

Neurocognitive Patterns for Episodic Metamemory Judgments In Young and Older Adults: First Insights

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SPS SGP SSP

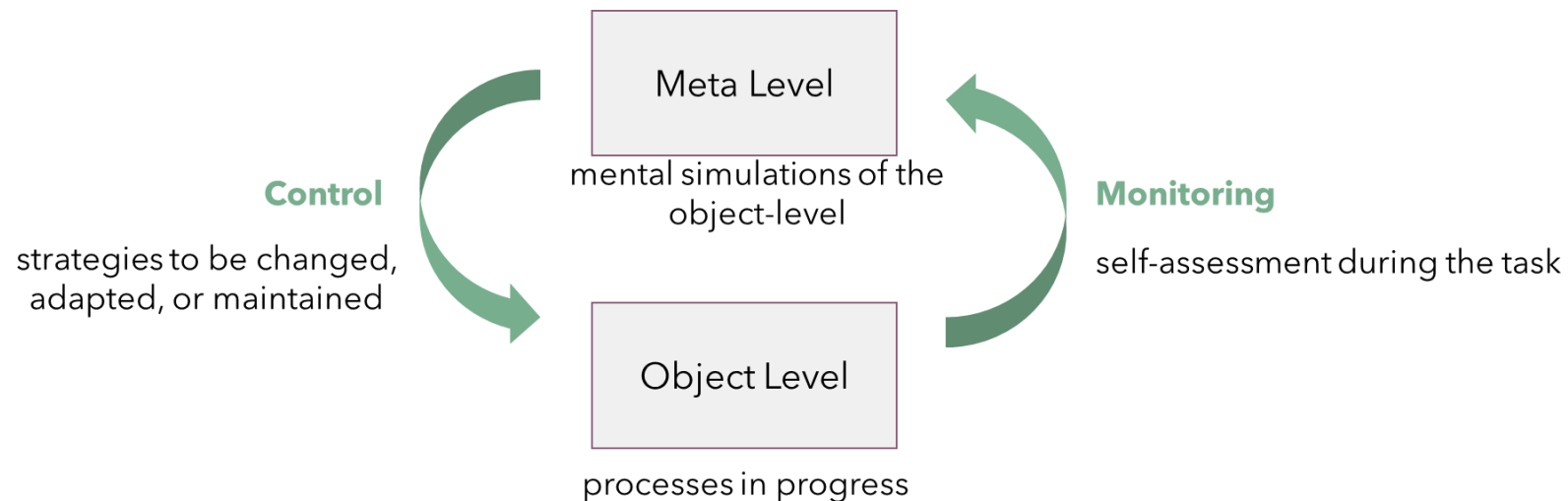
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Episodic Metamemory

ability to monitor and control the processes of episodic memory that is, memory for personally experienced events situated in a specific spatial and temporal context



Episodic Metamemory

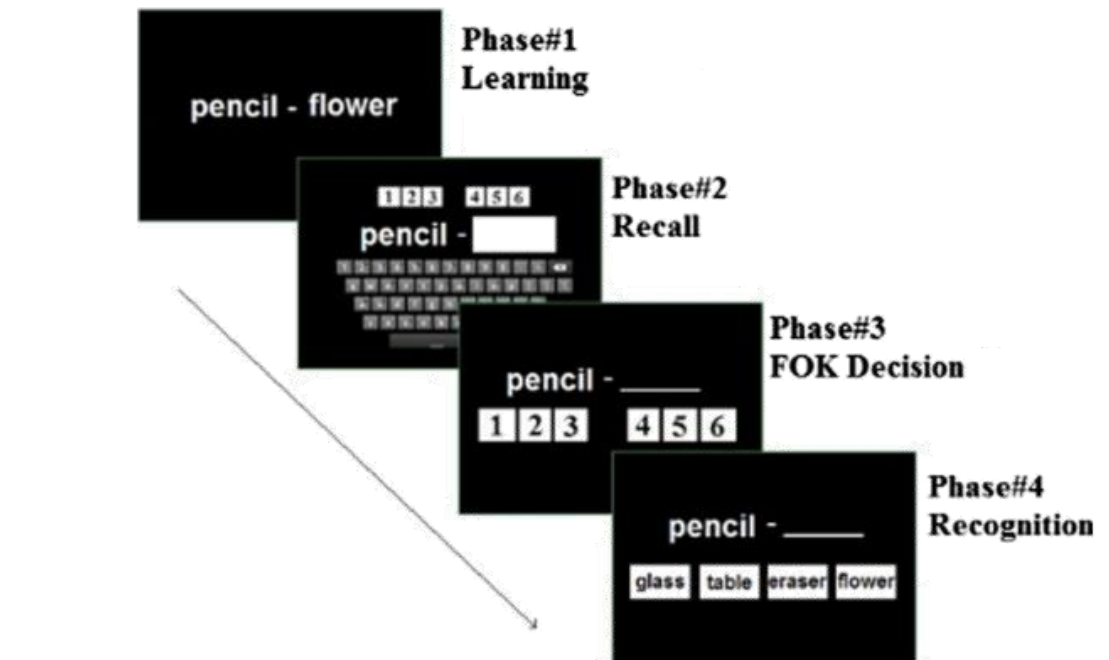
Usually assessed by a **Feeling-Of-**

Knowing (FOK) task

Allow for a distinction between **congruent vs. incongruent judgments (for unrecalled items)**

