Event-related potentials to landmarks during "Yellow Cab" – a virtual spatial navigation task

M.V. Mollison, J. Jacobs, I.O. Korolev, M.J. Kahana
Depts. of Psychology and Neuroscience, University of Pennsylvania, Philadelphia, PA

Introduction

Previous findings

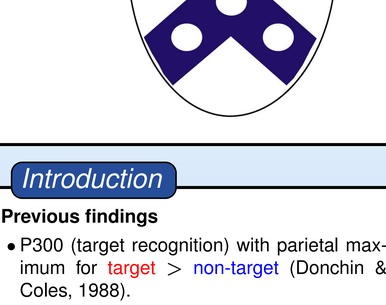
- P300 (target recognition) with parietal maximum for target > non-target (Donchin & Coles, 1988).
- P3a (orienting/arousal for non-targets) with frontal maximum for non-target > target (Squires et al., 1975; Courchesne et al., 1975; Katayama & Polich, 1998).

Hypotheses

- Our major question was whether event-related potentials (ERPs) that have previously been linked to novelty detection and to explicit recognition of old vs. new items would differentiate between the viewing of target and non-target landmarks in *Yellow Cab* – a virtual taxi-driver game.
- A secondary question was whether these hypothesized ERP differences would vary with subjects ability to efficiently navigate to their target landmarks.

We used high-density scalp EEG to assess the electrophysiological correlates of implicit landmark recognition in Yellow Cab.

The Yellow Cab Task

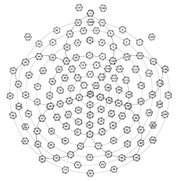


- Participants played the role of a taxi-driver in a virtual town, looking for specific destinations to which passengers ask to be delivered ("goal-seeking"), called target stores (Newman et al., in press).
- Each town: 6 × 6 grid, with a single store or building on each block (36 landmarks). 5 stores 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



- 128-channel system from Electrical Geodesics, Inc.
- 200 MΩ high-impedance amplifier.
- Recorded at 500 Hz.
- 20 young adults (ages 19 to 27; eleven male, nine female).
- Right-handed; normal or corrected-to-normal vision.

Analytical Methods

Selecting events

- All events are from periods in which participants have picked up a passenger and are searching for the target store.
- Do not know where a participant is looking on the screen; consequently, some latency variability may exist in the appearance of the store and the participant's recognition of a store.
- **Standardized event selection**
  - Set a *screen threshold* to mark when an object is considered "seen".
  - At a screen threshold of 0.35%, 95% of brief target store appearances would not be counted as seen.
  - Since we don't know when a subject actually sees a store, ERPs do not line up exactly.

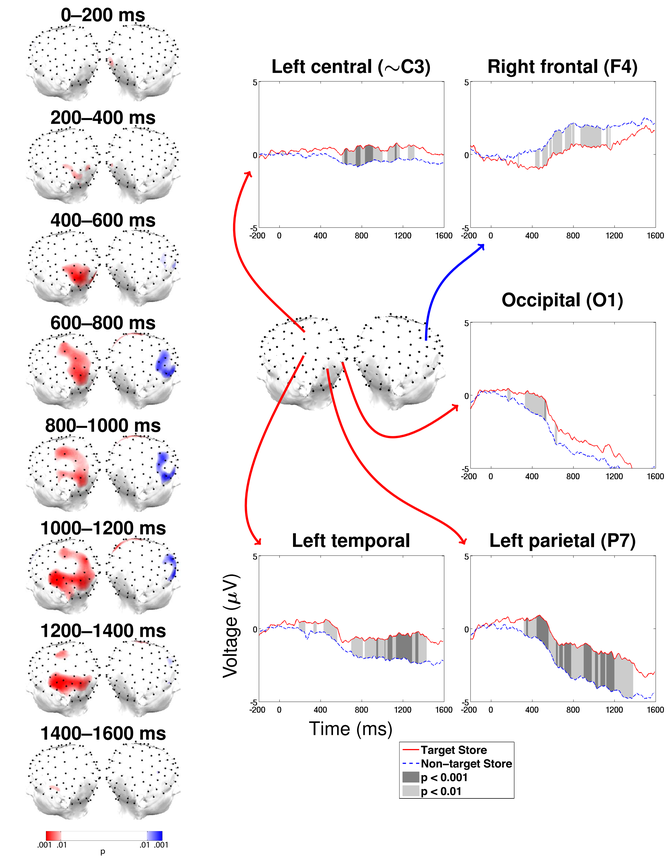
0.35% of the screen is occupied by the store.

