

Characterizing EEG signatures of inattention that predict forgetting

DRAPER



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INTRODUCTION

- Periods of inattention are associated with reduced cortical analysis of the external environment (perceptual decoupling)
- Perceptual decoupling is evident in attenuated ERP responses to stimuli that appear during off-task vs. on-task periods¹⁻³

Research Questions

Does perceptual decoupling occur in response to task-relevant and task-irrelevant stimuli during incidental encoding?

Do EEG markers of inattention predict subsequent long-term memory?

PARTICIPANTS

- 35 young adults (18 male)
- Mean age = 22.5 yrs
- Mean education = 15.5 yrs
- All right handed

EEG METHODS

- 32-channel EEG recorded during encoding
- Eye-blink artifacts corrected with ICA
- Artifact rejection by automatic/manual inspection
- Baselined -200 to 0ms before face / tone onset
- Re-referenced to average of L/R mastoid

Analysis

Periods of inattention defined by:

1. **Subjective self-report of attentional state**¹⁻³
 - Off-task vs. on-task reports
 - Analyzed by averaging 3 trials preceding attention prompt
2. **Behavioral measure of RT variability**⁴
 - Absolute deviance from within-subject mean RT

Perceptual decoupling analyses focused on a priori time windows and regions of interest:

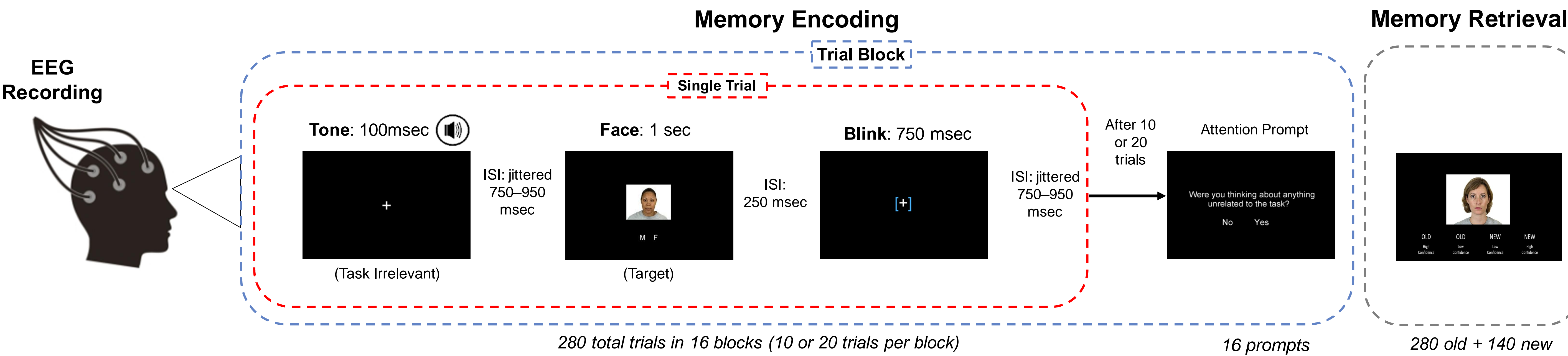
- P3 over centro-parietal electrodes¹⁻³
- Auditory N1 over central electrodes³
- Face-specific N170 over right occipito-temporal electrodes⁵

Memory analyses included these same attention-related ERPs as well as the canonical Dm effect

REFERENCES

1. Smallwood, J., Beach, E., Schooler, J., & Handy, T. (2008). Going AWOL in the Brain: Mind Wandering Reduces Cortical Analysis of External Events. *Journal of Cognitive Neuroscience*, 20(3), 458-469.
2. Kam, J. W., Dao, E., Farley, J., Fitzpatrick, K., Smallwood, J., Schooler, J. W., & Handy, T. C. (2010). Slow Fluctuations in Attentional Control of Sensory Cortex. 23(2), 460-470.
3. Baird, B., Smallwood, J., Lutz, A., & Schooler, J. W. (2014). The Decoupled Mind: Mind-wandering Disrupts cortical Phase-locking to Perceptual Events. *Journal of Cognitive Neuroscience*, 26(11), 2596-2607. doi:10.1162/jocn_a_00656
4. Esterman, M., Rosenberg, M., & Noonan, S. (2014). Intrinsic Fluctuations in Sustained Attention and Distractor Processing. *The Journal of Neuroscience*, 34(5), 1724-1730.
5. Rossion, B., Gauthier, I., Tarr, M.J., et al. (2000). The N170 occipito-temporal component is delayed and enhanced to inverted faces but not to inverted objects: an electrophysiological account of face-specific processes in the human brain. *Cognitive Neuroscience*, 11(1), 69-74.

