



Neural Correlates of Auditory Attention in an Exogenous Orienting Task



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Background

- Inhibition of return (IOR) and facilitation are attentional orienting mechanisms that either enhance or decrease speed and accuracy of response to a target stimulus [1].
- Both effects have been studied in the visual modality, using ERP components such as the N2pc [2].

No previous study has used electrophysiological methods to explore neural basis of exogenous attentional facilitation and IOR in the auditory modality, so in the present study we sought to fill this gap using the N2ac [3] as a neural marker of auditory spatial attention.

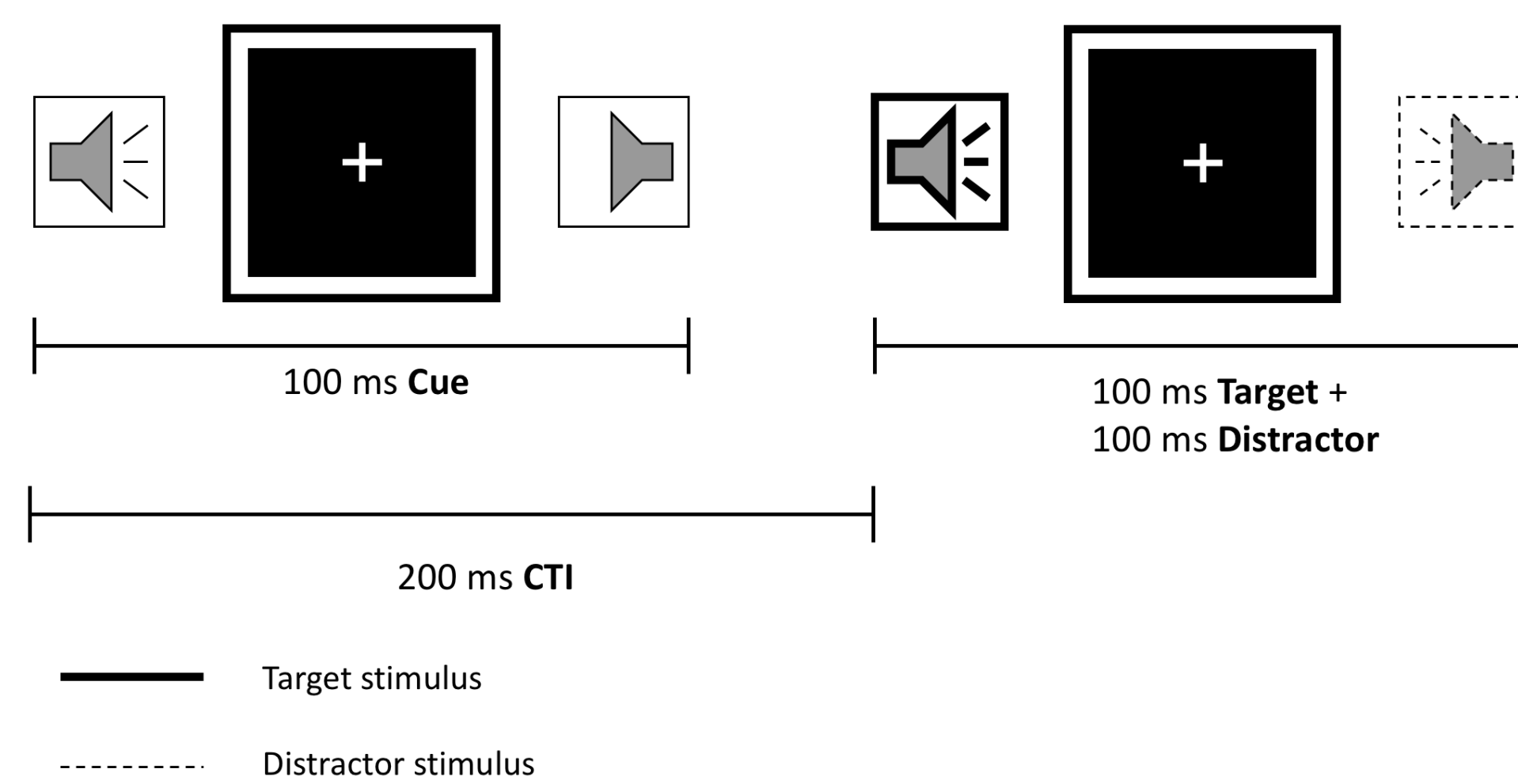
Stimuli