"Yes" or "4, 5, 6"
+ correct recognition
or
"No" or "1, 2, 3"
+ failed recognition

"Yes" or "4, 5, 6"
+ failed recognition
or
"No" or "1, 2, 3"
+ correct recognition



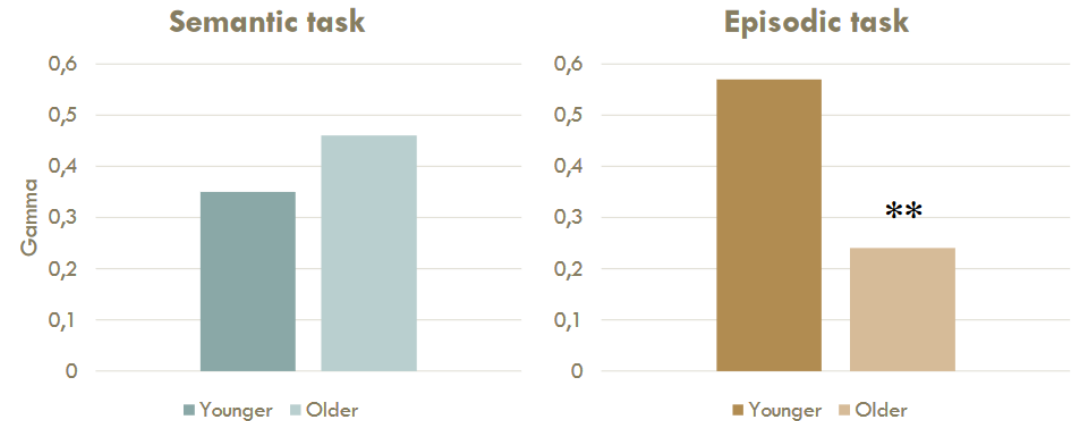
"Even though I don't remember the answer now, do I know the answer to the extent that I am able to pick the correct answer from among several choices in the future?"

Episodic metamemory in Aging

Decreased performance in memory and metamemory in older adults

BUT (always a BUT, right?)

Do metamemory performances depend on memory performances?



Souchay et al., 2007

Episodic and semantic feeling-of-knowing in aging: a systematic review and meta-analysis

Méline Devaluez^{1,3,4}, Audrey Mazancieux^{2,3,4} & Céline Souchay¹

Neuroimaging of episodic metamemory

- Few fMRI studies
- Even fewer in EEG
- Even fewer in FOK
- Very few with classic FOK tasks

From fMRI: prefrontal cortex, medial temporal lobe, parietal regions in metamemory

⇒ As these regions support memory retrieval, self-monitoring, and strategic regulation processes

Episodic Metamemory: Right frontoparietal areas (*Kikyo et al., 2002; Meunier-Duperray, Souchay, et al., 2025*), but also on the ventral region of posterior parietal cortex



Exploring the domain specificity and the neural correlates of memory unawareness in Alzheimer's disease

Lucile Meunier-Duperray^{a,b,*}, Céline Souchay^a, Lucie Angel^b, Eric Salmon^c, Christine Bastin^{c,d}

(see Vaccaro & Fleming, 2018 for a meta-analysis)

