Attentional and inhibitory networks under passive, active and covert conditions in college-aged adults using high density event-related potentials.

Kira L. Abrams, Shane M. O'Sullivan, Sarah E. Keir, Can Özger & Naseem A. Choudhury
Ramapo College of New Jersey, Mahwah, NJ, USA

"Everyone knows what attention is.
It is the taking possession of the mind in clear and vivid form of what seems several simultaneous objects of trains of thought."

William James, 1890, p.403

Introduction

Attention is the process by which individuals **selectively orient** and focus on discrete pieces of information while ignoring or **inhibiting** responses to other information deemed irrelevant (Posner, 2005).

Behaviorally, attention is assessed by measuring **overt** responses such as visual directedness, button presses to target or head movement in the direction of the target (Posner, 2005).

Attention activation can takes place without an observable behavioral responses. For example, when information is kept active in working memory through silent rehearsal, attention is said to be **covertly** oriented. Further, attention allocation can also happen reflexively, without voluntary control. Such as when a more perceptually salient stimulus, as compared to the background, is presented (e.g., a loud noise in a relatively quiet environment). In these situations, individuals reflexively orient to that stimulus (**passive** orientation) (Stigchel et al. 2007).

Both overt and covert attention requires that individuals respond only to the target stimulus and thus **inhibit responses** to non-target stimuli. It has been shown that the executive network is involved in processing and controlling such inhibitory behaviors (Klein, 2004).

Disorders of attention have been shown to be associated with both attention orienting and maintenance, and inhibitory processes (Mullane, et.al., 2010).

Aims

In this study we explore differences in the functional neural-networks underlying attention activation and inhibitory processes using three different conditions:

i) Passive orientation which is directed visual gaze with no behavioral response to target required.

ii) Active active attention requiring a button press to a target, and

iii) Covert active attention requiring a verbal report of the total number of targets presented.

Methods

Participants

35 healthy adults (21 females) with no report of visual or auditory processing disorders.

Age: 18 to 22 (M=19.2, SD=1.08)
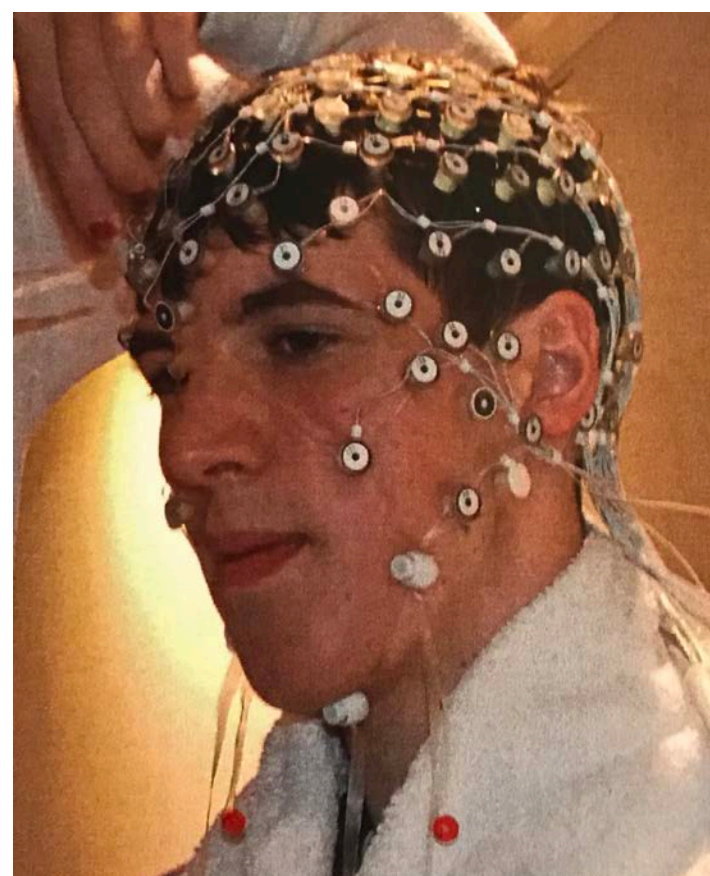
Methods

Stimuli and presentation

Stimuli were presented in an oddball paradigm. The ratio of standard*(**"O"**) to target (**"X"**) stimulus was 80:20 (160:40 events) The inter-trial interval (onset to onset) was 1200ms. Fixation point stays on for 200ms followed by the stimulus which remains on screen for 1000ms.

