Electrophysiological correlates of audiovisual binding in simultaneity perception

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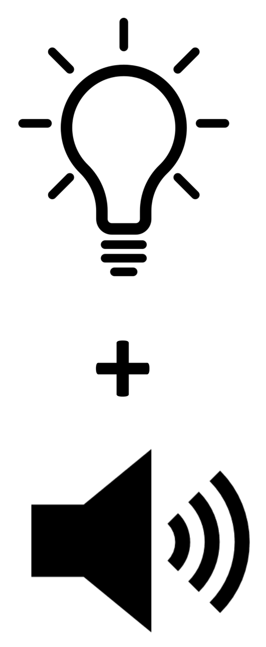
Introduction

Mechanisms allowing the brain to bind auditory and visual information into a unified percept over naturalistic delays are unknown

Phase resetting of ongoing neuronal oscillations by the leading stimulus has been proposed as a potential mechanism of integration[1-4]

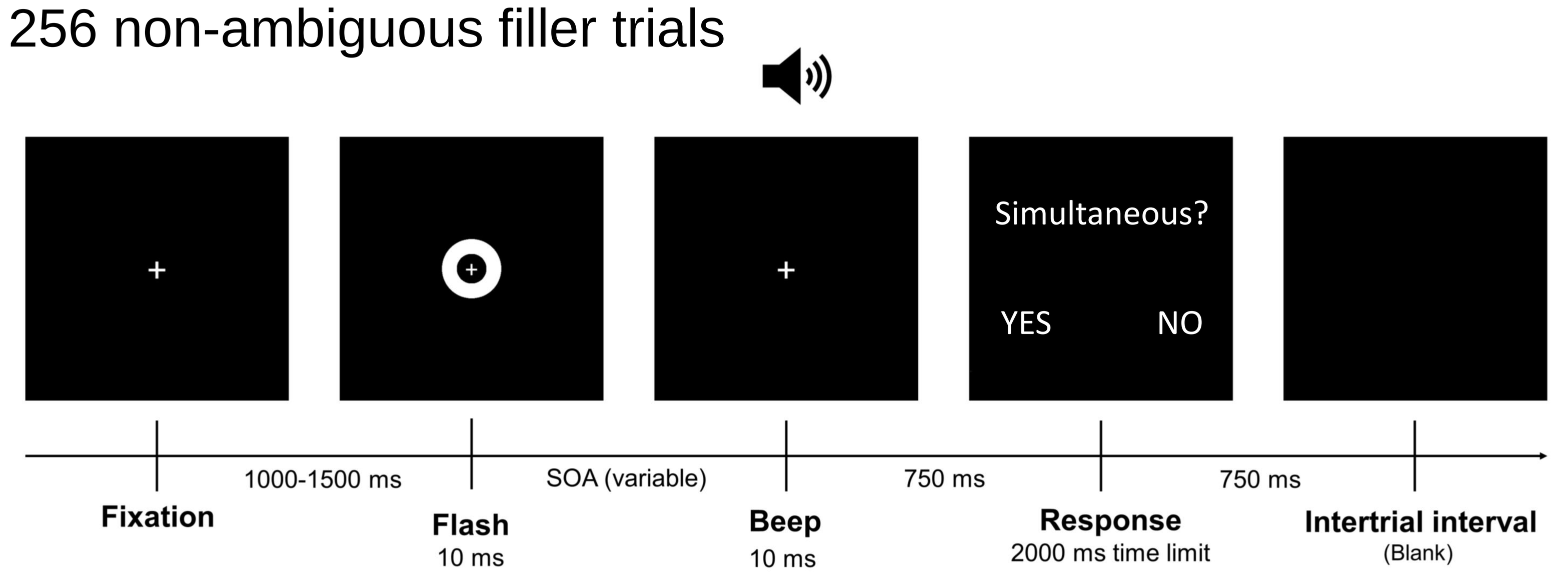
Limited evidence for association between phase resetting and perceptual binding exists[5]



Is audiovisual binding accompanied by crossmodal phase resetting?

