An EEG study of implicit landmark recognition during virtual navigation

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Introduction

- We examine whether the scalp EEG patterns found in working memory tasks appear in a complex virtual navigation task.

Previous findings

- Greater parietal voltage for viewing target stimuli than non-target stimuli (P300) (Donchin & Coles, 1988). One report of this in virtual navigation (Bayliss & Ballard, 2000).
- Theta (4–8 Hz) power increases for target stimuli with similar topography to the P300 (Klimesch et al., 2000).
- Elevated theta power during movement (Kahana et al., 1999) and rotation (Korolev, 2005) in a virtual navigation task.

Hypotheses

- My previous research found P300 ERP effects in landmark recognition (Mollison et al., 2006). Our next question was whether this effect was also present in theta oscillations.
- A secondary question was whether these phenomena vary with subjects' navigational efficiency.

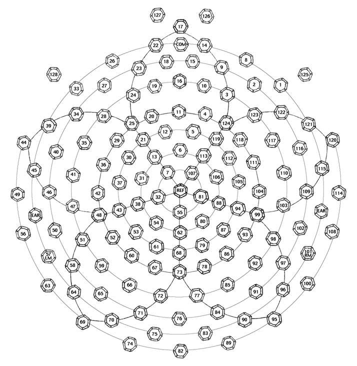
The Yellow Cab Task

- Participants played the role of a taxi-driver in a virtual town, looking for specific destinations to which passengers ask to be delivered, called target stores (Newman et al., in press).
- Each town: 6×6 grid, with a single store or building on each block (36 landmarks). 5 stores and 31 buildings in a town, each with a unique façade.
- During the delivery, the 4 stores that are not the target store are considered non-target stores.

Definitions:

- *Fast delivery*: $<$ 1 block above optimal path
  M = -0.19 excess blocks
- *Slow delivery*: $>$ 1 block above optimal path
  M = 6.0 excess blocks

Scalp EEG



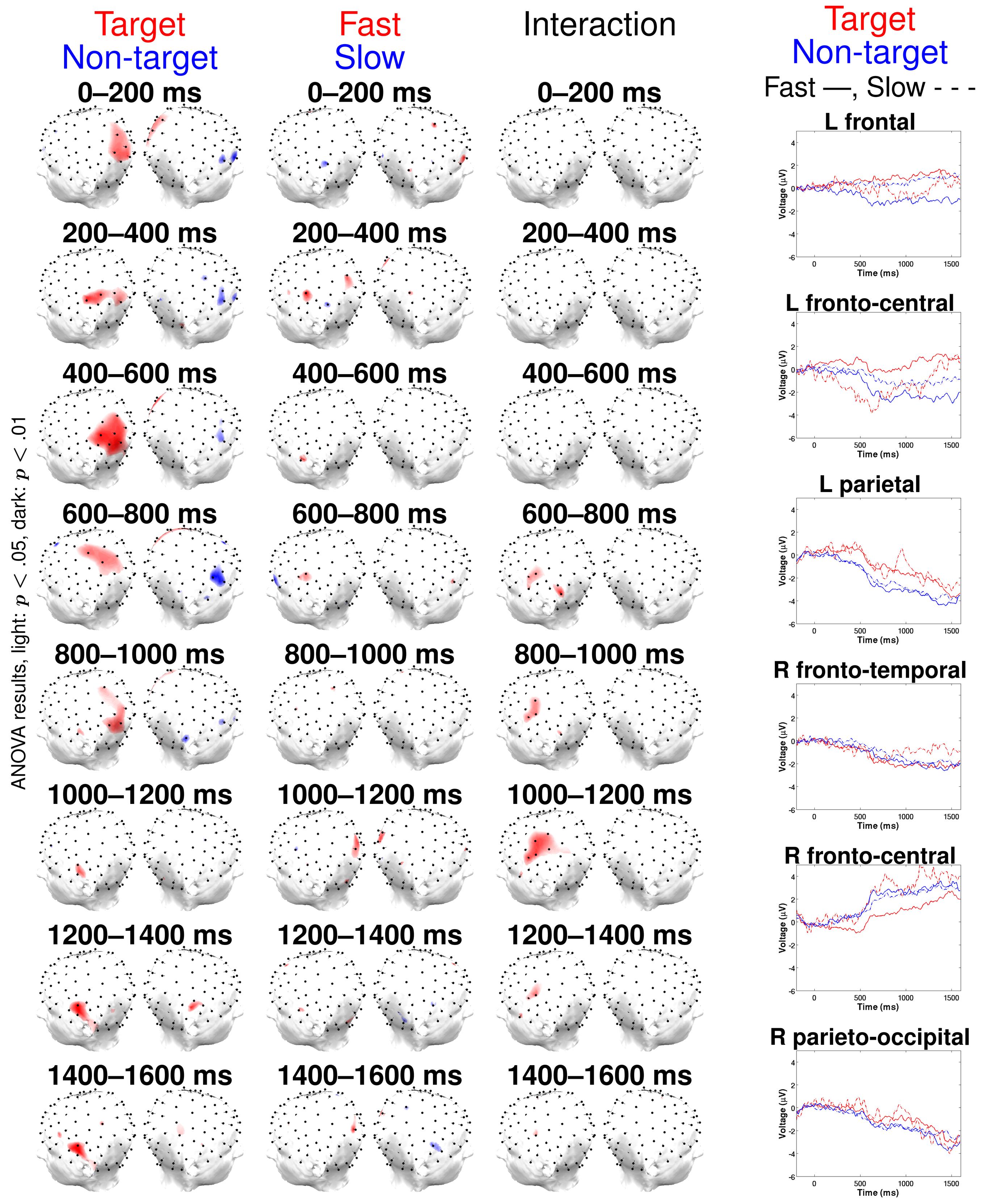
- 20 right-handed adults (ages 19 to 27; nine female)
- 128-channel 500-Hz EGI scalp EEG system
- 200 MΩ high-impedance amplifier
- Post-process EEG data
  - Eye artifact detection (EOG $>$ 100 μV)
  - Manually inspect EEG for bad channels
  - Average rereference
  - Kurtosis threshold of 5

