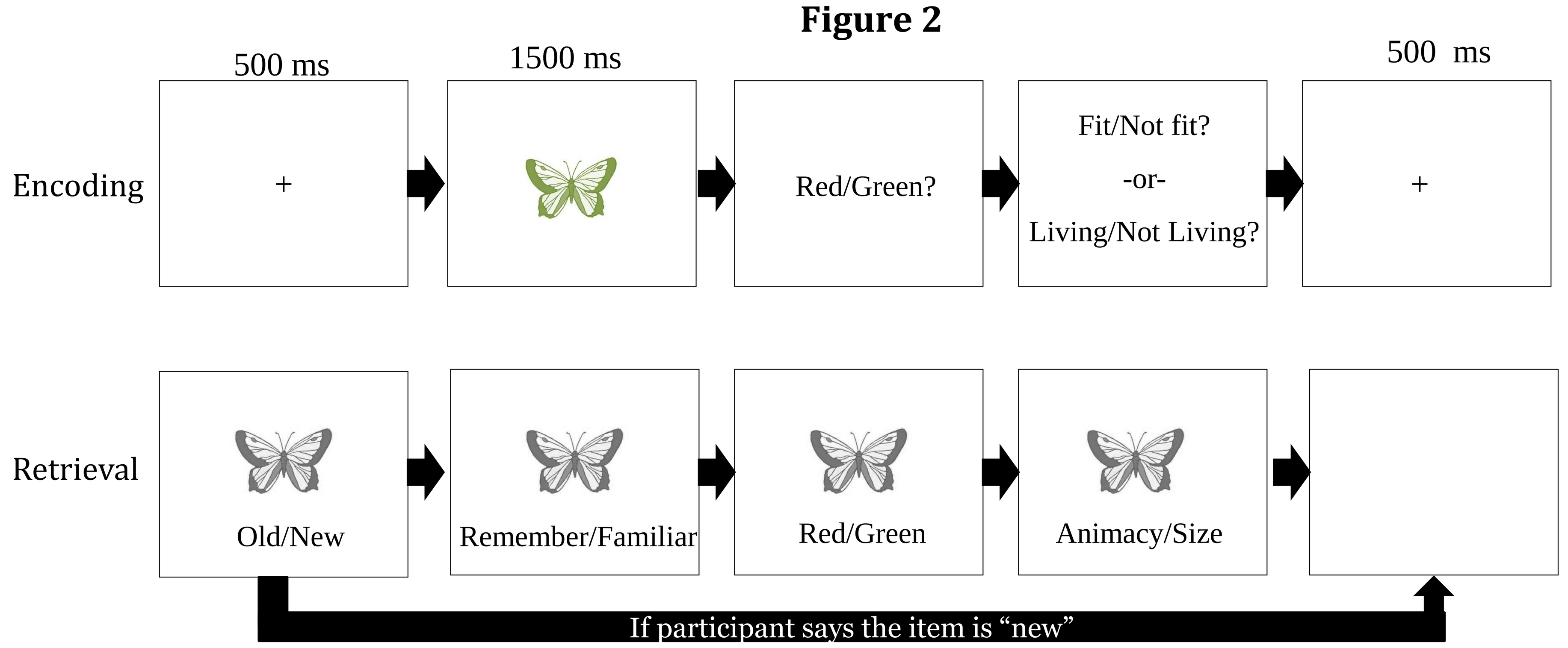
- ERP data were compared between 31 6-8-year-old children (*M* = 7.73, 12 males) and 30 adults (*M* = 20.45, 12 males). An additional 13 participants (6 adults) were excluded due to developmental disabilities, an inability to collect EEG data, noncompliance, and software malfunction. An additional 30 participants (6 adults) were excluded because of too few ERP trials due to movement artifact or performance on the behavioral paradigm (n = 14), poor mastoid quality (n = 15), or overall poor EEG quality (n = 1).