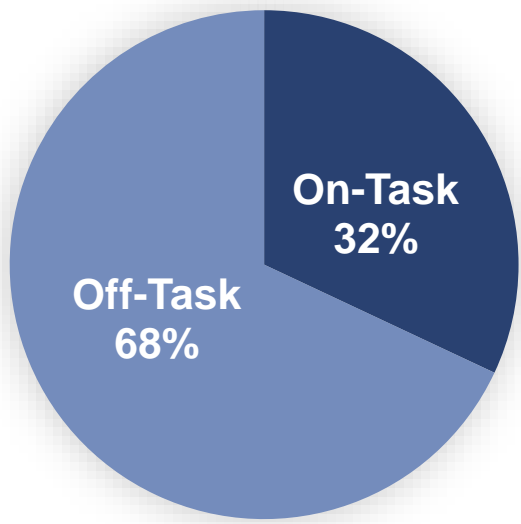
METHODS



BEHAVIORAL RESULTS

Encoding

- Mean Acc = 95% (SD = 4)
- Mean RT = 682ms (SD = 77)



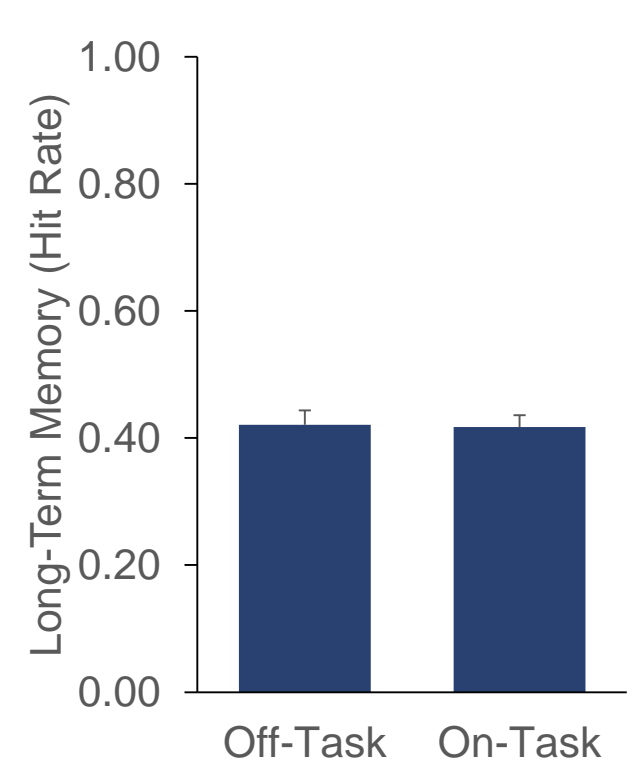
Attentional Fluctuations

- Frequent lapses of attention during encoding
- Trials preceding Off-Task reports less accurate than trials preceding On-Task reports ($p < .05$)
- Trials with more variable RTs less accurate than trials with more stable RTs ($p < .05$)