Stimuli were presented on a 27 x11 inch high resolution LG monitor placed 42 inches away from the participant. Visual angle:1° 21'.

Fixation "+" 200 ms — Target "X" 1000 ms — Standard "O" 1000 ms

segment length 1200 ms
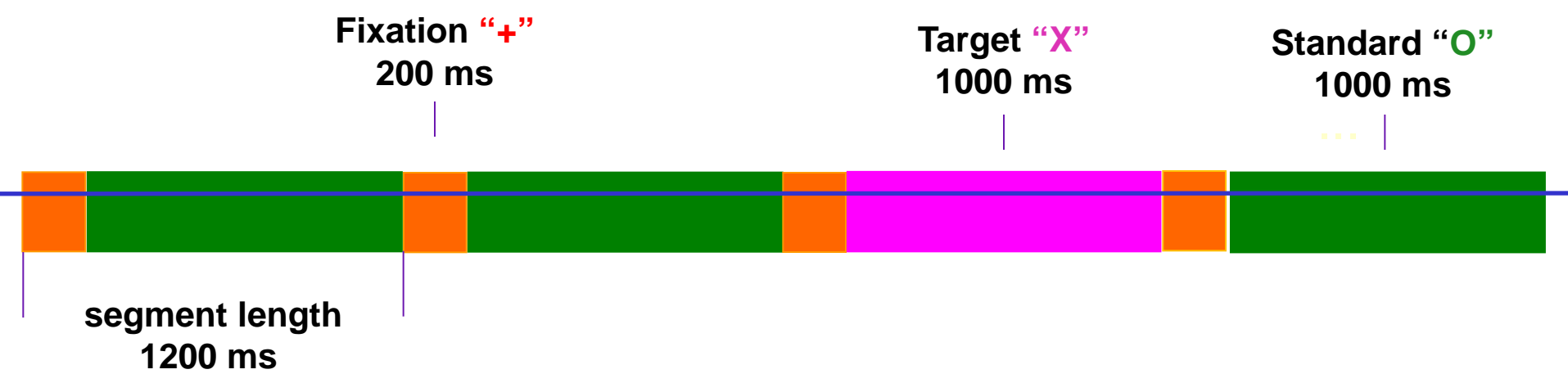
ERP recording and analysis

The EEG/ERP data were recorded with Hydrocel GSN 128 AgCl electrodes connected within a sensor net (Electrical Geodesics, Inc.).

The EEG electrodes were referred to the vertex electrode, and re-referenced off-line to an average reference. ERP's were filtered offline with a bandpass of 0.3-30 Hz and epochs containing signals higher than ± 200 μV were discarded.

Data Analysis

Remaining artifact free epochs were averaged by stimulus type (target or standard) for each condition (passive, active and covert).

For both target and standard conditions, the peak amplitude and latency values at occipital *(O_1, O_2 & O_z)*, parietal *(P_3, P_4 & P_z)*, central *(C_3, C_4 & C_z)*, frontal *(F_3, F_4 & F_z)* & prefrontal *(Fp_1 & Fp_2)*, channels were extracted for the first positive (C_1), the second positivity (P_1), the first attention peak (P_{300}) and a second attention peak (P_{400}) for all conditions and both stimulus type.