- The cue stimulus was a 100 ms monaural tone pip (1000 Hz) presented to either the right or left speaker. The monaural target tone pips were either a 1550 Hz sound (Target 1), or 2100 Hz sound (Target 2). Each target tone was presented simultaneously with a 100 ms distractor white noise burst in the opposite speaker (i.e. the distractor was presented on the left side for target tones appearing in the right side, and on the right side for target tones appearing in the left side).
- Trials were either valid, (the cue and target were presented from the same speaker), or invalid (the cue and target were presented from different speakers).
- Trials either had a 200ms cue-target interval (CTI) or a 700ms CTI.

Methods

- 22 subjects (15 female, mean age=21.45) participated in this study.
- Each subject participated in a single 2.5 hour session.

Valid Left Short CTI trial



Example trial

Sequence of events for Valid Left Short CTI trials. Cue stimuli are presented on the left side. The target stimuli (presented on the left side in Valid Left Short CTI) are symbolized by a bold line, with the distractor stimulus (white noise) symbolized by a dotted line. Left and right targets, and short and long CTIs, were equally probable.

Procedure:

- A discrimination task was used to elicit IOR and facilitation.
- Subjects were given two practice blocks.
- Subjects were instructed to press one with their index finger button for Target 1, and a different button with their middle finger for Target 2.

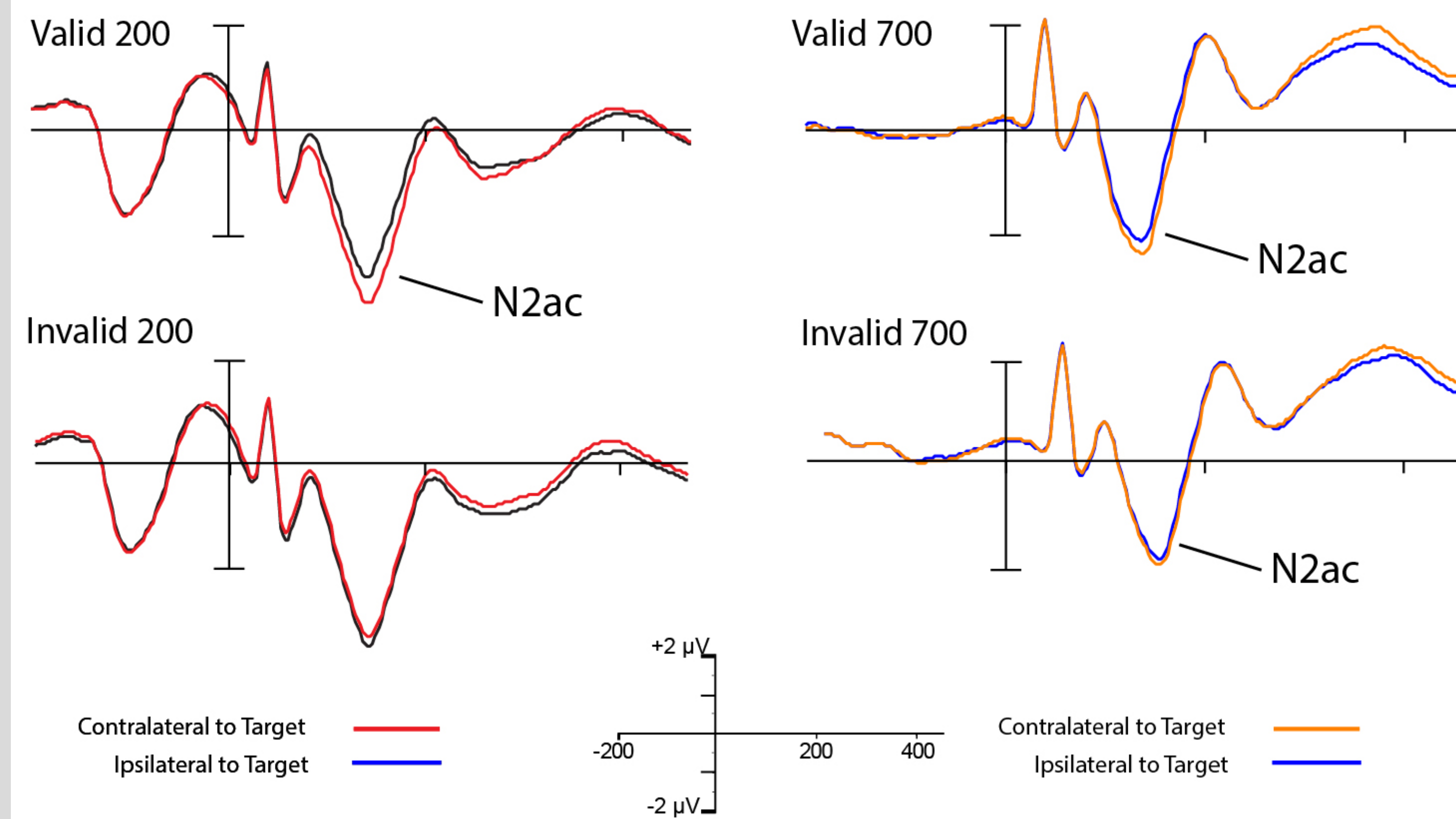
EEG Recording:

- 64 equidistant electrodes
- Average mastoid reference
- 500Hz sampling rate, 30Hz low-pass filter
- ERPs time-locked to onset of the cue sound (1000Hz) and the target sound (1550Hz or 2100Hz).

References

- ¹Mondor, T.A., and Breau, L.M. "Facilitative and Inhibitory Effects of Location and Frequency Cues: Evidence of a Modulation in Perceptual Sensitivity." *Perception & Psychophysics* 61, no. 3 (April 1999): 438–44.
- ²McDonald, J.J., Hickey, C., Green, J.J., and Whitman, J.C. "Inhibition of Return in the Covert Deployment of Attention: Evidence from Human Electrophysiology." *Journal of Cognitive Neuroscience* 21, no. 4 (April 2009): 725–33.
- ³Gamble, M.L., and Luck, S.J. "N2ac: An ERP Component Associated with the Focusing of Attention within an Auditory Scene: The N2ac Component." *Psychophysiology* 48, no. 8 (August 2011): 1057–68.

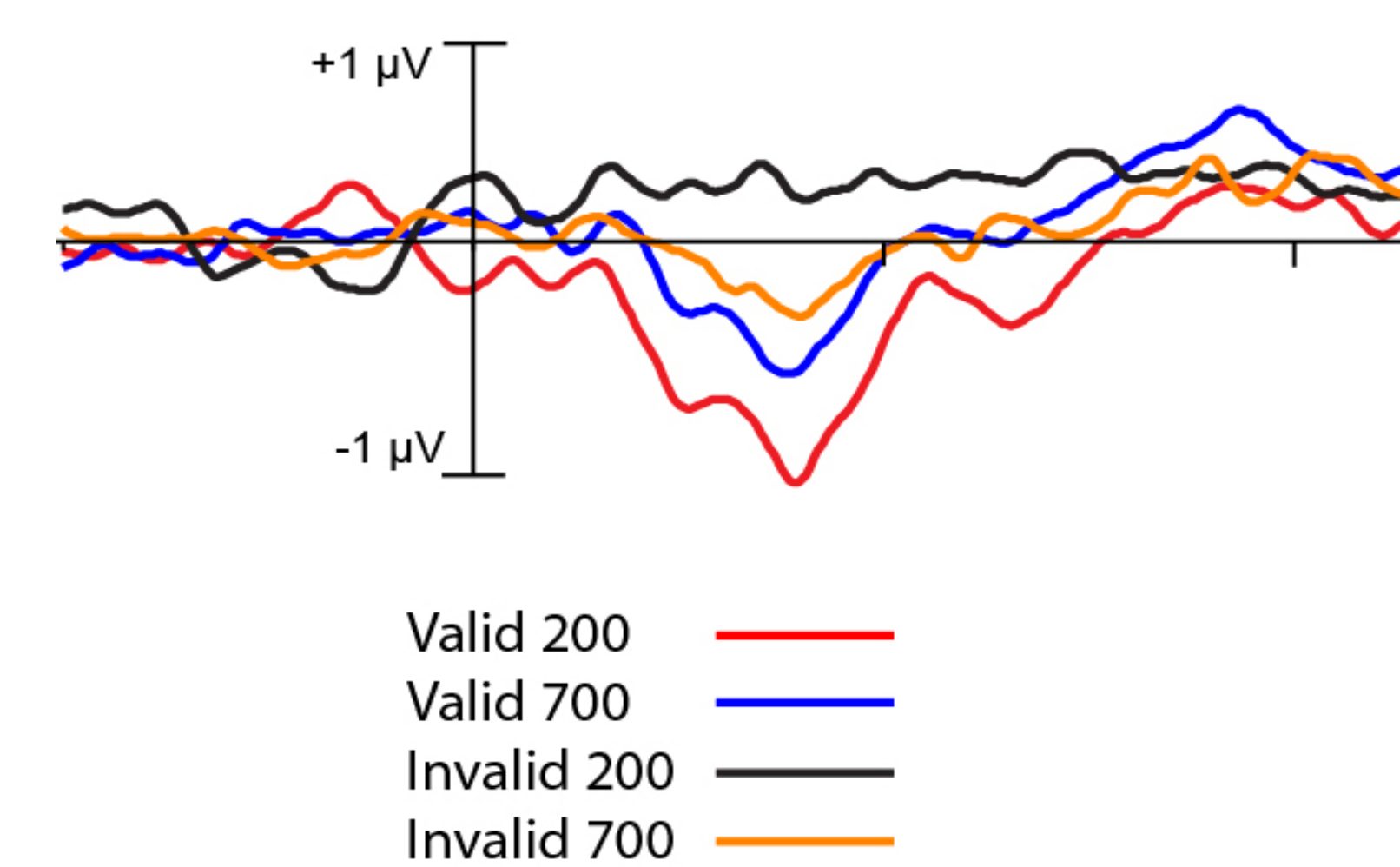
EEG Results – The N2ac



Contralateral waveforms overlaid onto ipsilateral waveforms for pooled anterior electrodes.