Electroencephalography

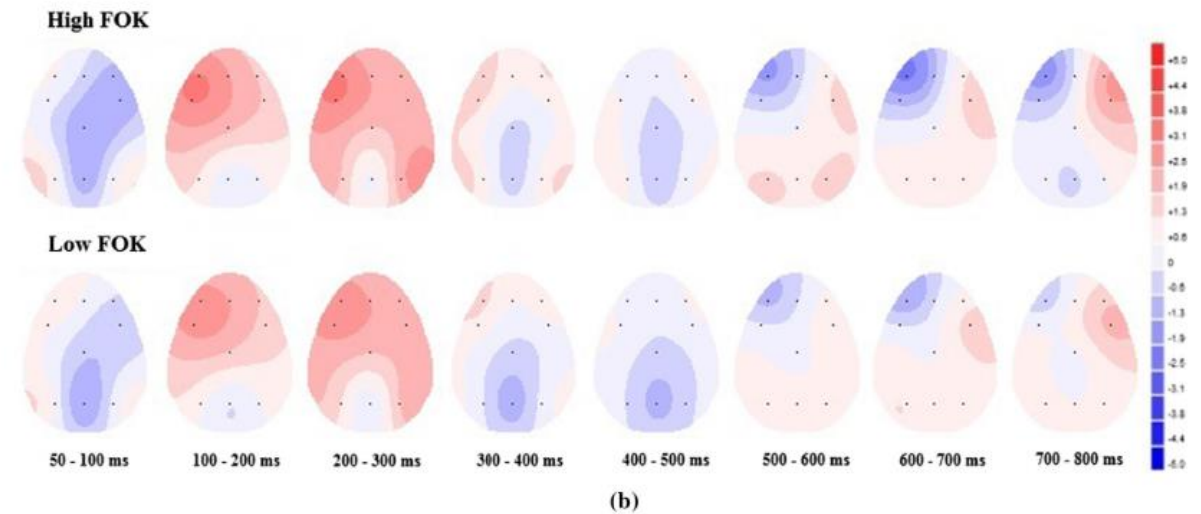
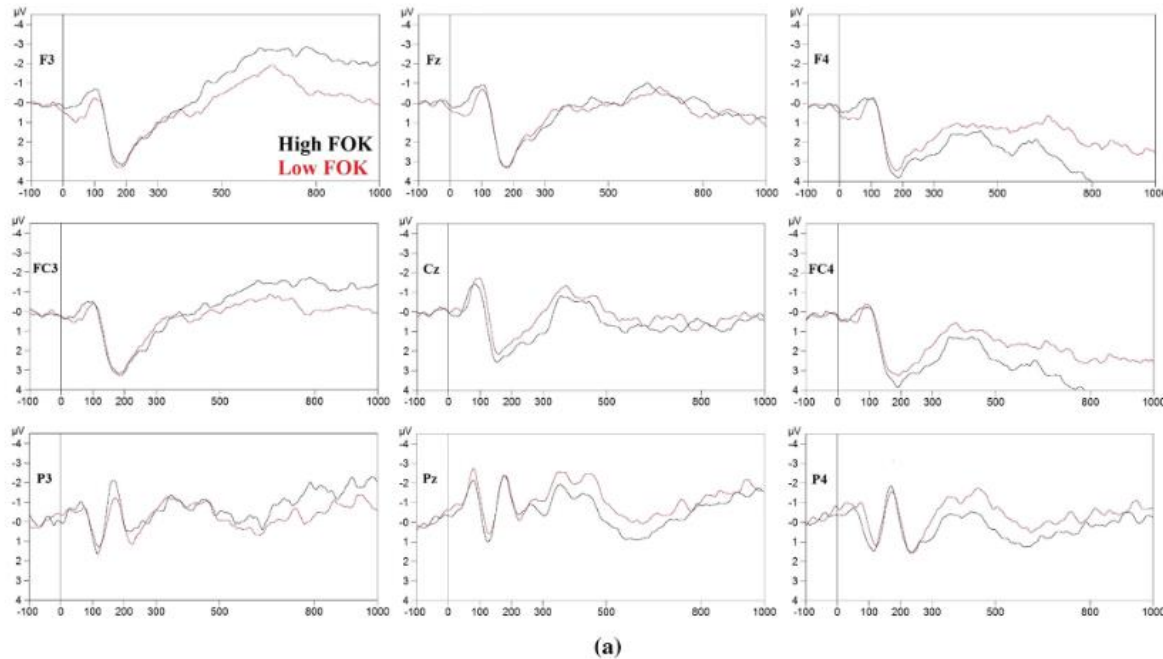


Fig. 3 Stimulus-locked ERP grand average ($n = 77$) in overall high (black line) and overall low (red line) FOK decisions a at F3, Fz, F4, FC3, Cz, FC4, P3, Pz, and P4 electrode sites and b Headplots

in overall high (top) and overall low (bottom) FOK decisions. Stimulation applied at '0.0 ms' time point (stimulus onset). (Color figure online)

FOK judgments were associated with greater positivity for P200 component at frontal, central/fronto-central and parietal electrode sites and greater negativity for the N200 component at parietal electrode sites

Main ERP of interest:

P200: 160-240 ms, involved in perception and similarity effects

N200: 150-280 ms, involved in control and monitoring processes during metacognitive judgments

P300: 240-400 ms, involved in updating, familiarity, decision-making, and confidence