Retrieval

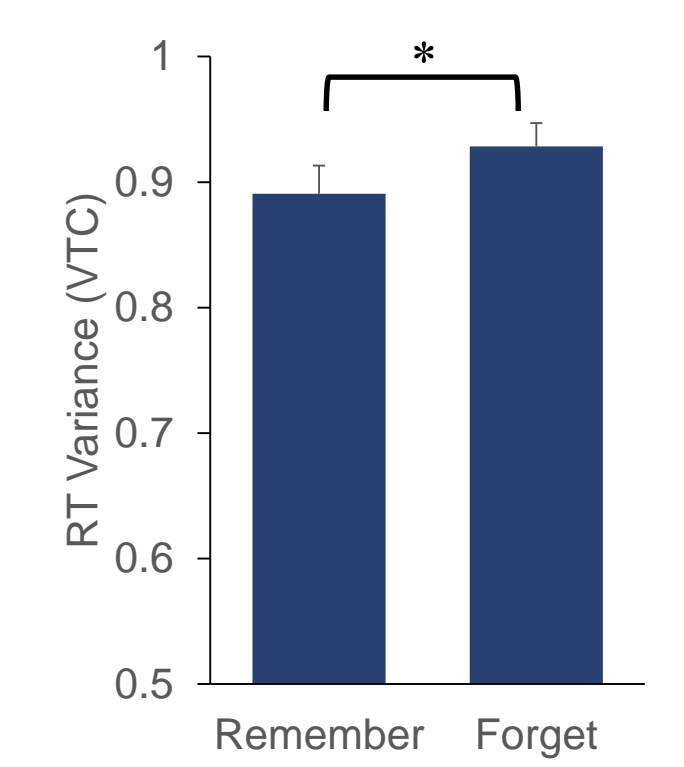
- 41% old items remembered (SD = 13)
- 59% old items forgotten (SD = 13)

Self-Reported Inattention



- Self-reported inattention at encoding does not predict subsequent memory

Behavioral Inattention



- RT variability measure of inattention does predict subsequent memory * $p < .02$

CONCLUSIONS

- Neural processing of task-relevant faces, but not task-irrelevant tones, was attenuated during periods of inattention defined by (1) off-task self reports and (2) behavioral RT variability.
- Face-related perceptual decoupling reduced the magnitude of the P3 component (typically associated with task-related attention) as well as the later LPC (typically associated with memory).

- The timing and topography of this face-related P3/LPC perceptual decoupling effect overlapped with the centro-parietal subsequent memory effect observed for faces.

- The mean amplitude of the P3/LPC in response to faces also predicted memory performance across individuals.

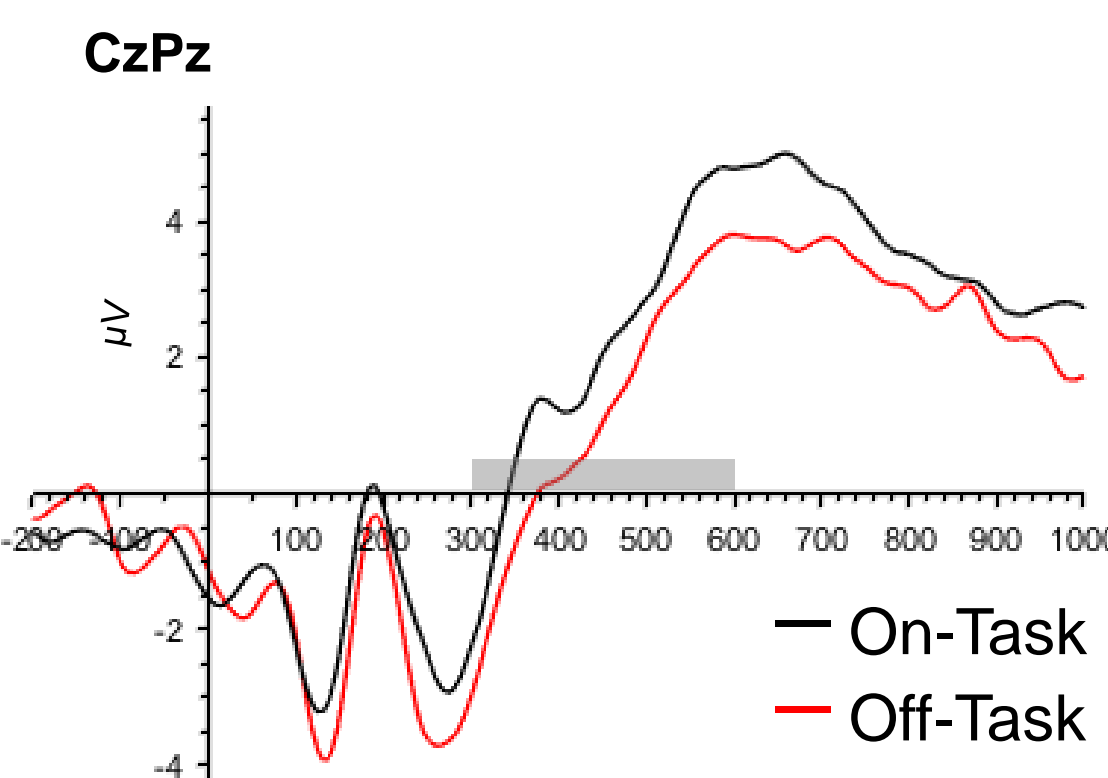
- Additional attention-related ERP effects that predicted forgetting, but did not overlap with those reflecting attentional state, were also identified:
 1. Modulation of the face-specific N170
 2. Attenuation of the auditory N1 in response to background tones

- These results indicate that fluctuations in attention are associated with neural activity patterns that are similar to those that predict subsequent memory.