T-tests, with Bonferroni corrections for multiple comparisons, were performed on the extracted values for all sites to assess group differences standards and targets. **One-Way ANOVA's** were conducted to assess the difference between responses for the standards and target for each condition.
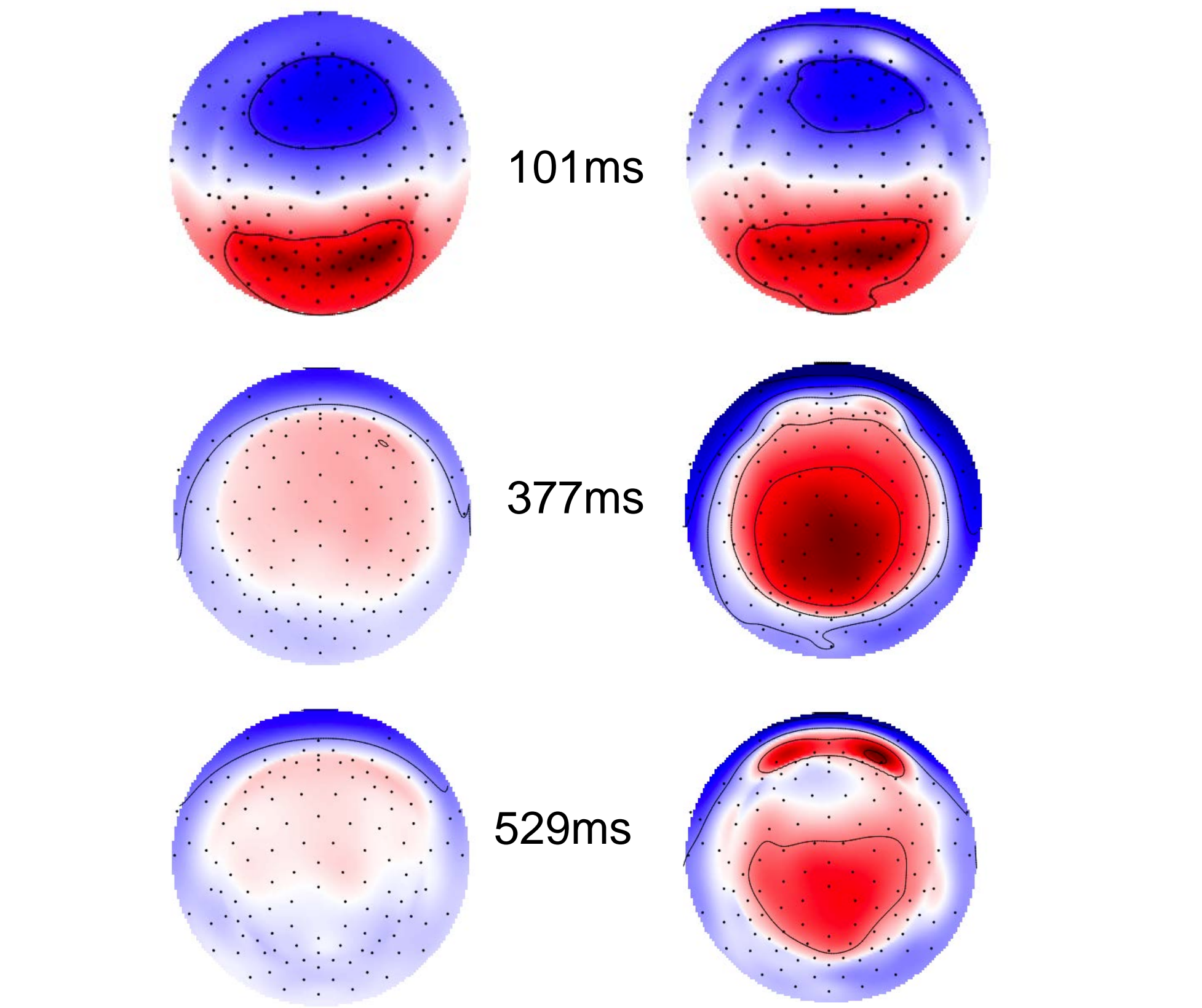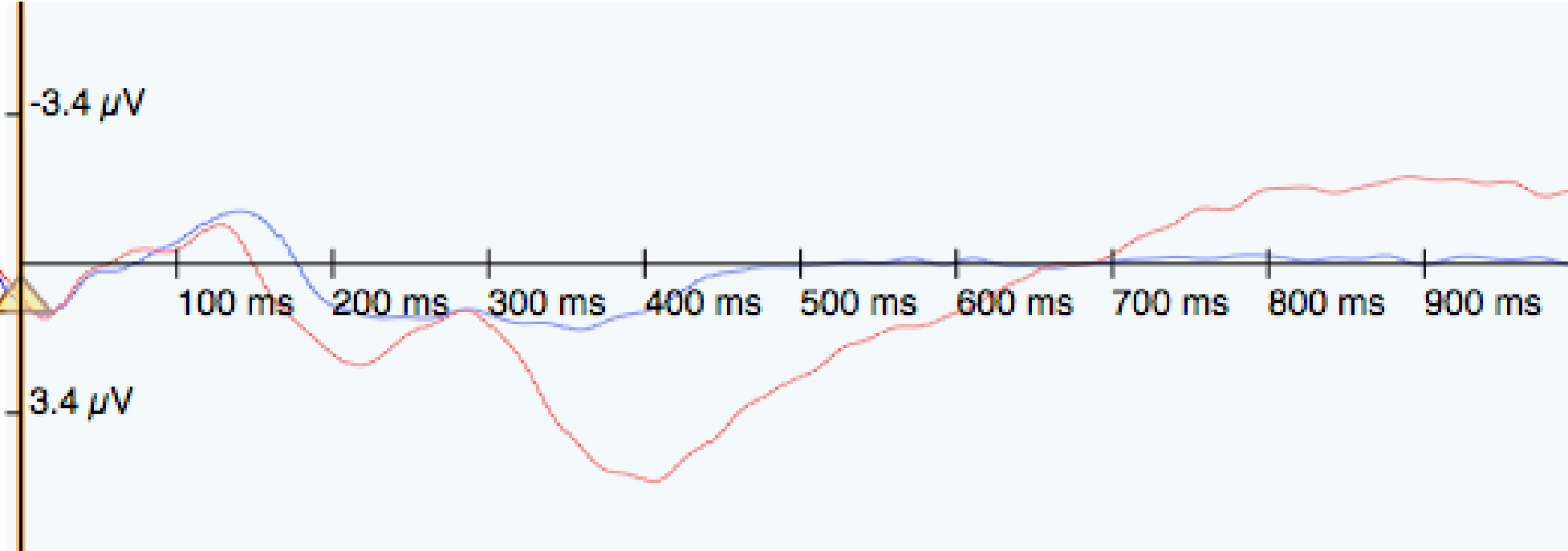
Results