Viewing Landmarks

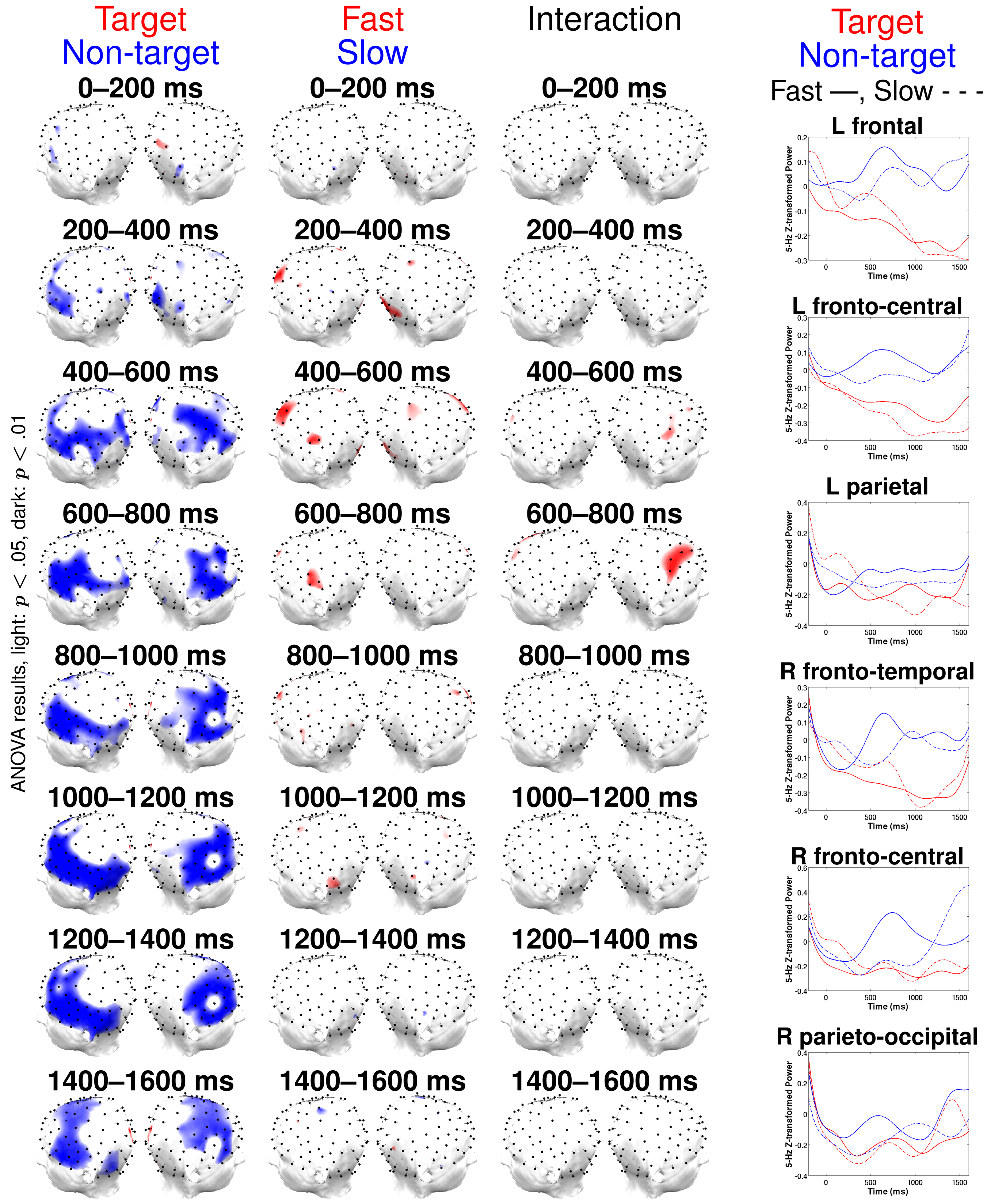
- Consider periods in which participants have picked up a passenger and are searching for the target store.
- Set a *screen-area threshold* (0.35%) and minimum viewing length (500 ms) to find when a landmark is "seen."
  - *Target-store events*: appear and stay on the screen until delivery is made
  - *Lure-store events*: seen on the way to the target, but target cannot be on the screen