- In addition, the success of memory encoding can be predicted by neural response to cross-modal, task-irrelevant distractors that precede critical mnemonic targets.

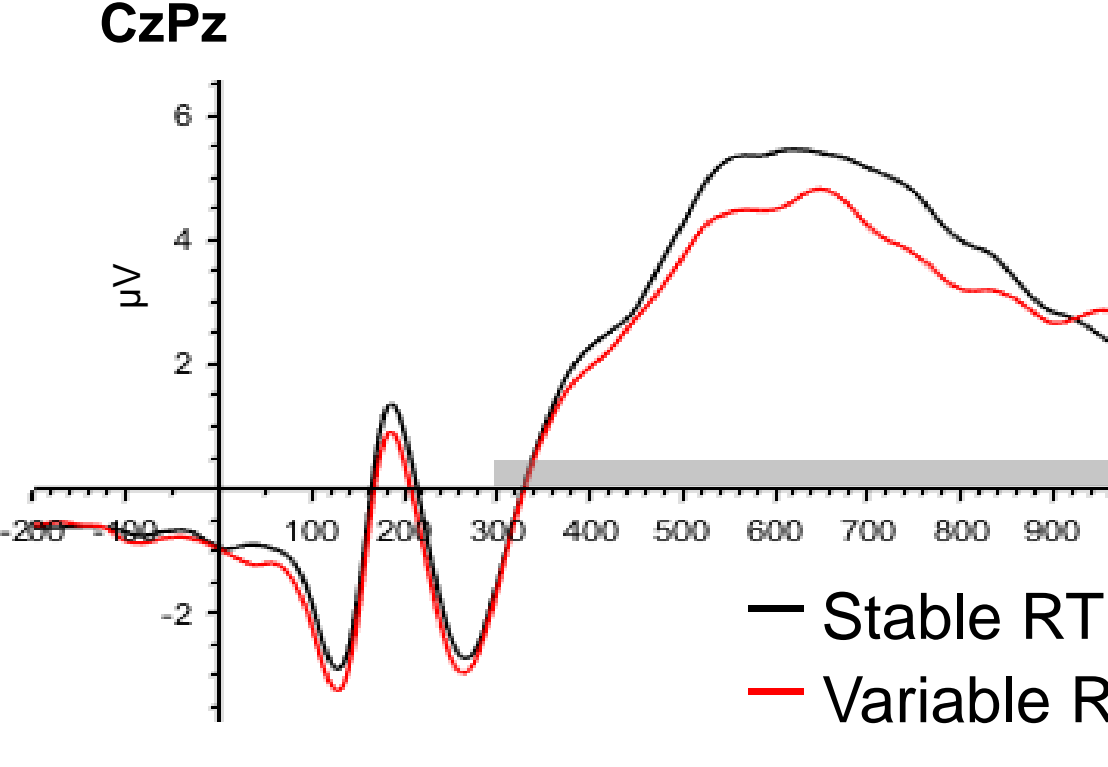
PERCEPTUAL DECOUPLING EFFECTS

Self-Reported Inattention

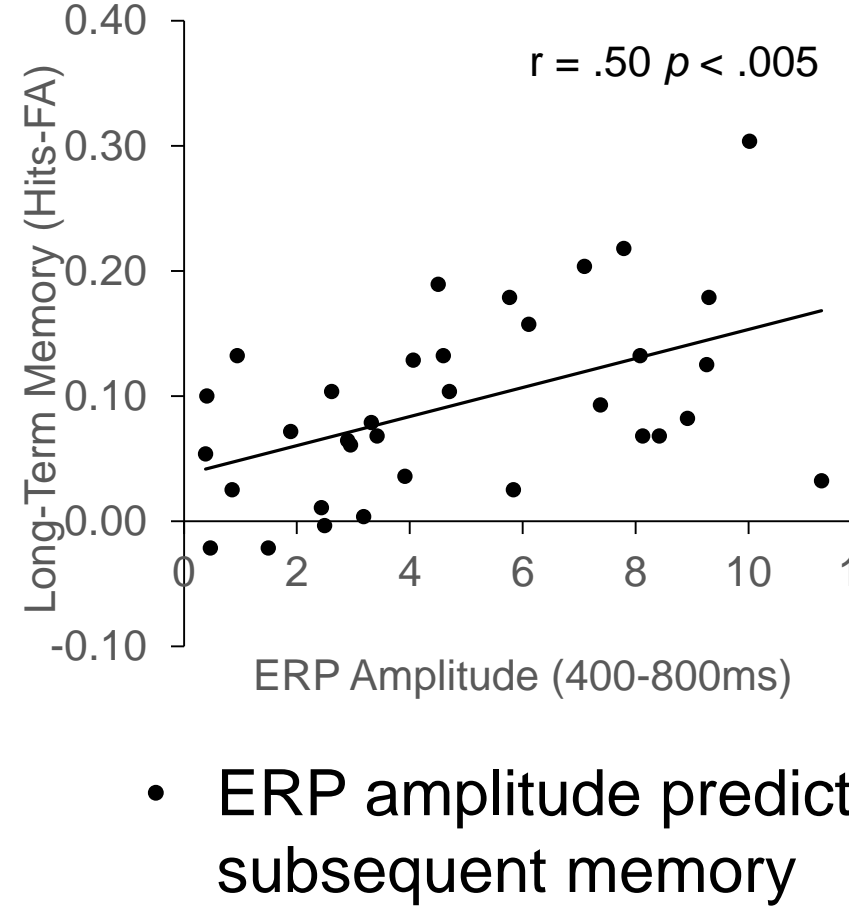