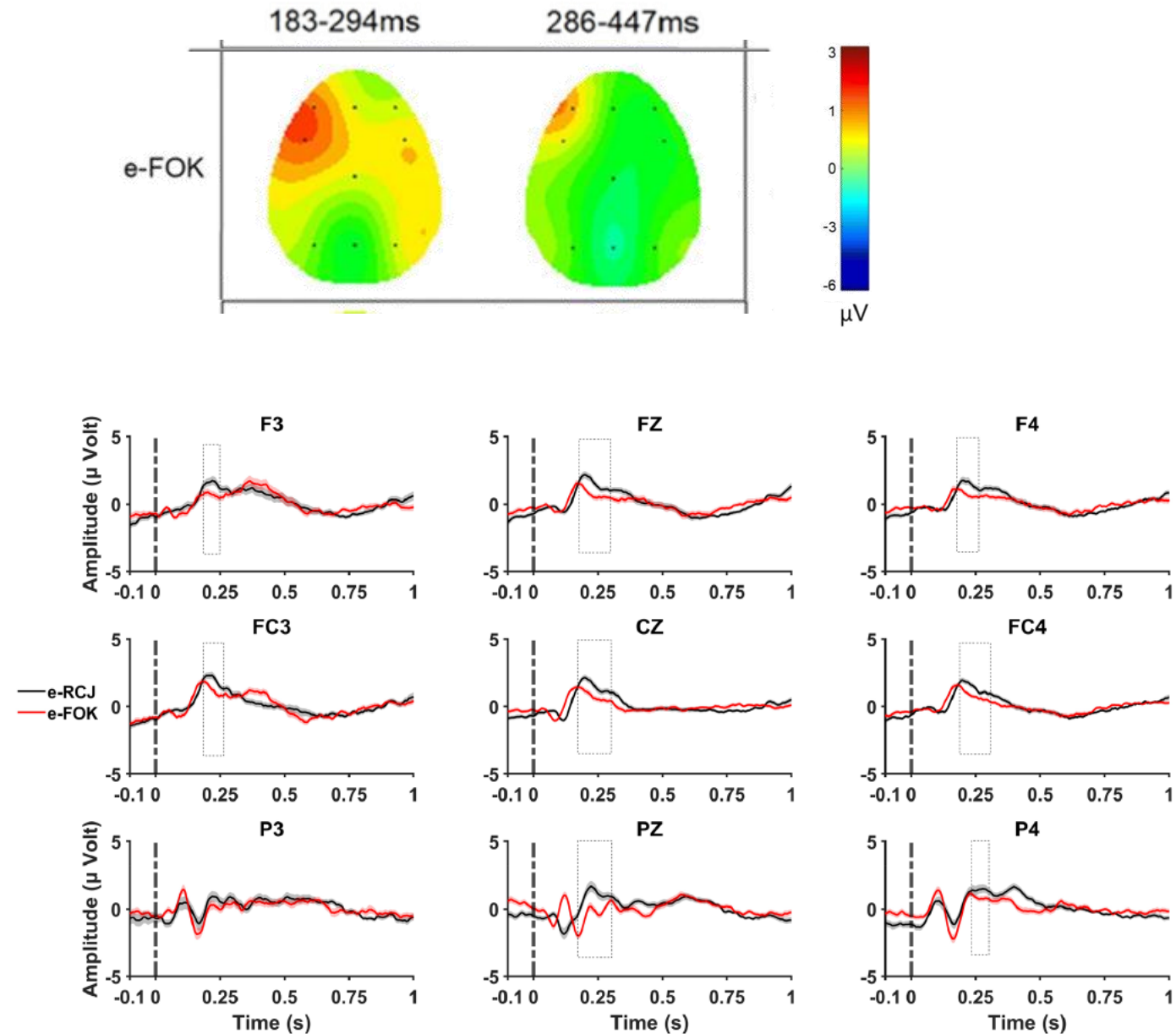


Figure 4. Stimulus-locked ERP grand average with standard errors during the episodic memory task for RCJ (black line) and FOK (red line) at F3, Fz, F4, FC3, Cz, FC4, P3, Pz, and P4 electrode sites. Stimulation applied at “0.0 ms” time point (stimulus onset). Cluster-based permutation tests were run within 50–900 ms, and dashed boxes indicate latencies that were found to exhibit significant effects.

Objectives

- 1 Propose a robust methodology based on the few studies evaluating the electrophysiological correlates of metamemory
- 2 Exploring the brain mechanisms underlying episodic metamemory via EEG
- 3 Evaluate how these patterns behave in young adults and older adults: difference between ERP in incongruent judgments via amplitude ↘ and latency ↗ and a ++ parietal recruitment

From the familiarity and recollection-based literature:

- familiarity-based processes are associated with frontal activity, 300 - 500 ms (P200)
- recollection-based processes are associated with parietal activity in the 400 - 800 ms (P300)

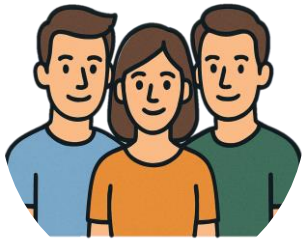
Would it be predictive of a differentiation between congruent vs. incongruent judgments? Based on the familiarity-recollection framework, would it be a characteristic of FOK processing in aging?