Behavioral Assessment

- The study required one 1.5-hour visit to the Neurocognitive Development Lab.
- Stimuli included 180 animals and common objects from colored Snodgrass and Vanderwart line drawings (Rossion & Pourtois, 2004) and external sources with comparable image coloration and visual complexity. Stimuli were colored red, green, and grayscale using Microsoft Powerpoint.
- Encoding (see Figure 2)
  - Four blocks (30 items/block)
  - Color Judgment (random within block)
  - Size/animacy judgment (alternating each block)
- Retrieval (see Figure 2)
  - Old/new
  - Subjective recollection: Remember/familiar
  - Objective recollection: Color of item
  - Objective recollection: Task performed at encoding

Figure 1

Figure 2



Electrophysiological Methods

Event-Related Potentials (ERPs)

- EEG was recorded with a sampling rate of 512 Hz (BioSemi Active 2) from 64 active Ag-AgCl scalp electrodes and two vertical and two horizontal electrooculogram (EOG) channels (see Figure 1)
- EEG data were re-referenced offline to an average mastoid reference using Brain Electrical Source Analysis (BESA) software (MEGIS Software GmbH, Gräfelfing, Germany). Ocular artifacts were corrected applying the Ille, Berg, & Scherg (2002) algorithm. Trials were hand-edited to remove movement related artifacts. Data were high and low pass filtered at 0.1 Hz and 80 Hz, respectively. Trials were epoched with a 100ms baseline and continued during stimulus presentation for 1500ms. Average ampltiude between 700-900 ms served as the dependent measure.

Results

Behavioral Data

- Adults had higher recognition rates (*M* = .70 .11) than children (*M* = .60 .14), *t*(59) = -3.38, *p* < .01. However, they also had higher false alarm rates (*M* = .09 .08) compared to children (*M* = .02 .02), *t*(59) = -4.64, *p* < .01. D-prime scores were marginally higher in children (2.34 .44) than adults (2.308 .59), *t*(59) = 1.97, *p* = .05.

•Objective Recollection was assessed using a 2 Group x 2 Objective Detail (Color, Task) mixed model ANOVA. Accuracy for these contextual details was only considered for items correctly identified as old. There was a main effect of Objective Detail, *F*(1,59) = 39.41, *p* <.01. Participants were more accurate at identifying the task performed at encoding (*M* = .70 .01) than the original color of the item (*M* = .61 .01).

- Relations between Subjective and Objective Memory (Table 2)
  - Accuracy for objective judgments was calculated separately for remember and familiar judgments and used to examine relations between objective and subjective recollection. We conducted a 2 Group (Children, Adults) x 2 Subjective Judgment ("Remember", "Familiar") x 2 Objective Detail (Color, Task) mixed model ANOVA. There were main effects of Objective Detail, *F*(1, 56) = 11.4, *p* <.01, and Subjective Judgment, *F*(1, 56) = 11.4, *p* =< .01, qualified by an Objective Detail x Subjective Judgment interaction, *F*(1, 56) = 4.75, *p* = .03. Accuracy differences between "Remember" and "Familiar" judgments were larger for task compared to color accuracy. No interaction with group was present suggesting that ***both children and adults were accurately using "Remember" and "Familiar" judgments.***

Table 2

		n	Remember	Familiar
Color Judgment	Children	29	.61(.17)	.59(.2)
	Adults	29	.65(.12)	.56(.13)
Task Judgment	Children	29	.73(.12)	.58(.26)
	Adults	29	.76(.12)	.63(.18)