- Attenuation of P3 to target faces in the interval preceding subjective reports of inattention
- No attenuation of earlier sensory components

Behavioral Inattention



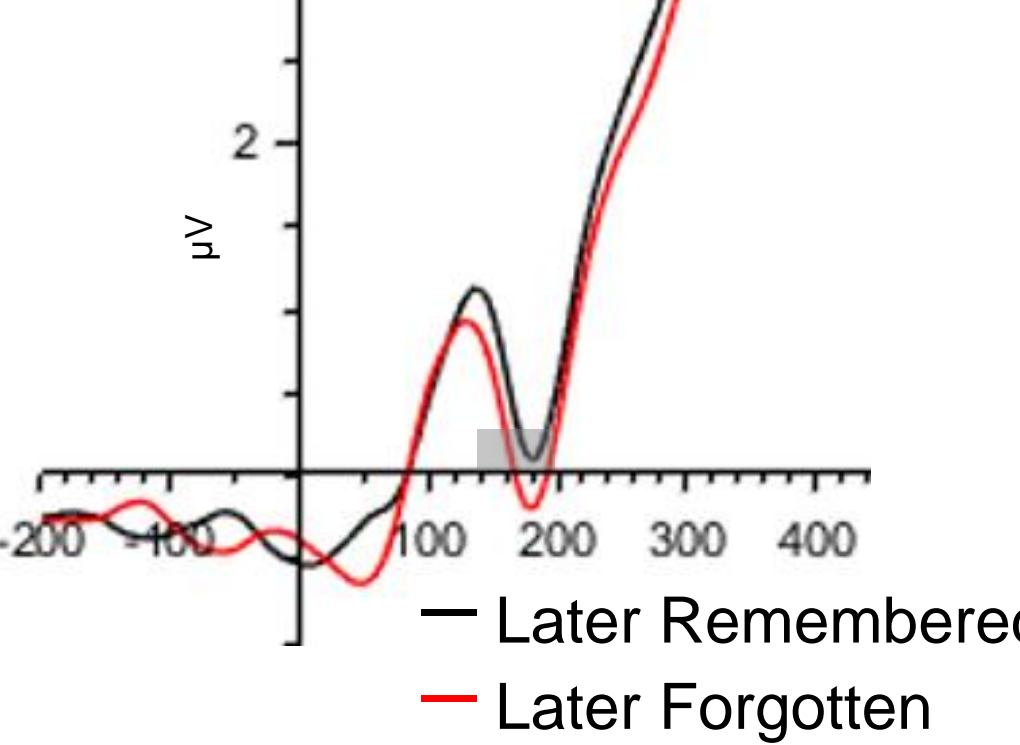
- P3 and LPC attenuated for trials with high RT variability