Method



31 Young Adults
20 – 40 years old

36 Older Adults
60 – 80 years old
MoCA > 23

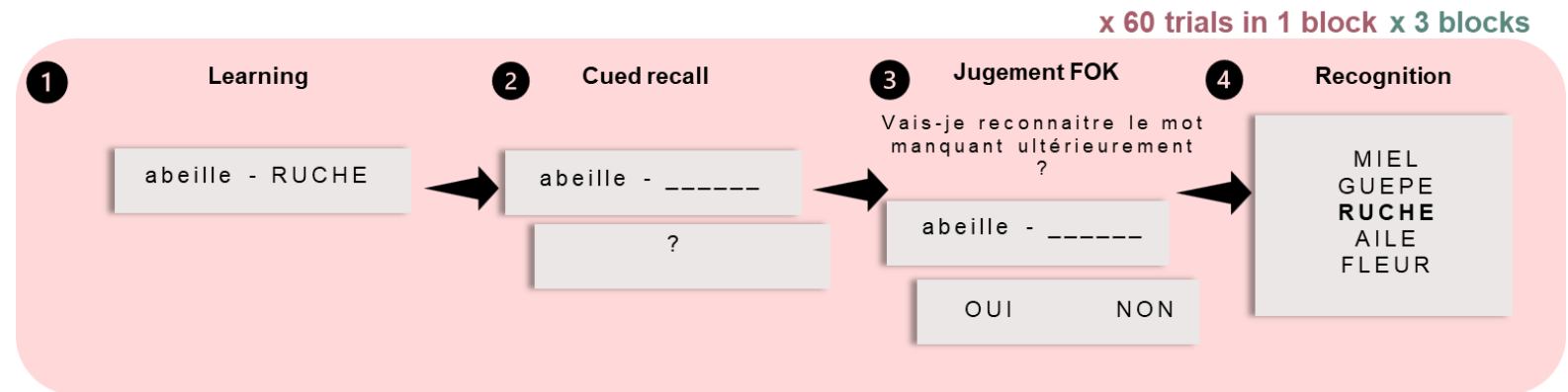


Educational level: **J = A**, $BF_{10} = 0.28$

Anxiety : **J = A** , $BF_{10} = 0.28$

Depression : **J = A** , $BF_{10} = 0.91$

⇒ Vocabulary level : **J < A**, $BF_{10} = 1108$

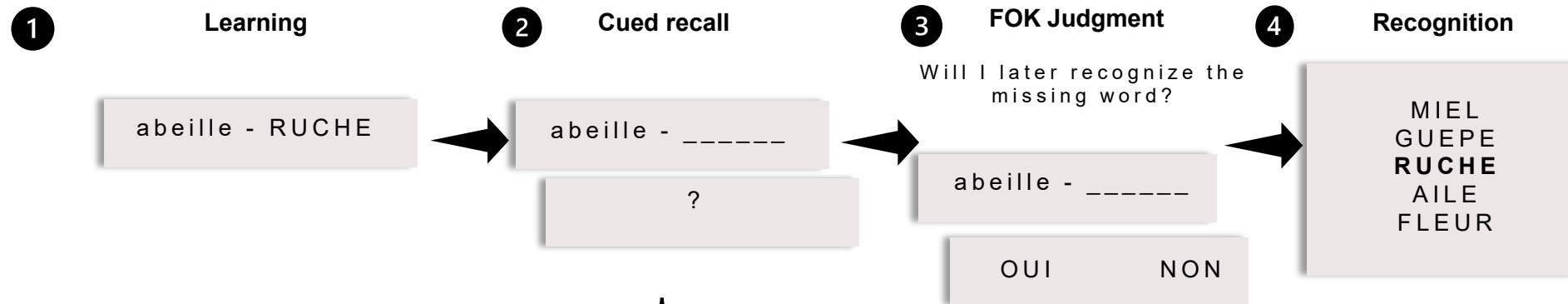


Memory scores:
Correct Recalls
Correct Recognitions

Metamemory score:
Congruency: percentage of hit/yes responses
Gamma FOK = $\gamma = \frac{\text{jugements congruents} - \text{incongruents}}{\text{jugements congruents} + \text{incongruents}}$

Feeling-Of-Knowing Paradigm

x 60 trials in 1 block x 3 blocks



EEG Recording

64 electrodes

2 VEOG

2 HEOG

AFz as Ground



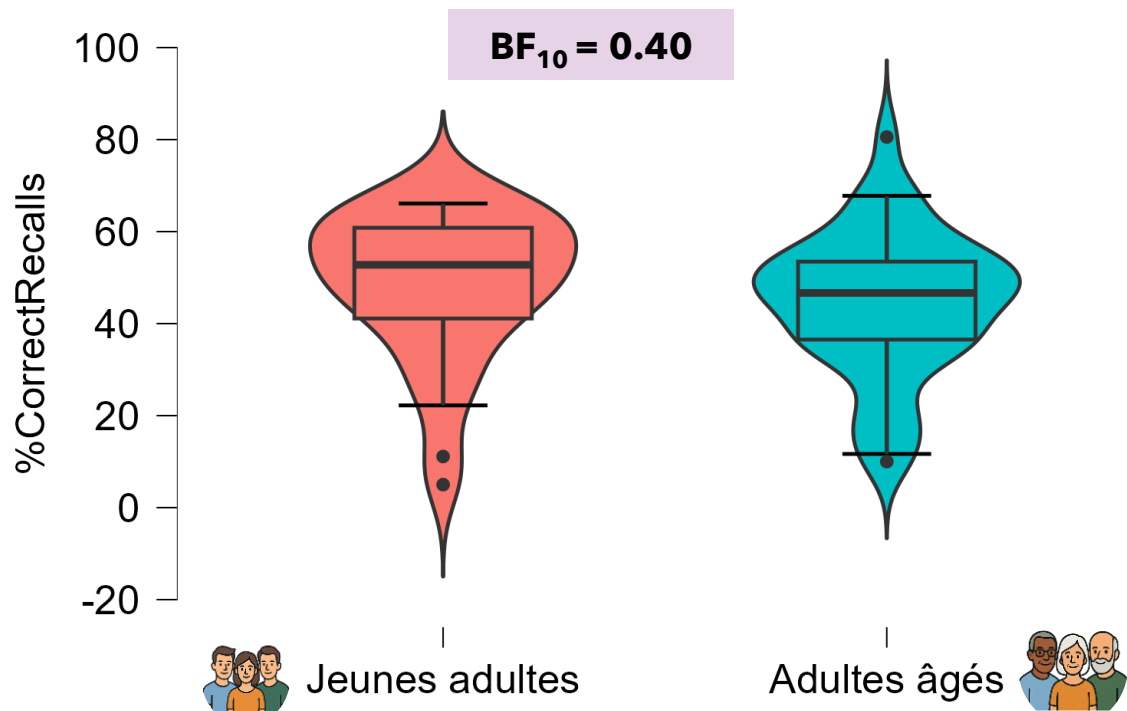
ERP stimulus-locked during the cued-recall phase

Would it be predictive of a differentiation between subsequent congruent vs. incongruent judgments?