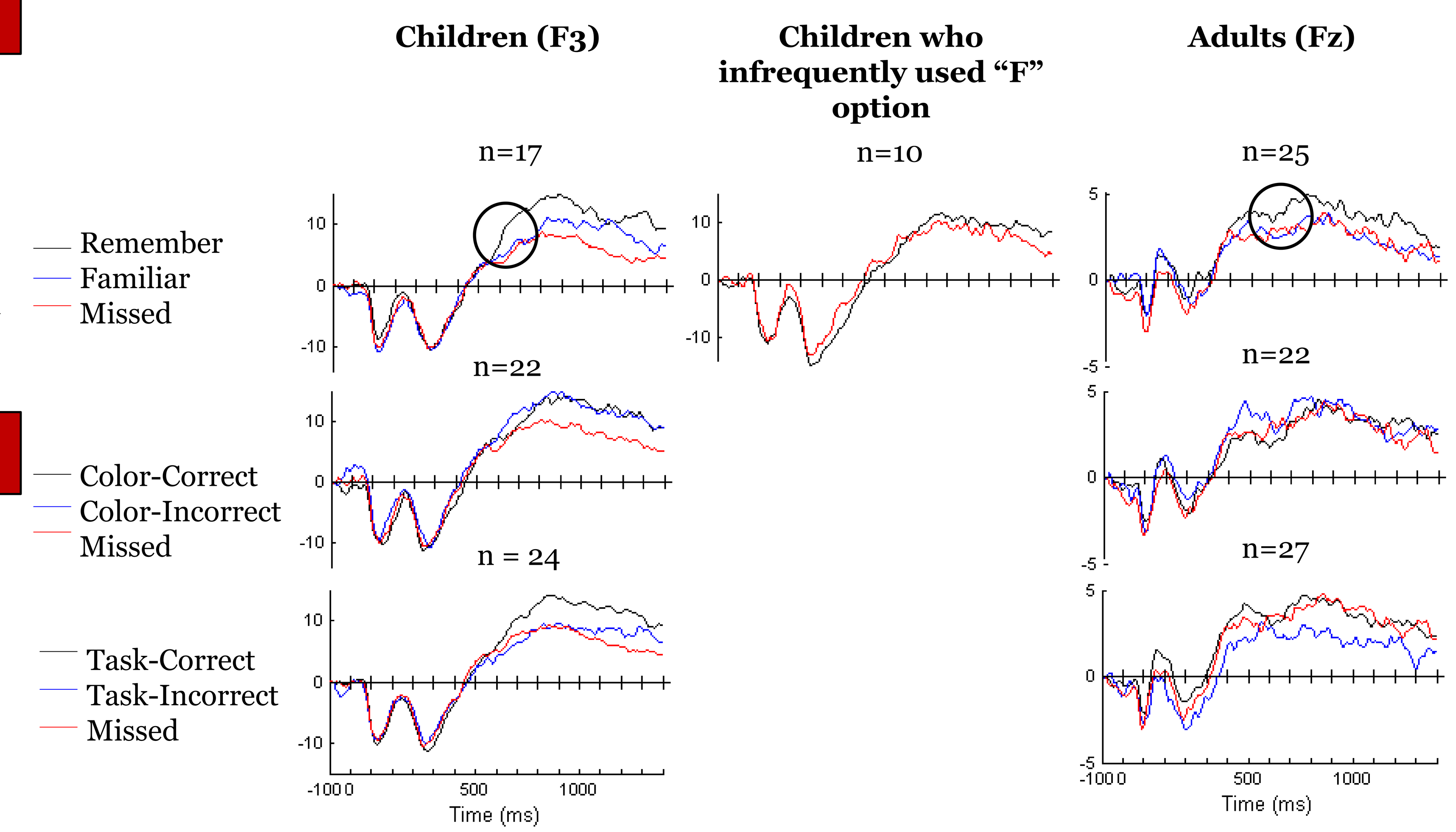
ERP data (Figure 3)

- Mean ERP amplitudes were assessed using mixed model ANOVAs at midline and lateral electrode sites (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4).

Subjective Recollection ERP Data

- Children vs. Adults: Remembered vs. Familiar vs. Missed
  - There was a main effect of condition, F(2, 80) = 8.821, p < .001, and a condition x sagittal x coronal plane interaction F(8, 320) = 2.38, p < .05. ***At frontal, central, and parietal leads a subsequent recollection effect was present.*** Mean amplitudes to items subsequently "Remembered" (8.0 .74 µV) were more positive than amplitudes to "Familiar" (5.7 .81 µV) and missed items (5.22 .7 µV).
- Children using "R" & "F" (N=17) vs. Children primarily using "R"(N=10): "Remembered" vs. Missed
  - There was a marginal condition x group interaction, *F*(1, 25) = 3.37, *p* = .08. There no were differences between groups in amplitude elicited to subsequently missed items, *F*(1, 25) = .09, *p* = .77, there was a difference between groups in amplitude elicited to subsequently "Remembered" items, *F*(1, 25) = 4.55, *p* < .05. The amplitude to "Remembered" items was larger in children who reliably used the R/F distinction (11.82 1.24 µV) than in children who predominantly provided "Remember" responses (7.47 1.62 µV).