- ERP amplitude predicts subsequent memory

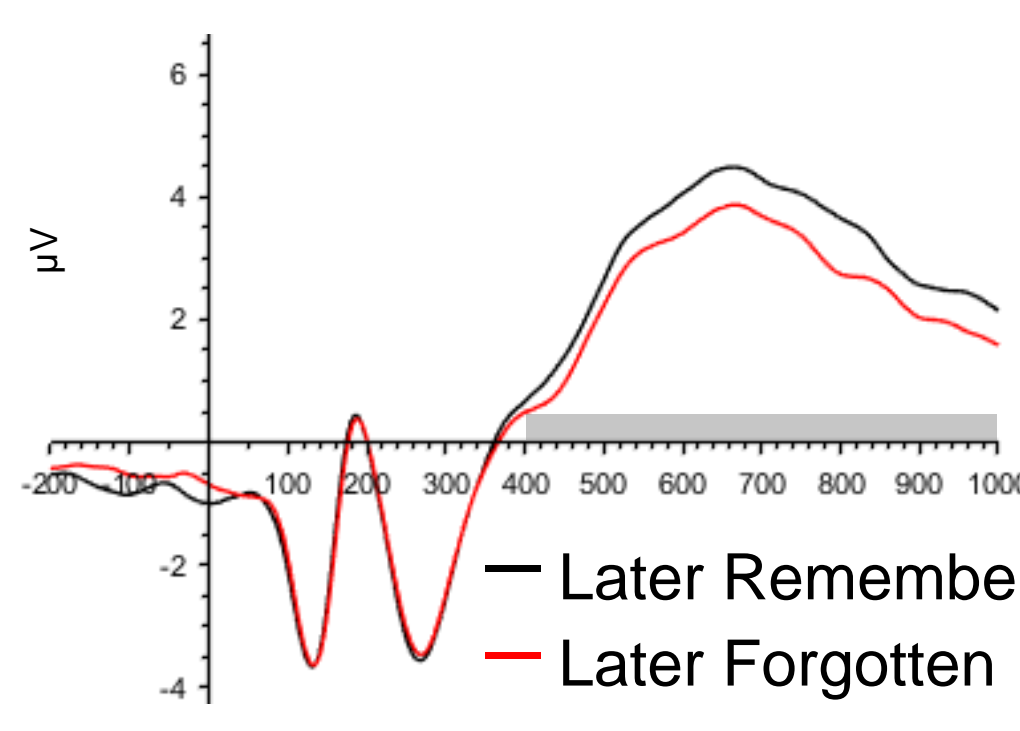
SUBSEQUENT MEMORY EFFECTS

T6



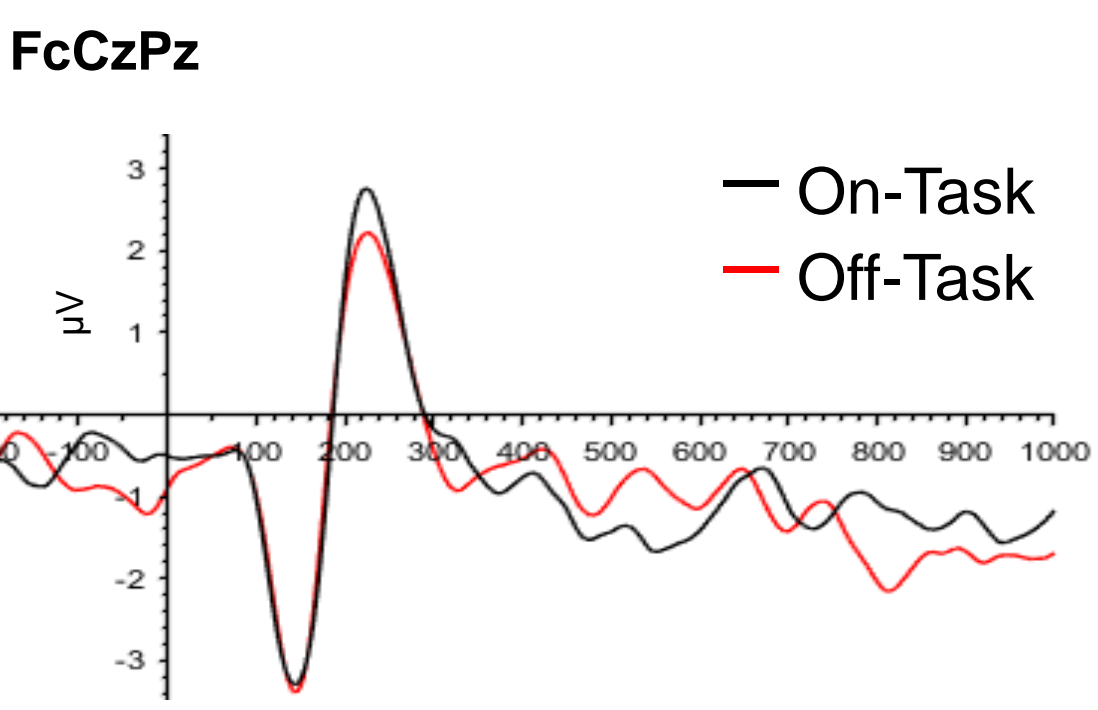
- Modulation of early N170 face processing ERP predicts subsequent forgetting

C3CzC4