0.35% of the screen is occupied by the store.

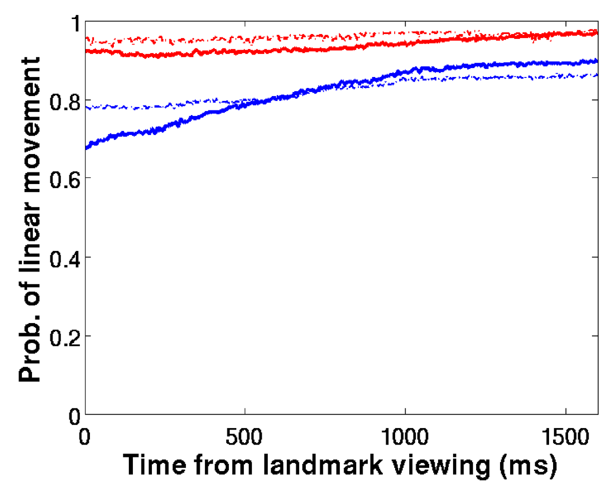
Results: ERPs

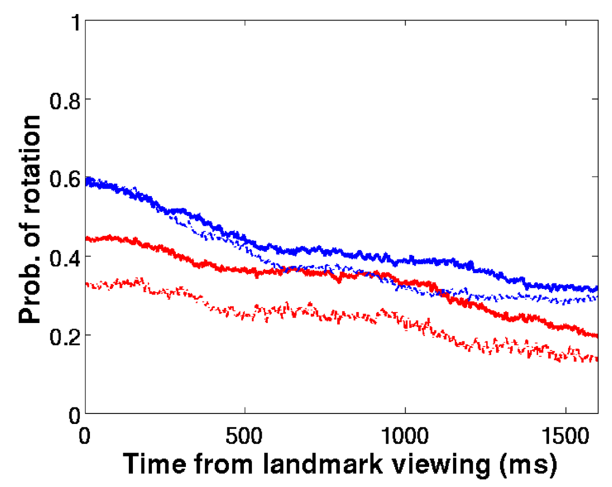


Results: 5-Hz Z-transformed Power



Results: Behavioral





Conclusions

- P300 differentiates viewing of target and non-target landmarks during navigation.
  - Increase in left parietal voltage for recognition of a target store (match).
  - Increase in right frontal signals for recognition of a non-target store (mismatch).
- Increase in theta power for non-target $>$ target.
  - This does not follow the literature, and I suspect this is due to rotation after viewing non-target stores.

Next Steps

- Analyze oscillations for rotation vs. linear movement in targets and non-targets.
- Look at a larger range of frequencies.
- Use eye-tracking technology to more precisely lock electrophysiological signals to visual events.

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