ERPs to Error-related Feedback During a Spatial Memory Task in Older and Younger Adults.

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Purpose

To examine the effect of age on behavioural and neural response to error-feedback on a spatial task.

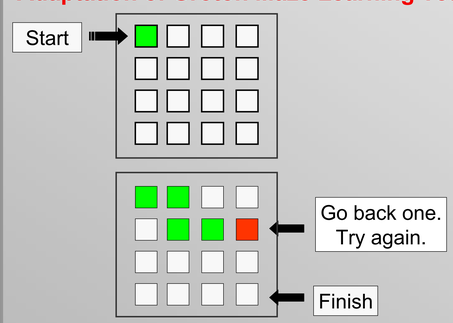
Background:

- According to Reinforcement Learning Theory[1], the FB-ERN should be largest when feedback is most relevant during the initial learning trials of a memory task. As the task is learned, participants should become less dependent on external feedback resulting in a reduction in the FB-ERN.
- Older adults may be less likely to internalize the feedback during spatial-memory learning trials[2] so dependency of external feedback should be maintained with no decline in the FB-ERN.

Methods

Participants: 20 young adults (18-26 y); 20 older adults (65-87 y). All healthy. Equivalent education ($p > .25$). Vocabulary score: old > young ($p < .001$).
Stimuli: Eight 4 x 4 grids of neutral tiles on a touch-screen tablet computer. There is a hidden pathway in each grid.

Adaptation of Groton Maze Learning Test [3]



Learning trial: Ss use a stylus to sequentially select tiles that would reveal the hidden pathway. Tiles turn green for correct moves and red for errors.
Memory trials: Ss get 2 attempts to retrace the pathway found during the learning trial. Tiles continue to turn green or red for feedback.

ERPs:

- 250 sites. EOG regression corrected.
- Bandpass 1 - 30 Hz.
- Epochs: 1800 ms epochs; -200 to 0 ms pre-response baseline.

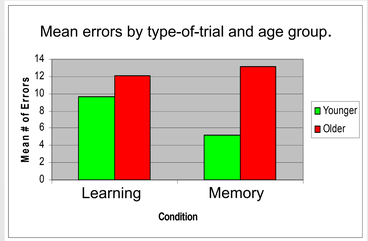
Results

Behavioural Error Rates

Interaction with Task and Age:

- Young adults' error rate dropped during memory trials.
- Older adults error rate did not.

[Age X Task = $p < .01$]



Feedback ERN (FB-ERN)

Interaction with Task and Age ($p < .05$)

- Young adults produced a deeper FB-ERN during learning trials (M = .02 μV) than during memory trails (M = .92 μV).
- Older adults did the opposite: they produced a deeper FB-ERN during memory trials (M = -.18 μV) than learning trials (M = .58 μV).

Feedback Pe (FB-Pe)

Interaction with Task and Age ($p < .01$)

- Young adults produced larger FB-Pe for memory errors (M = 8.84) relative to learning trial errors (M = 5.72).
- Task had little effect on older adults' FB-Pe (Memory: M = 5.35; Learning: M = 5.23).

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FB-Pe (not FB-ERN) correlates with maze performance

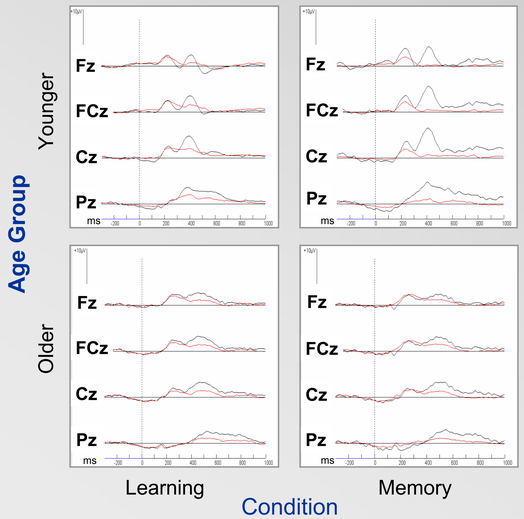
- Young adults who made fewer errors on learning trials produced higher amplitude FB-Pe's in response to errors during memory trials ($p < .01$)

High performers on learning trial = more surprised by errors?

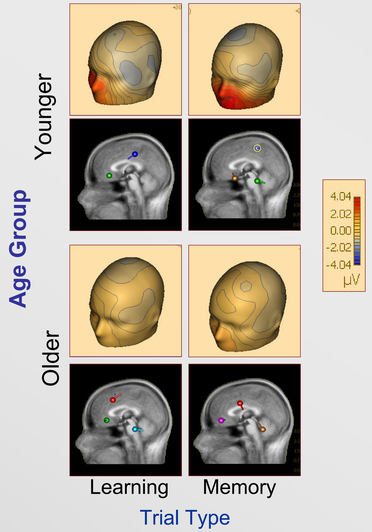
- Older adults who had shallower FB-Pe amplitudes on learning trials made more maze errors on memory trials. $P < .05$)

Elders who react more to errors on learning trials = better performance on memory trials

ERPs by Condition, Age, and Site
(Errors in black, corrects in red)



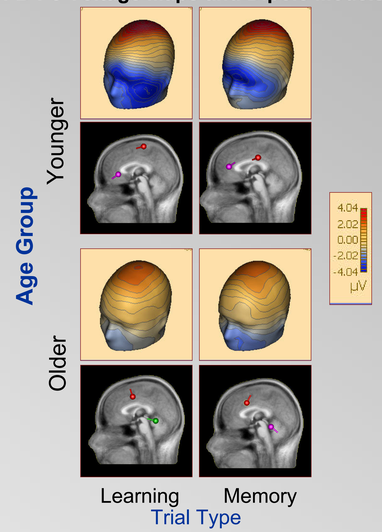
FB-ERN Voltage Maps and Dipole Models



FB-ERN Dipoles (RVs from 5 – 10%):

- Symmetrical pairs of dipoles produced the best model of the FB-ERN for both young and older adults.
- They consist of dorsal ACC, rostral prefrontal, and posterior base of brain, similar to Miltner.[4]

FB-Pe Voltage Maps and Dipole Models



FB-Pe Dipoles (RVs from 7 – 10%)

- Best fit for younger adults required a shift in dipole location between learning and memory trials.
- Best fit for older adults was achieved by maintaining same sources during both types of trials.

Conclusions

1. Data fit reinforcement learning theory framework. For young adults FB-ERN is reduced during memory trials as dependence on external feedback declines. Older adults' FB-ERNs do not diminish across memory trials[5] suggesting their dependency on external feedback is maintained.
2. The FB-Pe provides complementary information, interacts with age and task, and relates to behavioural response as demonstrated by Mathewson et al. for the standard Pe.[6]
3. Dipole models vary across task for the young but less so for the older adults suggesting more task-specific neural engagement in older relative to younger persons (see Reuter-Lorenze).[7]

References

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