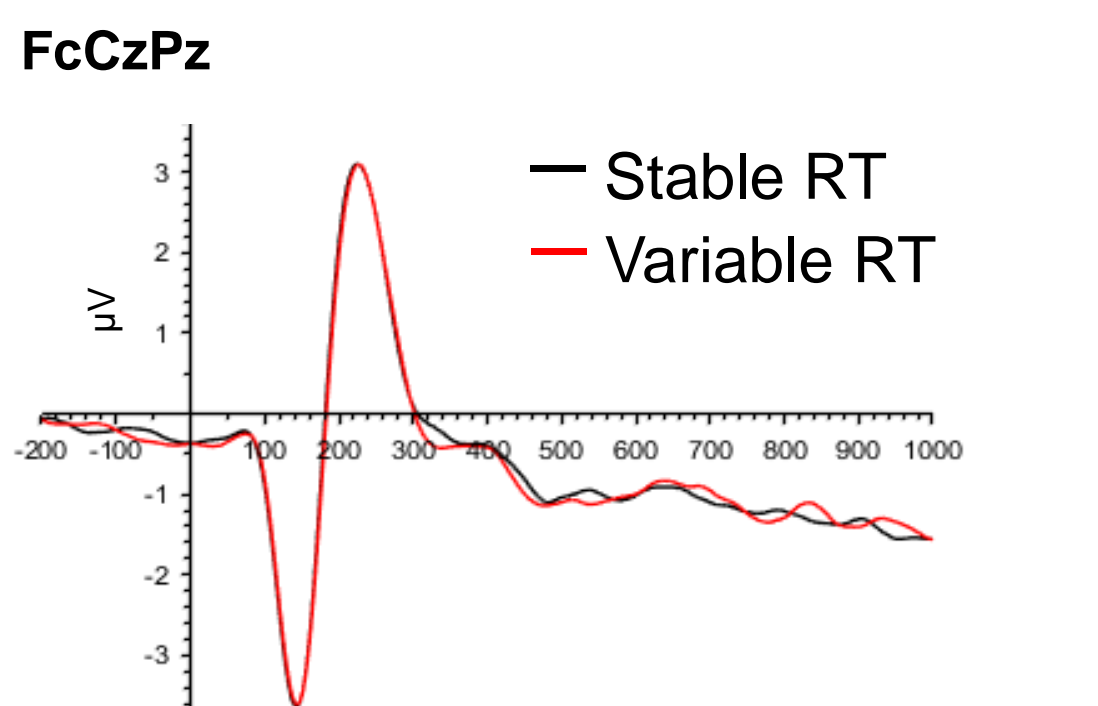
- Classic frontal / centro-parietal subsequent memory effect (Dm)
- Timing & topography of centro-parietal amplitude reduction for subsequently forgotten faces mirrors face perceptual decoupling effect