Methods

Audiovisual simultaneity judgment task[6]
128 ambiguous trials x 2 (AV and VA)
256 non-ambiguous filler trials



n = 21 healthy young adults

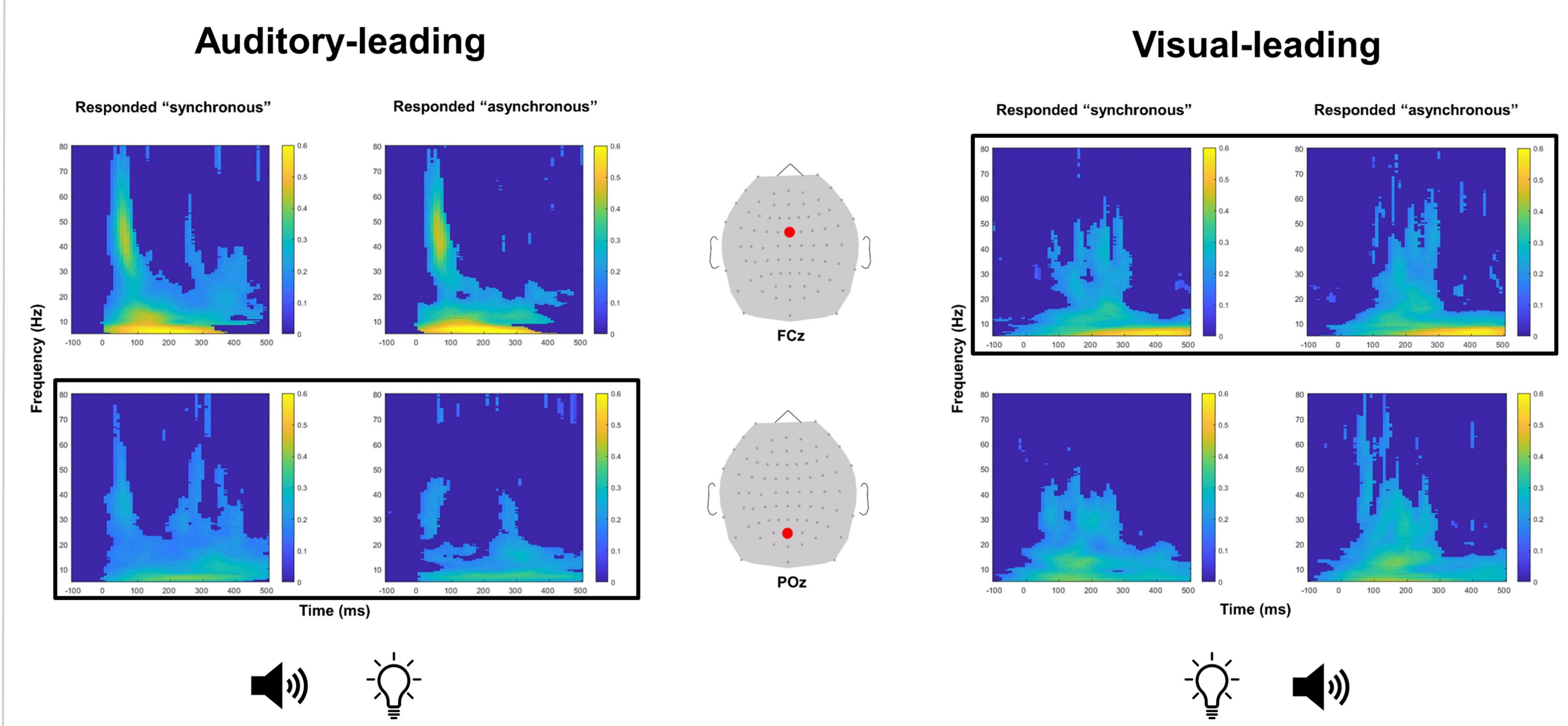
76-channel EEG

Phase resetting: Intertrial coherence (ITC) computed with Morlet wavelets (1 Hz, FWHM 3 s)