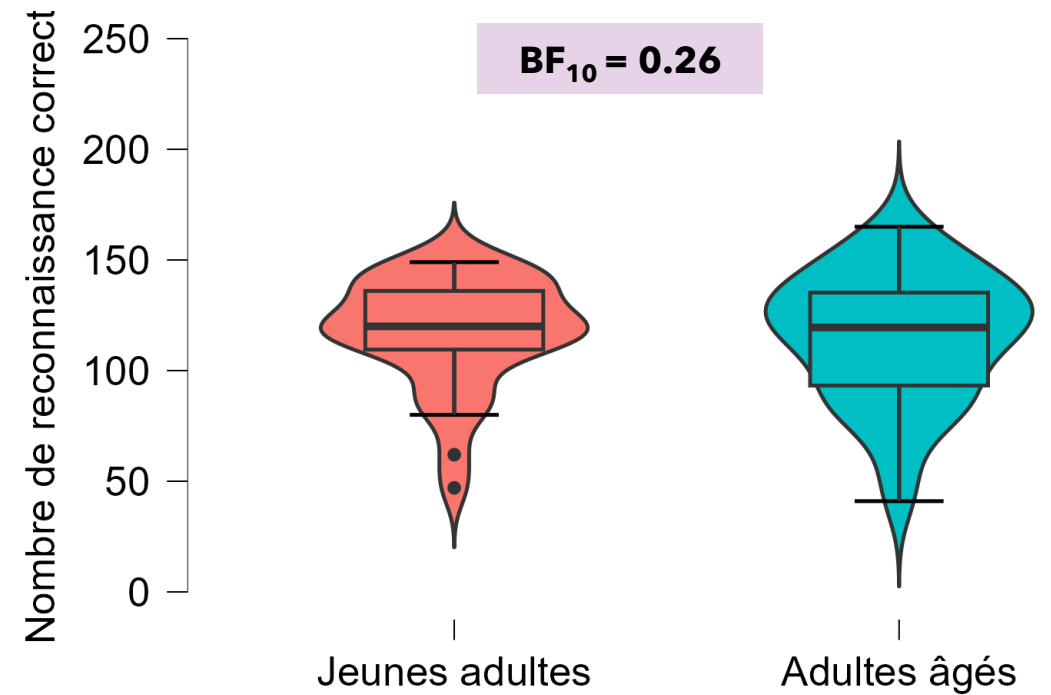
Based on the familiarity-recollection framework, would it be a characteristic of FOK processing in aging?