Self-Reported Inattention



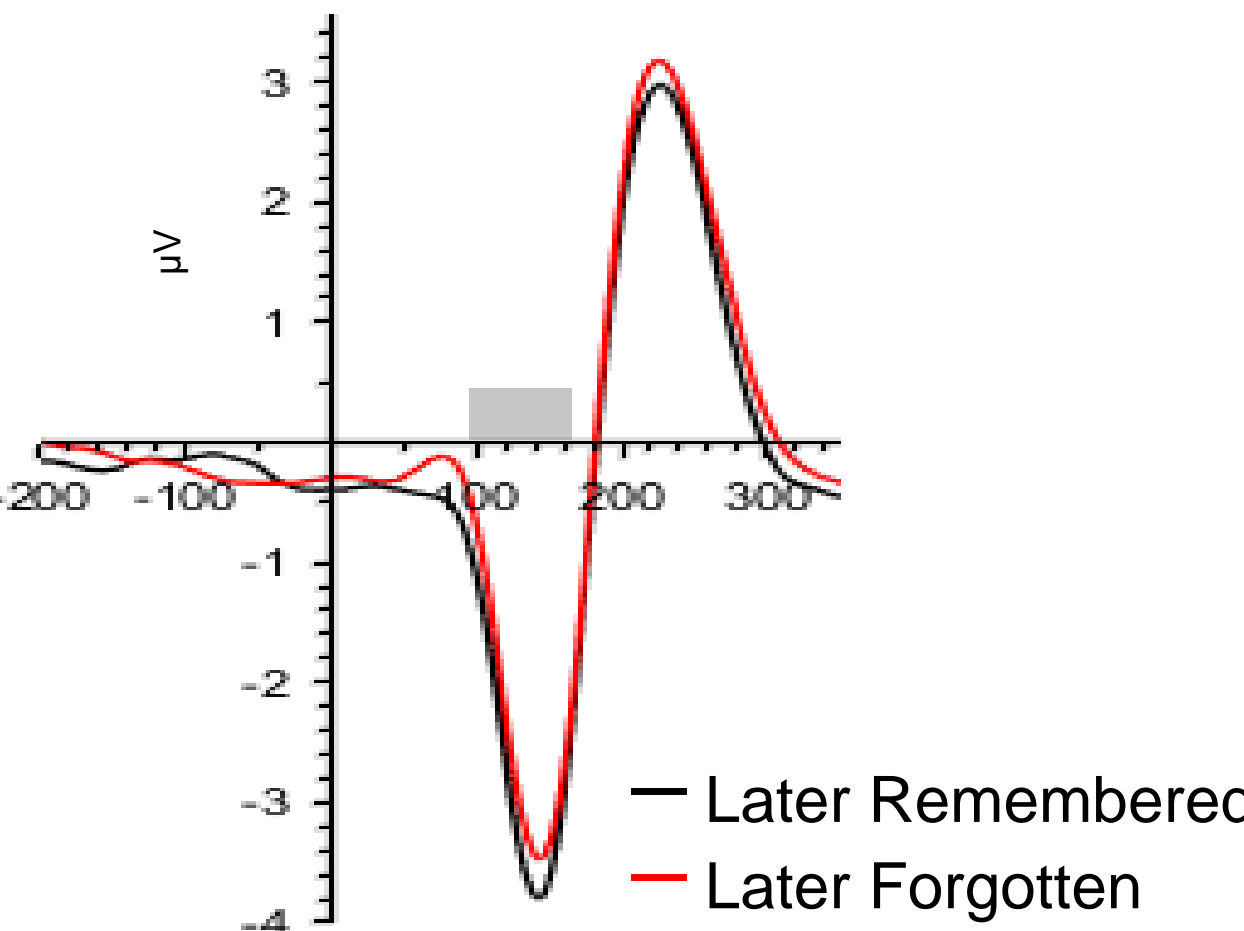
- No attenuation of auditory N1 to distractor tones in the interval preceding subjective reports of inattention

Behavioral Inattention



- No attenuation of auditory N1 to distractor tones preceding trials with high RT variability

FzCzPz



- Attenuation of auditory N1 to distractor tones predicts subsequent memory for target faces

- Neural response to cross-modal, auditory distractors preceding target faces predicts later face memory