Figure 3



Objective Recollection ERP Data

- Objective Recollection: Color (Color-Correct vs. Color-Incorrect vs. Missed)
  - There was no main effect of or interaction with condition.
- Objective Recollection : Task (Task-Correct vs. Task-Incorrect vs. Missed)
  - There was a marginal condition x coronal x group interaction, (4, 196) = 2.44, p = .06. No main effect of or interaction with condition was present in children. In adults, there was a main effect of condition, *F*(2, 52) = 4.47, *p* < .05, characterized by more positive amplitudes to Task-Correct (3.49 .81 µV) and Missed (3.56 .78 µV) than Task-Incorrect Items (2.2 .85 µV).

Discussion

- Consistent with previous ERP studies using the remember/know paradigm or similar methods (Friedman and Trott. 2000; Mangels et al., 2001; Yovel & Paller, 2004, c.f. Smith, 1993) we found recollection effects using the subjective measure of recollection. No differences were present between children and adults. In contrast, recollection effects were not present when recollection was indexed by accuracy for color or task performed at encoding, similar to other studies of objective recollection (Guo et al., 2006; Friedman & Trott, 2000; Rollins & Riggins, in press).
- Future research should investigate factors related to individual differences in "Remember"/"Familiar" judgments in children and the development of neural regions involved in subjective recollection.

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References

Duarte, A., Ranganath, C., Winward, L., Hayward, D., Knight, R. T. (2004). Dissociable neural correlates for familiarity and recollection during the encoding and retrieval of pictures. *Cognitive Brain Research*, *18*, 255-272. doi:10.1016/j.cogbrainres.2003.10.010

Friedman, D., & Trott, C. (2000). An event-related potential study of encoding in young and older adults. Neuropsychologia, 38, 542-557. doi:10.1016/S0028-3932(99)00122-0

Guo, C., Duan, L., Li, W., & Paller, K. A. (2006). Distinguishing source memory and item memory: Brain potentials at encoding and retrieval. *Brain Research*, *1118*, 142-154. doi:10.1016/j.brainres.2006.08.034

Ghetti, S., Mirandola, C., Angelini, L., Cornoldi,C., & Ciaramelli, E. (2011). Development of subjective recollection: Understanding of and introspection on memory states. *Child Development*, *82*(6), 1954-1969.

Ille, N., Patrick, B., & Scherg, M. (2002). Artifact correction of the ongoing EEG using spatial filters based on artifact and brain signal topographies. *Journal of Clinical Neurophysiology*, *19*(2), 113-124. doi:10.1097/00004691-200203000-00002

Mangels, J.A., Picton, T.W., Craik, F.I. (2001). Attention and successful episodic encoding: An event-related potential study. *Cognitive Brain Research*, *11*, 77– 95. doi:10.1016/S0926-6410(00)00066-5

Rollins, L., & Riggins, T. (in press). Developmental changes in memory encoding: Insights from event-related potentials. Developmental Science.

Rossion, B., & Pourtois, G. (2004). Revisiting Snodgrass and Vanderwart's object set: The role of surface detail in basic-level object recognition. *Perception*, *33*, 217-236. doi:10.1002/spe.4380050212

Smith, M.E. (1993). Neurophysiological manifestations of recollective experience during recognition memory judgments, *Journal of Cognitive Neuroscience*, *5*, 1-13. doi:10.1016/S0926-6410(00)00066-5

Wagner, A. D., Koutstaal, W., Schacter, D. L. (1999). When encoding yields remembering: Insights from event-related neuroimaging. *Philosophical Transactions of the Royal Society of London Series*, *354*, 1307-1324. doi:10.1098/rstb.1999.0481

Yovel, G., & Paller, K. A. (2004). The neural basis of the butcher-on-the-bus phenomenon: when a face seems familiar but is not remembered. *Neuroimage*, *21*, 789-800. doi:10.1016/j.neuroimage.2003.09.034