Behavioral results: Memory performance

Number of Correct Recalls

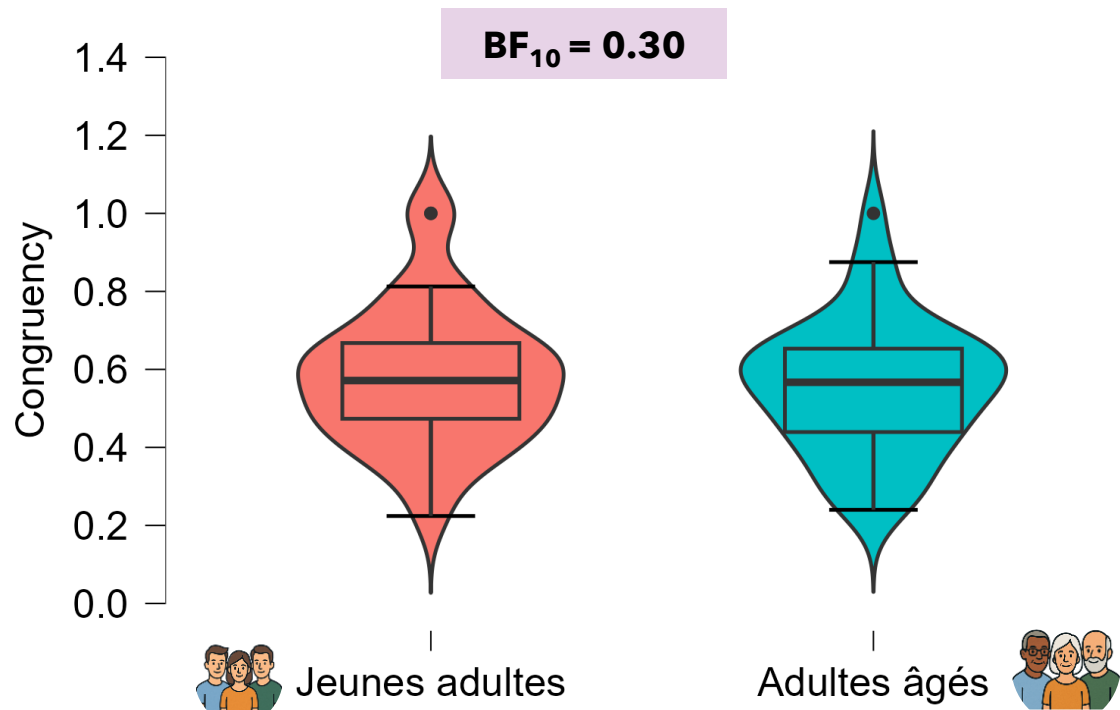


Number of Correct Recognitions

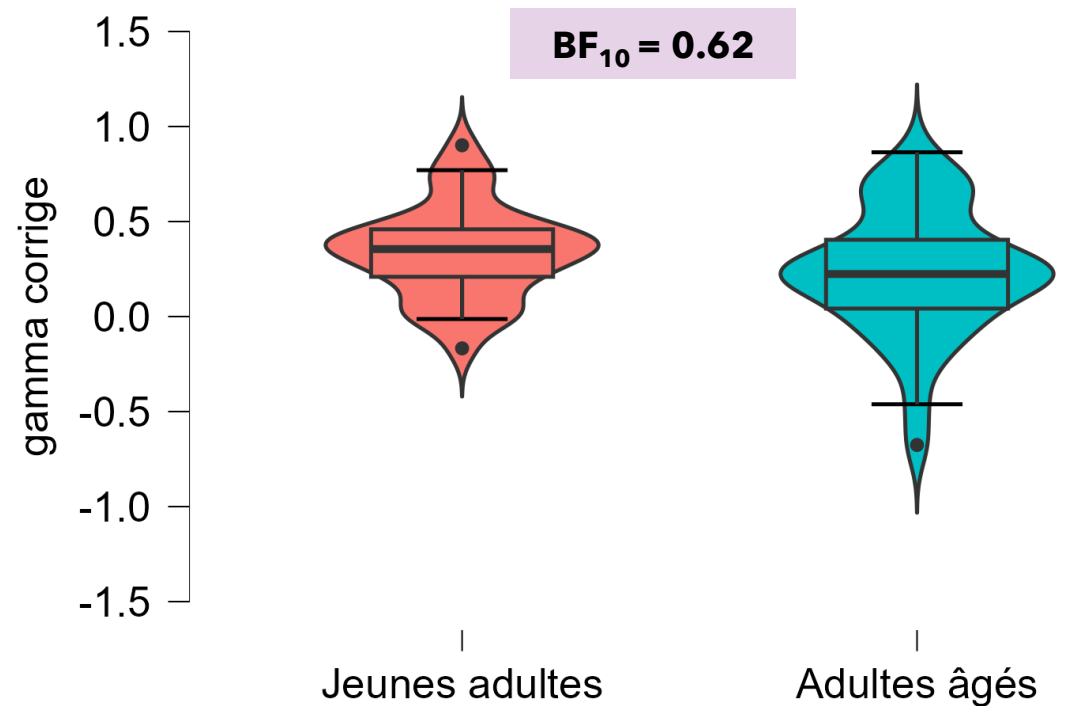


Behavioral results: Metamemory performance

Congruency



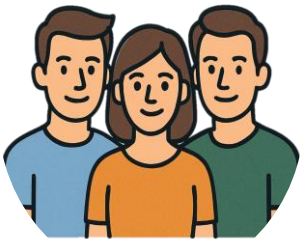
Gamma



Behavioral results: discussion

Equivalent in episodic memory & metamemory

$BF_{10} < 3$



"[...] that when there is no difference between OA and YA in terms of recognition performance, the eFOK difference vanishes."

"When memory performance is equal across groups, the eFOK deficit in older adults does not exist anymore"

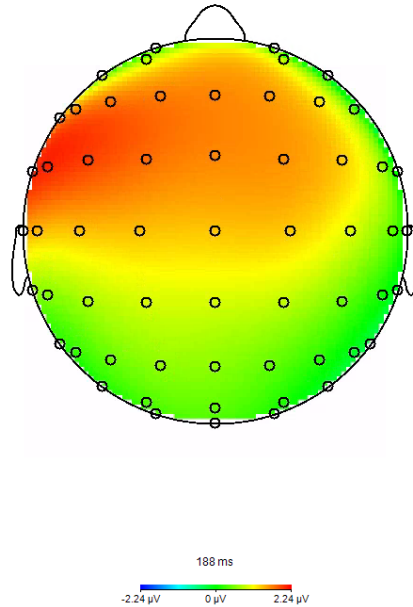
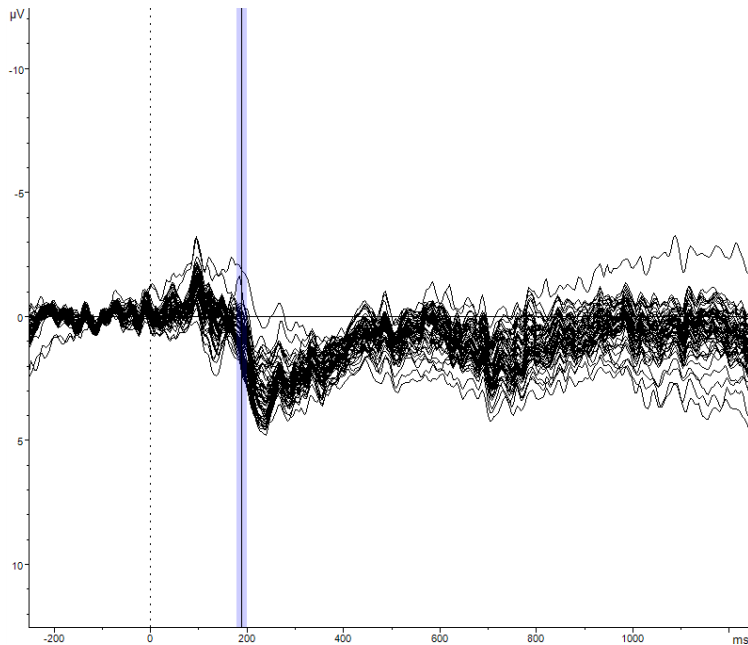
- ✓ Devaluez et al. (2023)
- ✓ Meunier-Duperray et al., (2025b)