Latency of Peak Amplitudes in Across Conditions					
	Active		Covert		Passive
C1O	T: 74-75 S:77-83		T: 72-83 S:76-81		T: 74-80 S: 79-83
C1P	T: 69-78 S: 69-75		T: 69-81 S: 70-82		T: 67-76 S: 71-78
P1O	T: 112-113 S: 126-130		T: 114-115 S: 121-125		T: 109-113 S: 123-125
P1P	T: 108-116 S: 110-125		T: 108-120 S: 108-122		T: 102-115 S: 111-128
P3P	T: 384-397 S: 248-278		T: 383-405 S: 249-272		T: 289-325 S: 255-267
P3C	T: 371-384 S: 280-313		T: 391-415 S: 264-295		T: 283-335 S: 373-289
P3F	T: 297-348 S: 301-336		T: 284-345 S: 288-309		T: 318-330 S: 280-308
P3pF	T: 292-305 S: 367-388		T: 274-280 S: 387-402		T: 352-374 S: 374-378
P4P	T: 428-429 S: 440-484		T: 420-443 S: 447-468		T: 459-468 S: 460-468
P4C	T: 412-423 S: 436-473		T: 416-422 S: 451-495		T: 454-462 S: 459-483
P4F	T: 447-456 S: 473-510		T: 436-447 S: 463-522		T: 462-493 S: 492-516
P4pF	T: 514-528 S: 522-540		T: 520-529 S: 532-541		T: 505-515 S: 519-534