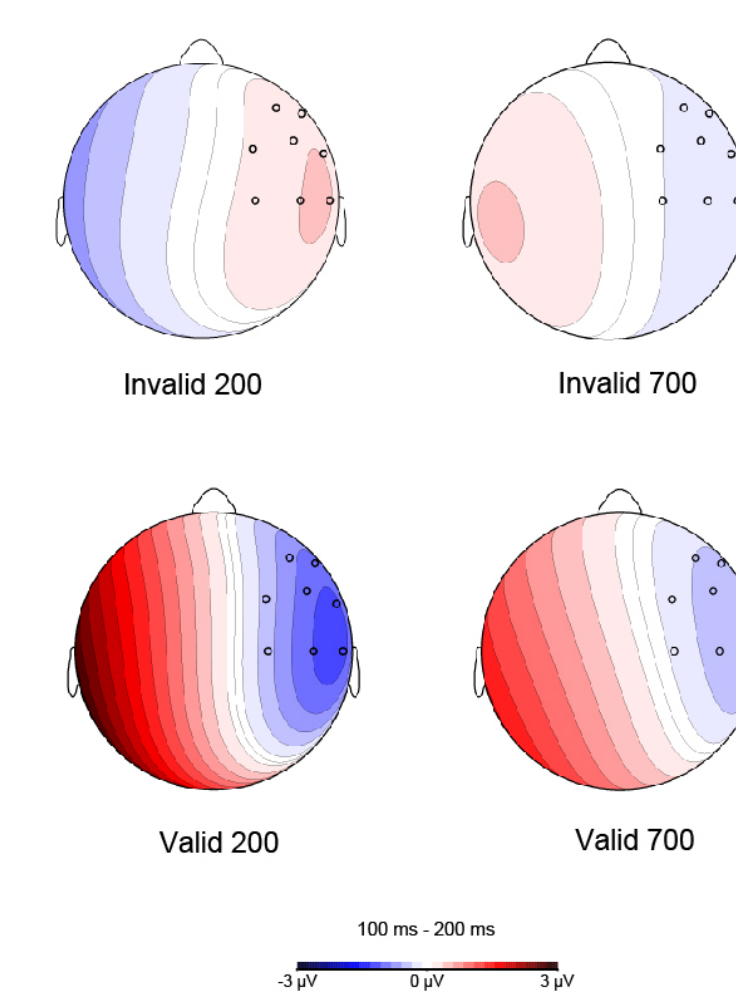
- The N2ac effect is shown here with grand averages of contralateral waveforms overlaid onto ipsilateral waveforms for all four conditions. The N2ac effect was observed in the Valid 200 (most significant effect), Valid 700, and Invalid 700 conditions.

EEG Results – The N2ac difference waves



N2ac difference waves

- Contralateral-minus-ipsilateral difference waves (averaged across an anterior electrode cluster) for each experimental condition.