⇒ **Best-case scenario to compare EEG signals**

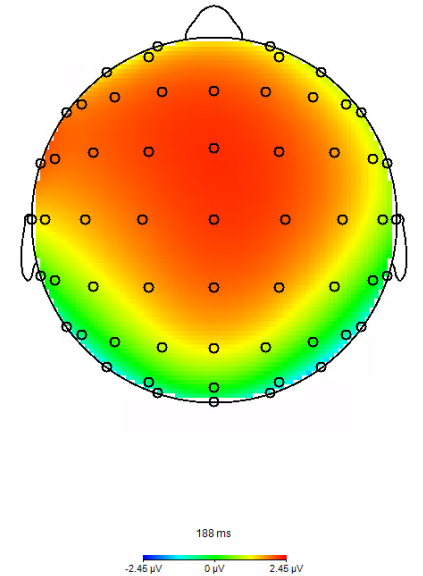
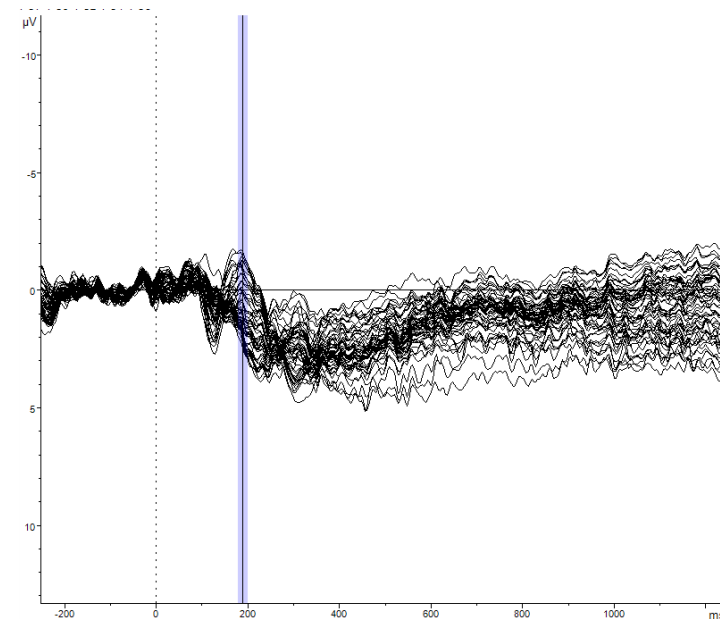
Visual inspection for uncongruent judgments

Using Mapping View and LORETA on Groups Grand Average

Young adults



Older adults



Focal left-frontal P200 for incongruent judgments. They rely on early, selective cue-based familiarity signals that can mislead metamemory monitoring?

Reduced focalization and more widespread activation, consistent with the **Compensation hypothesis** (HAROLD model) or **dedifferentiation** (less specific neural responses)

Discussion

- EEG *seems visually* comparable with Irak et al. (2019, 2023) for YA
- Still, it's just primary visual inspection, we are currently running analyses!
- Irak et al: stimulus-locked at FOK judgment, not cued recall
- Insights are welcomed

Thanks

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Céline Souchay
Grenoble



Chris Moulin
Grenoble



Christine Bastin
Liège

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& to Chiara & SPS

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Other useful papers from our project

Mazancieux, A., Dinze, C., Souchay, C., & Moulin, C. J. A. (2020). Metacognitive domain specificity in feeling-of-knowing but not retrospective confidence. *Neuroscience of Consciousness*, 2020(1), niaa001.

<https://doi.org/10.1093/nc/niaa001>

Mazancieux, A., Fleming, S. M., Souchay, C., & Moulin, C. J. A. (2020). Is there a G factor for metacognition? Correlations in retrospective metacognitive sensitivity across tasks. *Journal of Experimental Psychology: General*, 149(9), 1788-1799.

<https://doi.org/10.1037/xge0000746>

Meunier-Duperray, L., Mazancieux, A., Souchay, C., Bastin, C., Angel, L., & Moulin, C. J. (2025b). On the complexity of metacognitive judgments of memory : Evidence from retrospective confidence, feeling of knowing, and older adults. *Neuroscience of Consciousness*, 2025(1), niaf003.

Meunier-Duperray, L., Mazancieux, A., Souchay, C., Fleming, S. M., Bastin, C., Moulin, C. J., & Angel, L. (2025c). Does age affect metacognition? A cross-domain investigation using a hierarchical Bayesian framework. *Cognition*, 258, 106089.



Thank you for your attention!

Lucile Meunier PhD Thesis, p.36

Table 2. Summary of the metacognitive measures.

Index	Framework	Measure of...	Calculation	Advantages	Disadvantages
Gamma and phi correlations (Goodman & Kruskal, 1979)	Correlational approach	Metacognitive sensitivity	Non-parametric correlation between accuracy and confidence	Valid measure of metacognition	Influenced by bias and first-order performance
AUROC2 (Galvin et al., 2003)	Signal detection theory	Metacognitive sensitivity	Area under the Type-2 ROC curve	Bias free	Influenced by first-order performance
M_{ratio} (Maniscalco & Lau, 2012, 2014)	Signal detection theory	Metacognitive efficiency	Ratio between <i>meta-d'</i> (i.e., <i>d'</i> value estimated from second-order performance) and <i>d'</i>	Bias free, independent from first-order performance	Need many trials to be reliable
HMeta-d (Fleming, 2017)	Model-based approach	Metacognitive efficiency	M_{ratio} estimates using a hierarchical Bayesian framework	Task-performance independency and strong test-retest reliability, even when the number of trials is limited	