Development of Subjective Recollection: Evidence from Event-Related Potentials

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Introduction

• In adults, ERPs at encoding and retrieval are sensitive to the recollection of contextual details. When recollection is indexed by Tulving's remember/know paradigm (1985), the ERP amplitude differentiates "remember" versus "know" judgments (for reviews see Friedman & Johnson, 2000; Rugg & Curran, 2007).

•Developmental studies suggest that children as young as 6 years of age can reliably perform the remember/know paradigm (Ghetti, et al., 2011) and that recollection follows a longer developmental trajectory than familiarity (Ghetti & Angelini, 2008). However, the neural mechanisms that underlie these developmental trajectories remain relatively unexplored (cf. Ghetti et al., 2010).

•The goal of the current studies was to assess age-related changes in ERPs associated with subjective recollection at encoding (Study 1) and retrieval (Study 2) in children, adolescents, and adults.

Behavioral Methods

Participants

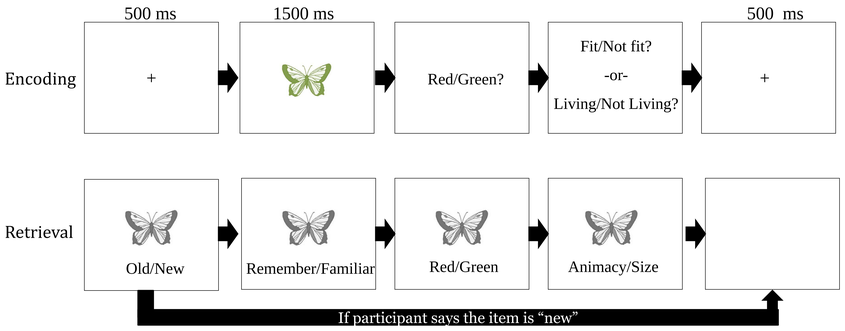
- **Study 1: Encoding**
  - A total of 124 participants provided complete behavioral data for this study, 55 children (mean age = 7.63 years, *SD* = .75, 32 females, 23 males), 32 adolescents (mean age = 12.79 years, *SD* = .61, 18 females, 14 males), and 37 adults (mean age = 20.22 years, *SD* = 2.26, 20 females, 17 males). ERP analysis included 17 children, 24 adolescents, and 26 adults.
- **Study 2: Retrieval**
  - A total of 103 participants provided complete behavioral data for this study, 41 children (mean age = 7.44 years, *SD* = .56, 28 females, 13 males), 26 adolescents (mean age = 12.66 years, *SD* = .64, 18 females, 8 males), and 36 adults (mean age = 20.23 years, *SD* = 2.3, 23 females, 13 males). ERP analysis included 20 children, 19 adolescents, and 29 adults.

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)

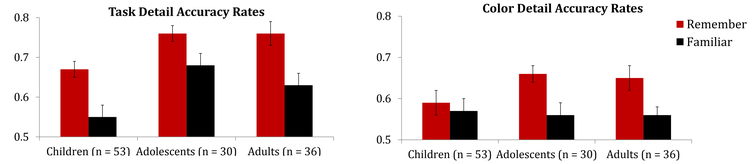
- EEG was recorded with a sampling rate of 512 Hz (BioSemi Active 2) from 64 active Ag-AgCl scalp electrodes and two vertical and two horizontal electrooculogram (EOG) channels (see Figure 1)
- EEG data were re-referenced offline to an average mastoid reference using Brain Electrical Source Analysis (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.

Results

Behavioral Performance (3 Age Group x 2 Subjective Judgment x 2 Objective Judgment)

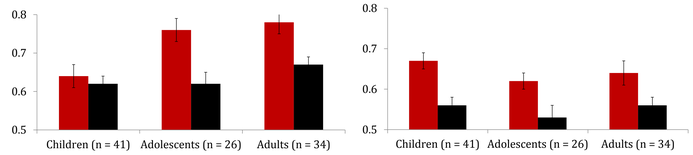
Study 1: Encoding

- Children had poorer memory for details than adolescents and adults, $F(2, 116) = 6.18$, $p = .003$
- Participants had better memory for the task than the color of the item, $F(1, 116) = 17.38$, $p < .001$
- Accuracy was higher when participants provided "remember" judgments, $F(1, 116) = 41.77$, $p < .001$



Study 2: Retrieval

- Participants had better memory for the task than the color of the item, $F(1, 98) = 37.11$, $p < .001$
- Children performed similar to other age groups on color but worse on task, $F(2, 98) = 6.39$, $p = .002$
- Accuracy was higher when participants provided "remember" judgments, $F(1, 98) = 36.48$, $p < .001$
- Children's subjective judgments differentiated color but not task memory, $F(2, 98) = 4.08$, $p = .02$