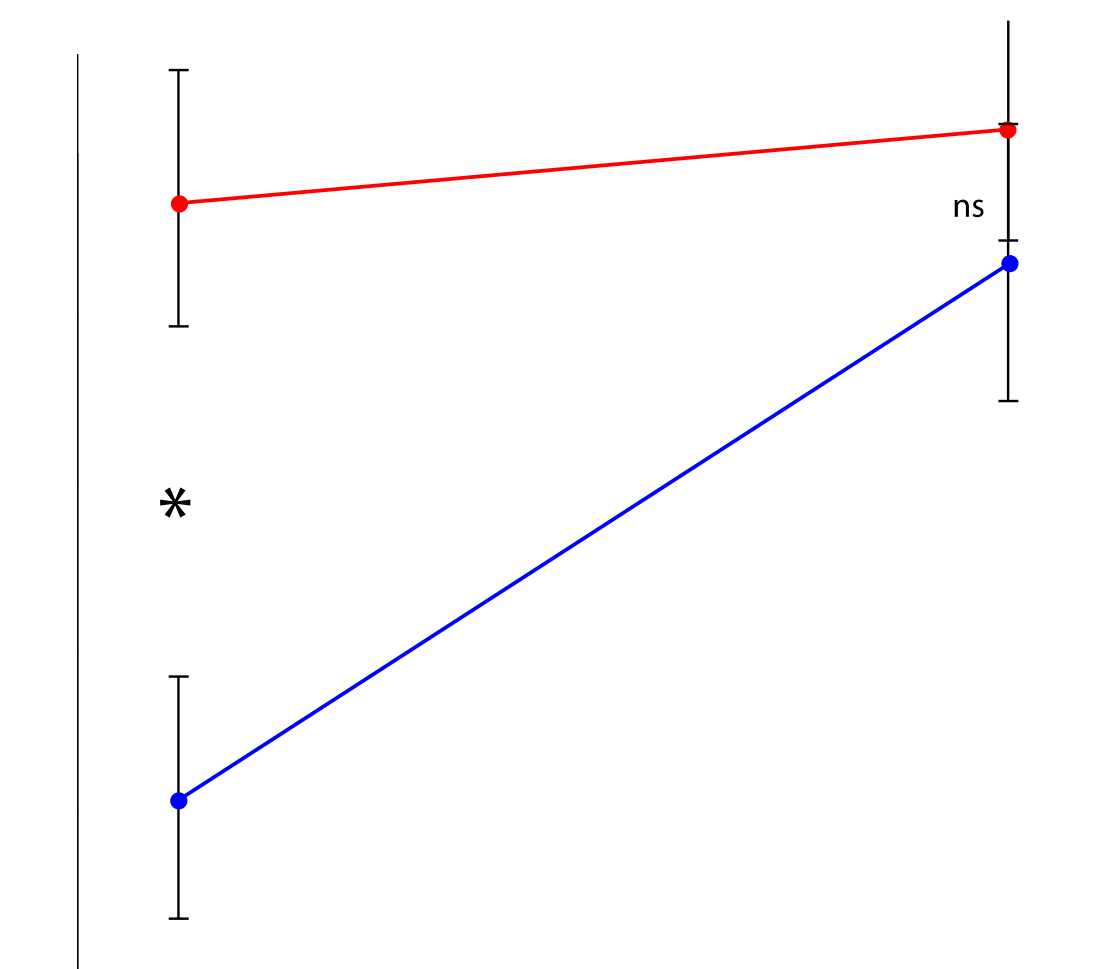


N2ac difference maps

- Difference maps showing mean amplitude differences averaged across the 100ms – 200ms time window for each of the four conditions. Electrodes used in data analysis are indicated with small circles.

Behavioral Results

Discrimination Task Reaction Times



Behavioral results for facilitation and IOR:

- Mean RTs for Valid 200, Invalid 200, Valid 700, and Invalid 700 conditions, collapsing across laterality and excluding all incorrect responses. The significant difference between Valid 200 and Invalid 200 is evidence for facilitation.
- These results indicate the typical pattern of behavior for facilitation (significant difference between Valid 200 and Invalid 200).
- The RTs for Valid 700 and Invalid 700 were statistically identical, but the interaction CTI and validity neared significance, indicating a possible trend for IOR,.

Conclusions

N2ac Predictions		N2ac Findings	
	Valid	Invalid	
200 CTI	N2ac Larger amplitude Earlier latency	N2ac Smaller amplitude Delayed latency	200 CTI
			Valid
			Invalid
			No N2ac
700 CTI	N2ac Smaller amplitude Delayed latency	N2ac Larger amplitude Earlier latency	700 CTI
			Valid
			Invalid
			N2ac
			Smaller amplitude

N2ac Findings

- The N2ac in the Valid 200 condition had the largest amplitude. Combined with our behavioral results, this shows that facilitation elicits the N2ac.
- The Valid 700 and Invalid 700 conditions elicited the N2ac, but their amplitudes were statistically identical. This indicates that our task did not produce a robust IOR effect.
- We observed no N2ac for the Invalid 200, and this condition elicited the opposite of the normal N2ac effect.
- We found clear behavioral and EEG evidence of facilitation, but only trending behavioral and EEG evidence of IOR.
- We did not find any significant differences in latency.

Future Research

- Further behavioral studies should be conducted in order to fully determine how to elicit both the N2ac and IOR in the same paradigm.
- Including cue-only trials in every experimental block could help to isolate the positive amplitude effect of the Invalid 200 condition.
- The cue-only trials could also be used to separately examine the activation of the right and left hemispheres in response to contra- and ipsilateral stimuli, such that the effect of the target is isolated.