Post-processing EEG data

- Eye-movement artifact detection (electro-oculogram > 100 μV)
- Bad-channel detection (manual inspection of the EEG)
- Average rereference

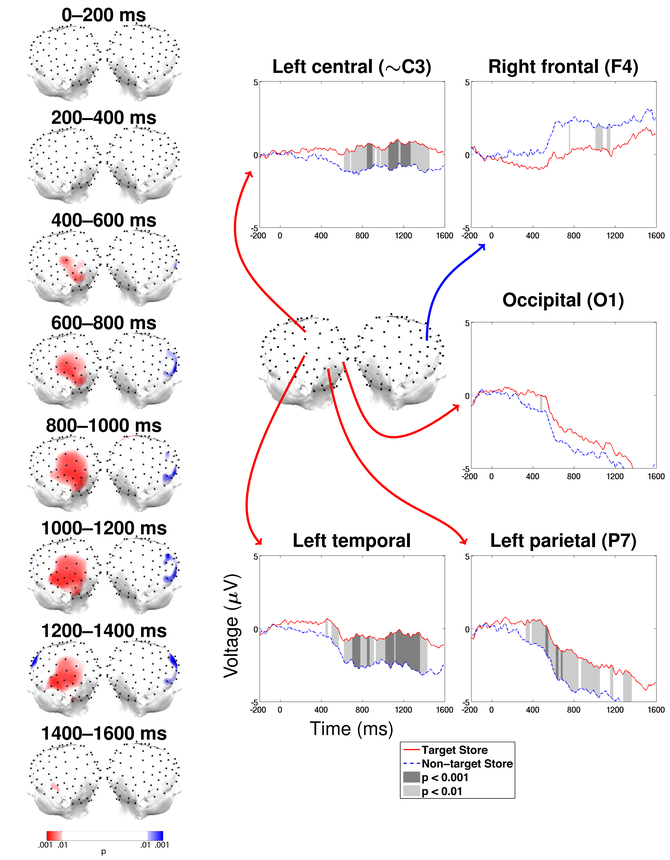
Results: All deliveries

Target Store vs. Non-target Store



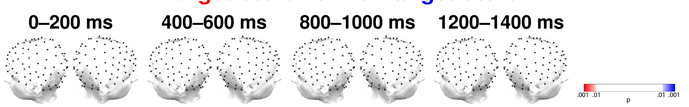
Results: Fast deliveries only

Target Store vs. Non-target Store



Results: Slow deliveries only

Target Store vs. Non-target Store



References

Courchesne, E., Hillyard, S. A., & Galambos, R. (1975). Stimulus novelty, task relevance and the visual evoked potential in man. *Electroencephalogr Clin Neurophysiol, 39*(2), 131-143.

Donchin, E., & Coles, M. G. (1988). Is the P300 component a manifestation of context updating? *Behavioral and Brain Sciences, 11*(3), 357-427.

Katayama, J., & Polich, J. (1998). Stimulus context determines P3a and P3b. *Psychophysiology, 35*(1), 23-33.

Newman, E. L., Caplan, J. B., Kirschen, M. P., Korolev, I. O., Sekuler, R., & Kahana, M. J. (in press). Learning your way around town: How virtual taxicab drivers learn to use both layout and landmark information. *Cognition.*

Squires, K. C., Squires, N. K., & Hillyard, S. A. (1975). Decision-related cortical potentials during an auditory signal detection task with cued observation intervals. *Journal Experimental Psychology: Human Perception and Performance, 1*(3), 268-279.

Conclusions

- The P3 differentiates viewing of target and non-target landmarks during navigation.
  - This manifests itself as an increase in left parietal voltage for recognition of a target store (match), and an increase in right frontal signals for recognition of a non-target store (mismatch).
- This P3 profile only appears when subjects navigate efficiently to their destination.
  - This dependence on navigation efficiency suggests that the P3 effects are modulated by attentional state.
- By time locking the voltage signal to the appearance of targets on the screen during navigation we were able to report the first analysis of ERPs in a virtual navigation task.
- Future studies could use eye-tracking technology to more precisely lock electrophysiological signals to visual events.