Results

Passive

121ms
365ms

Active

101ms
377ms
529ms

Results

Covert

118ms
298ms
498ms
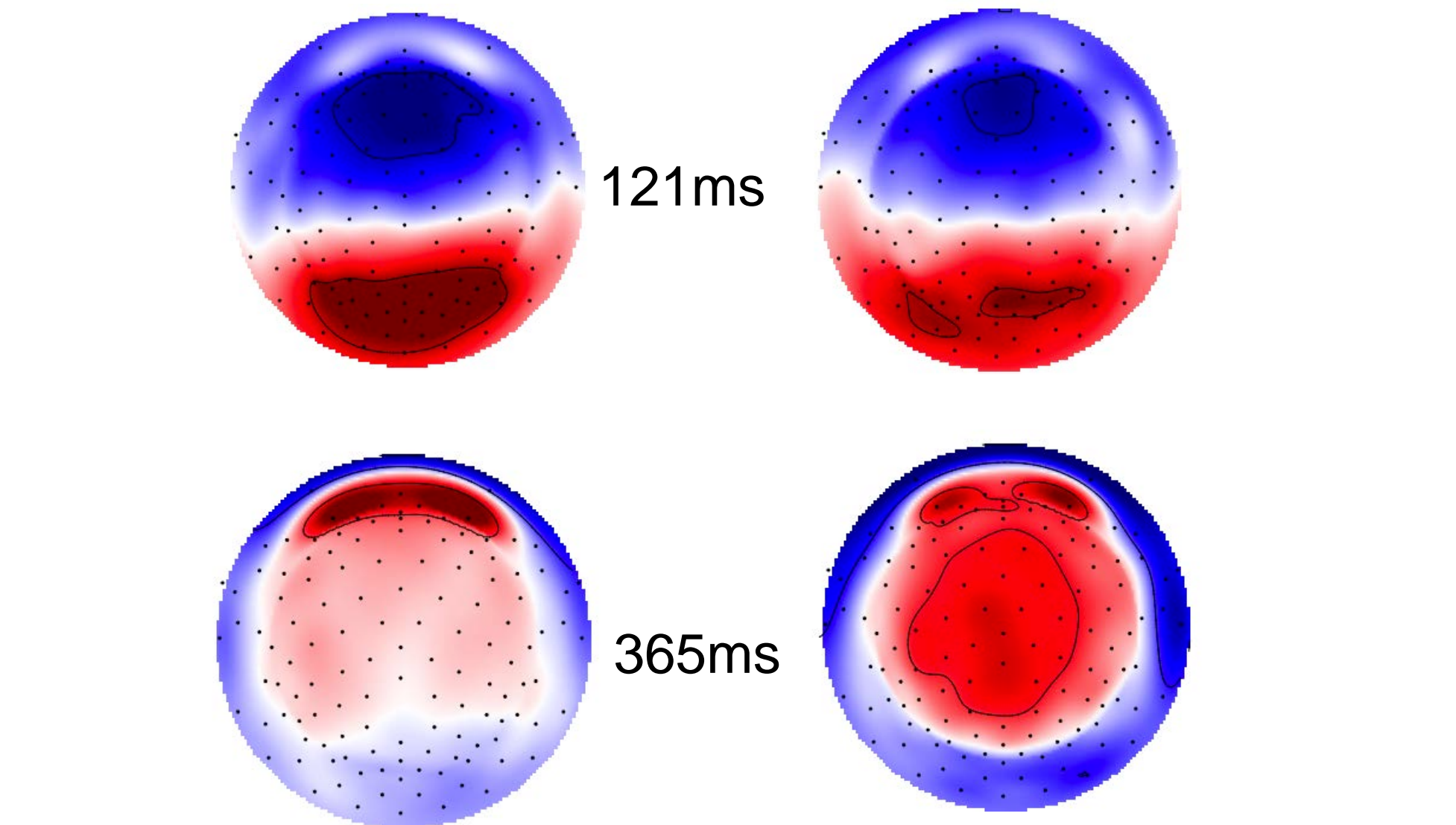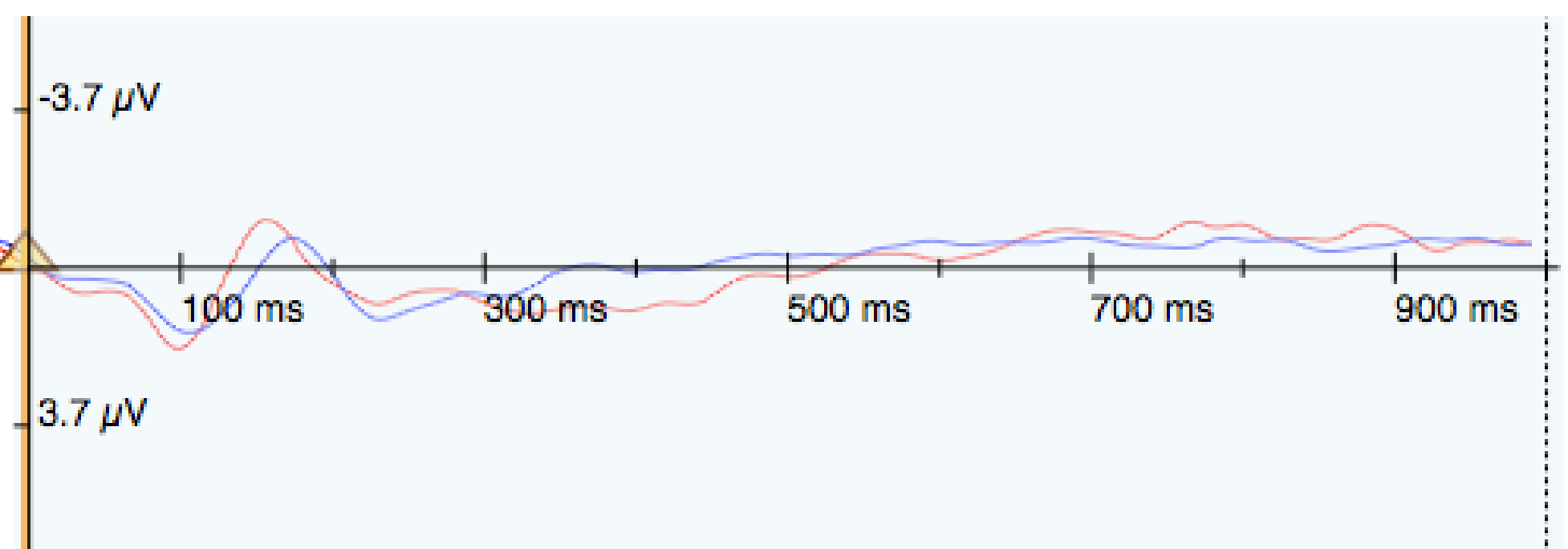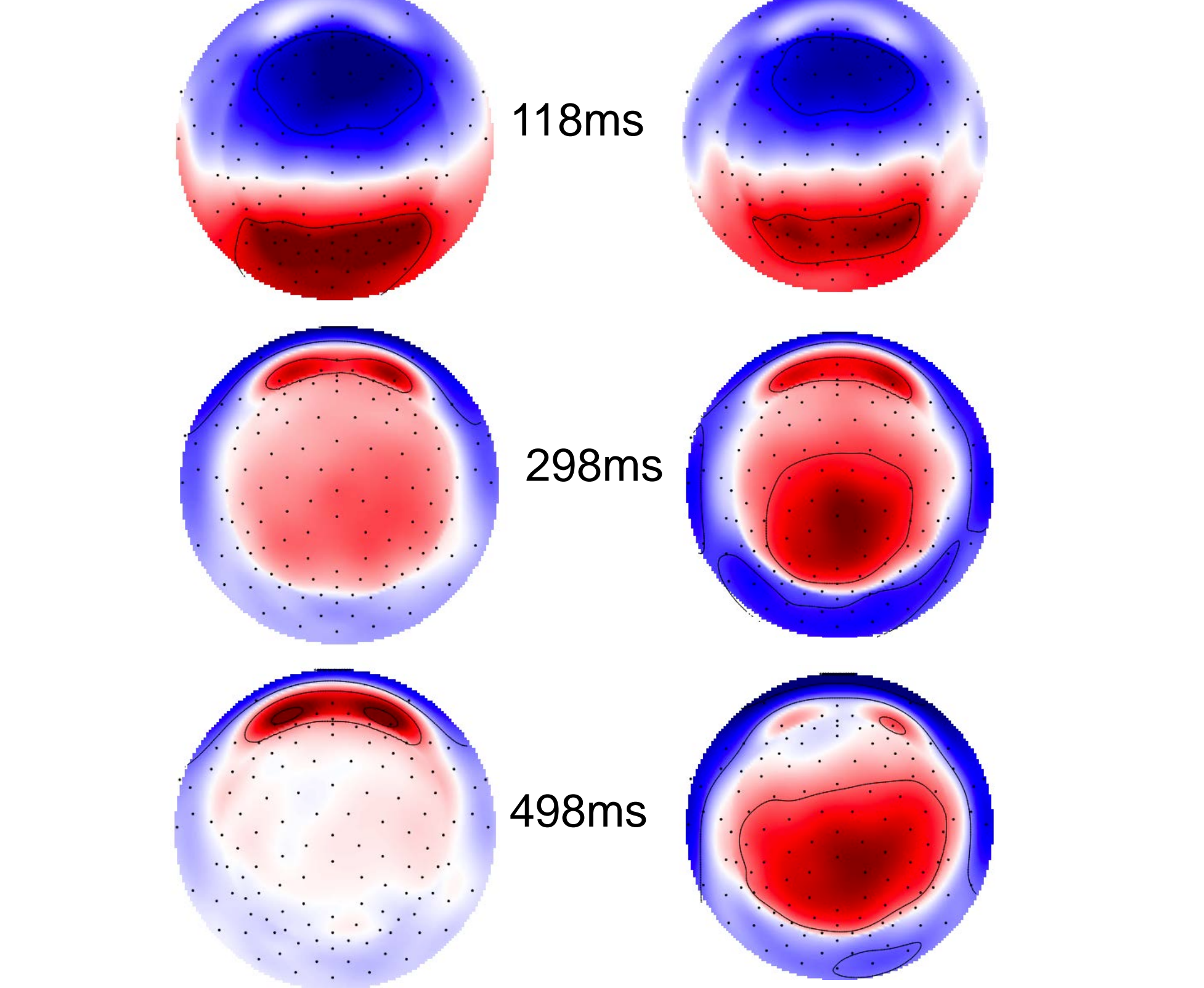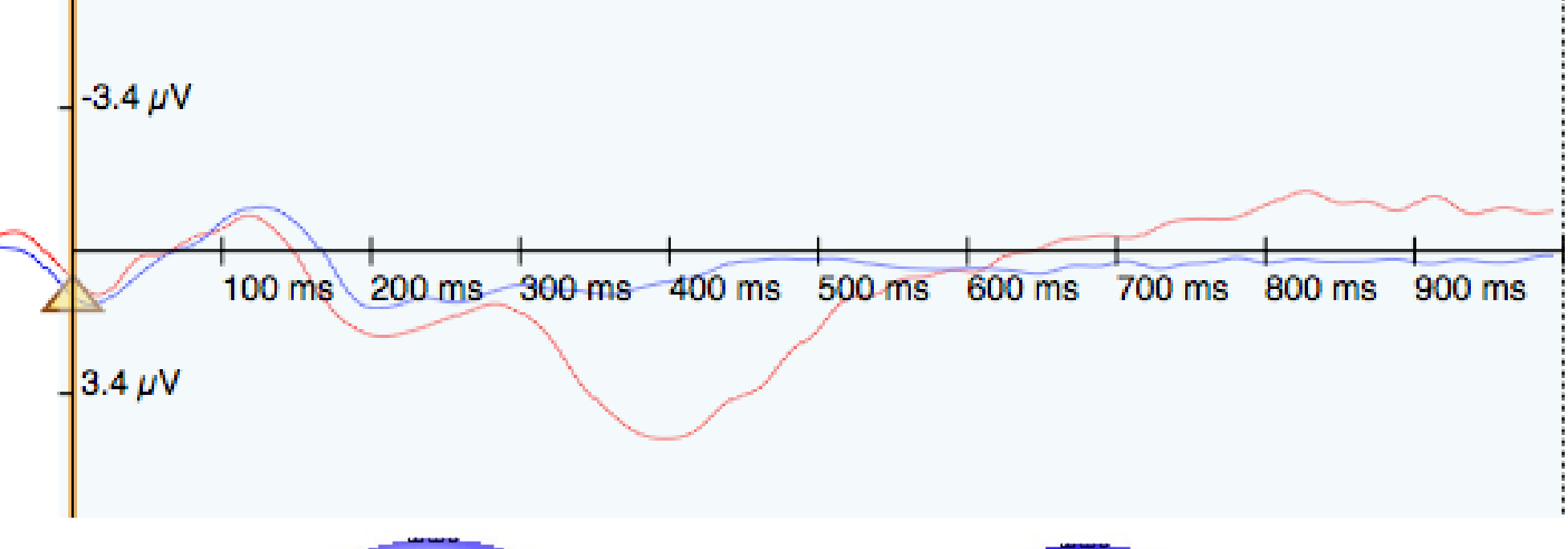
Paired t-tests
Revealed no significant differences between standards and targets in amplitude for **C1 & P1** for any condition. In all three conditions, P1 response to targets appeared faster in latency compared to the standard.

For the **P300** peak, response to targets were significantly larger than those to standards, in all three attention conditions. Significant differences were observed in central regions. In passive & active conditions targets were faster compared to standards.

P400 peak differences were observed for frontal and lateral regions. No latency differences were observed.

One-Way ANOVA's
Significant differences were found for occipital and parietal regions for the **P1** peak: active responses were larger than passive. No latency differences.

For the **P300** peak, passive amplitude was consistently and significantly smaller than Active and Covert. Latency differences were only observed for the target: passive peak appeared consistently faster than active and covert.

For the **P400** peak, passive amplitude was consistently and significantly smaller than Active and Covert. Latency differences were only observed for the target: passive peak appeared consistently faster than active and covert.