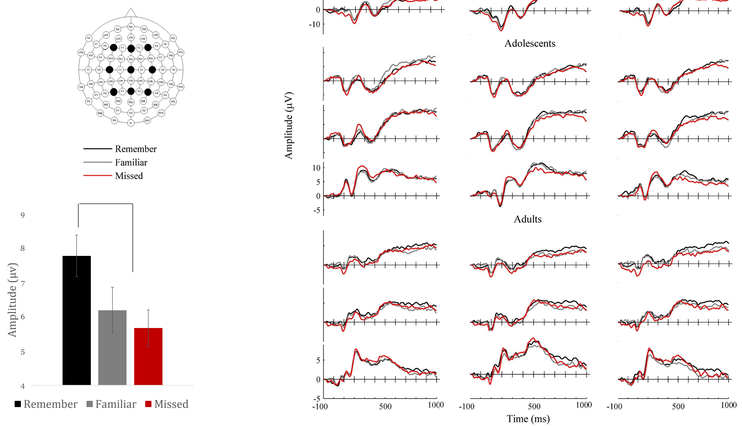
Note: Children in the ERP analysis for Study 2 had behavioral performance more similar to children in Study 1.

ERP Data

3 Age Group x 3 Condition x 3 Coronal x 3 Sagittal

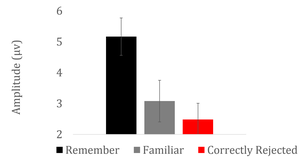
Study 1: Encoding

- 700-900 ms
- Condition, $F(2, 128) = 7.19$, $p = .001$

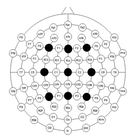


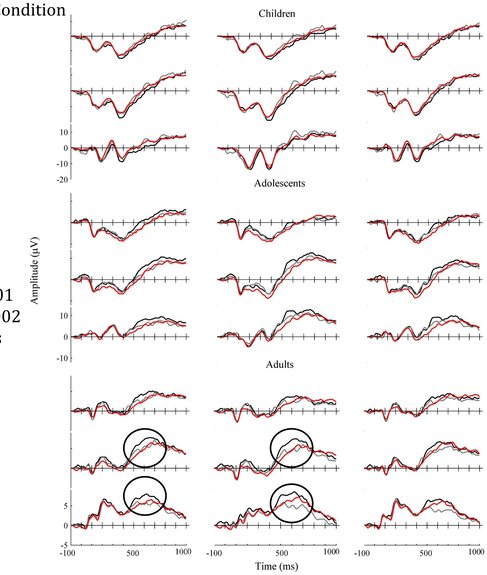
Study 2: Retrieval

- 500-700 ms
  - Age Group x Condition, $F(4, 130) = 7.19$, $p = .001$
  - Age Group x Condition x Sagittal Plane, $F(8, 260) = 2.86$, $p = .012$
  - **Children**
    - No main effect of or interaction with Condition
  - **Adolescents**
    - Condition, $F(2, 36) = 7.3$, $p = .002$



  - **Adults**
    - Condition, $F(2, 56) = 7.1$, $p = .002$
    - Cond. x Coronal, $F(4, 112) = 4.09$, $p = .01$
    - Cond. x Sagittal, $F(4, 112) = 4.44$, $p = .002$
    - Maximal over left centro-parietal leads





Discussion

- No age-related changes were present in the ERP response associated with subjective recollection in Study 1 suggesting similarity of processing at encoding across age groups.
- At retrieval (Study 2), a recollection effect was absent in children, widespread in adolescents, and maximal over left centro-parietal leads in adults.
  - The increased localization of the effect at retrieval is consistent with previous developmental cognitive neuroscience studies and theories that conceptualize development as occurring due to the development of neural regions and their connectivity (e.g., Johnson, 2001).
- Future studies need to investigate which neural regions underlie the age-related differences present at retrieval.

Acknowledgements

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References

Friedman, D, & Johnson, R. (2000). Event-related potential (ERP) studies of memory encoding and retrieval: A selective review. *Microscopy Research and Technique*, *51*(1), 6–28. doi:10.1002/1097-0029(20001001)51:1<6::AID-JEMT2>3.0.CO;2-R

Johnson, M. H. (2001). Functional brain development in humans. *Nature Reviews Neuroscience*, *2*, 475-483. doi: 10.1038/35081509

Ghetti, S., & Angelini, L. (2008). The development of recollection and familiarity in childhood and adolescence: evidence from the dual-process signal detection model. *Child Development*, *79*(2), 339–58. doi:10.1111/j.1467-8624.2007.01129.x

Ghetti, S., DeMaster, D. M., Yonelinas, A. P., & Bunge, S. A. (2010). Developmental differences in medial temporal lobe function during memory encoding. *The Journal of Neuroscience*, *30*(28), 9548–56. doi:10.1523/JNEUROSCI.3500-09.2010

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

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

Rugg, M. D., & Curran, T. (2007). Event-related potentials and recognition memory. *Trends in Cognitive Sciences*, *11*(6), 251–7. doi:10.1016/j.tics.2007.04.004

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology/Psychologie Canadienne*, *26*(1), 1-12. doi: 10.1037/h0080017