Univariate and multivariate (PLS) comparisons at sensor and source levels

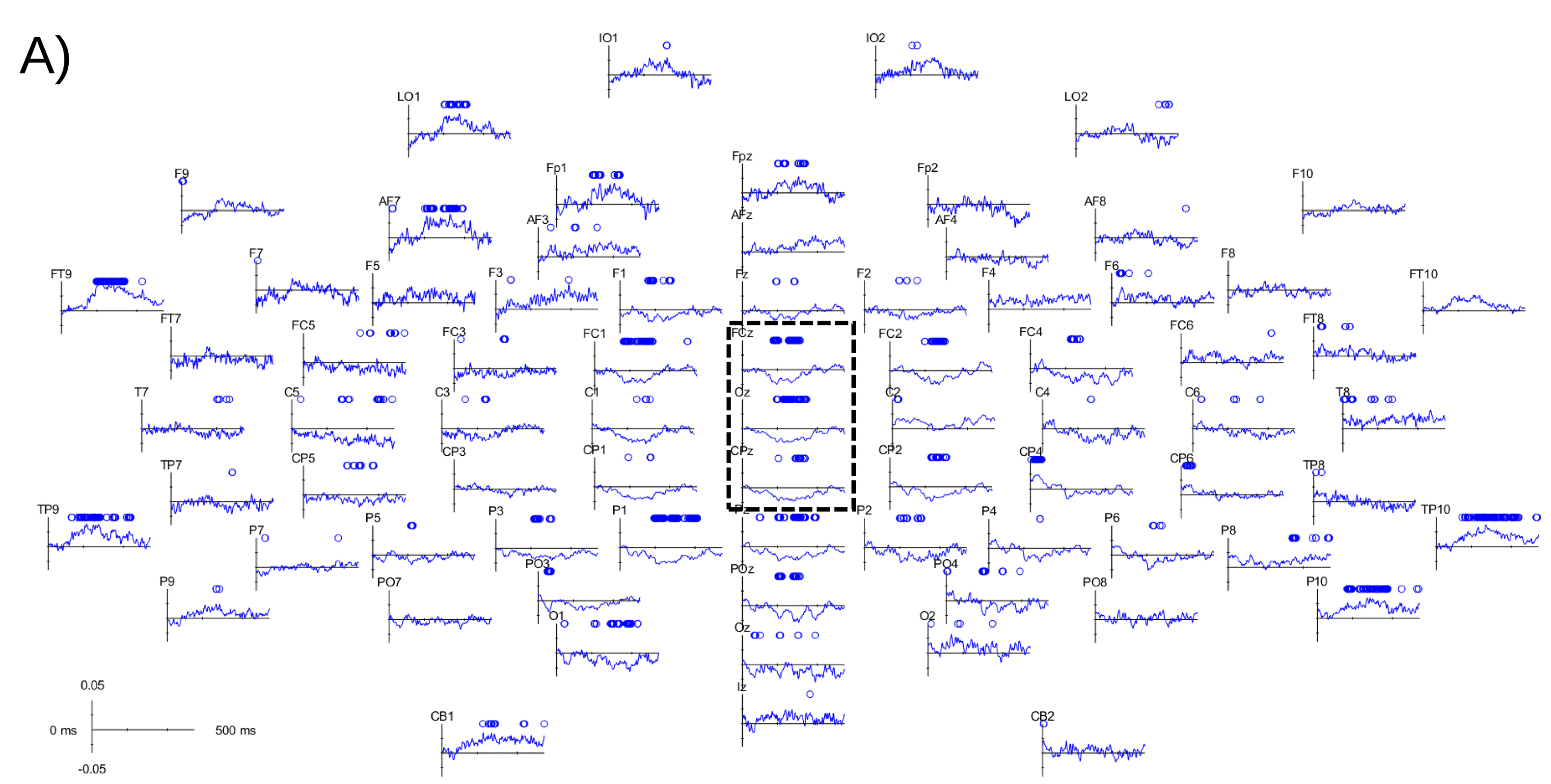
Intertrial Coherence

No significant difference in intertrial coherence detected between “synchronous” and “asynchronous” percepts

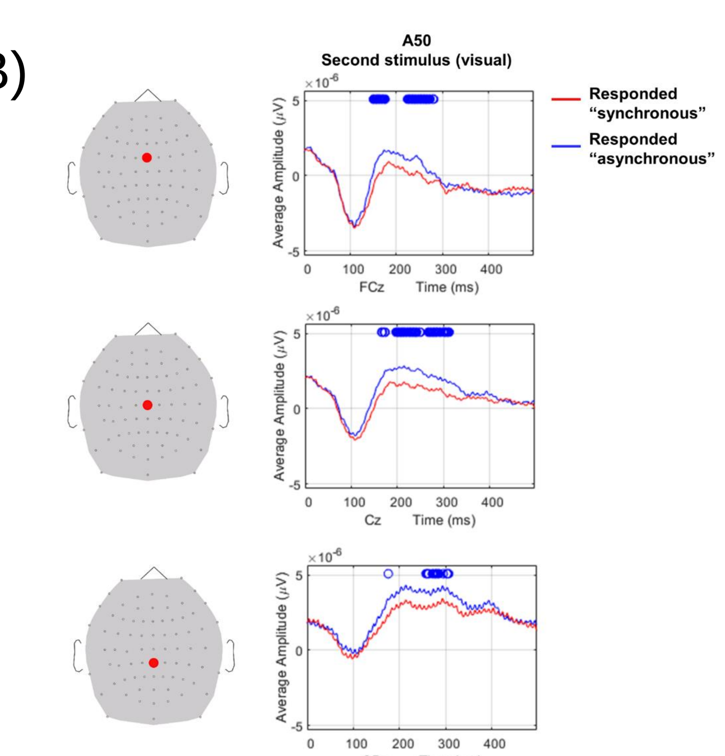


Event-Related Potentials

A)



B)



A) Auditory leading condition: Partial-least squares[7] (PLS) identified one latent variable (LV) differentiating “synchronous” and “asynchronous” percepts

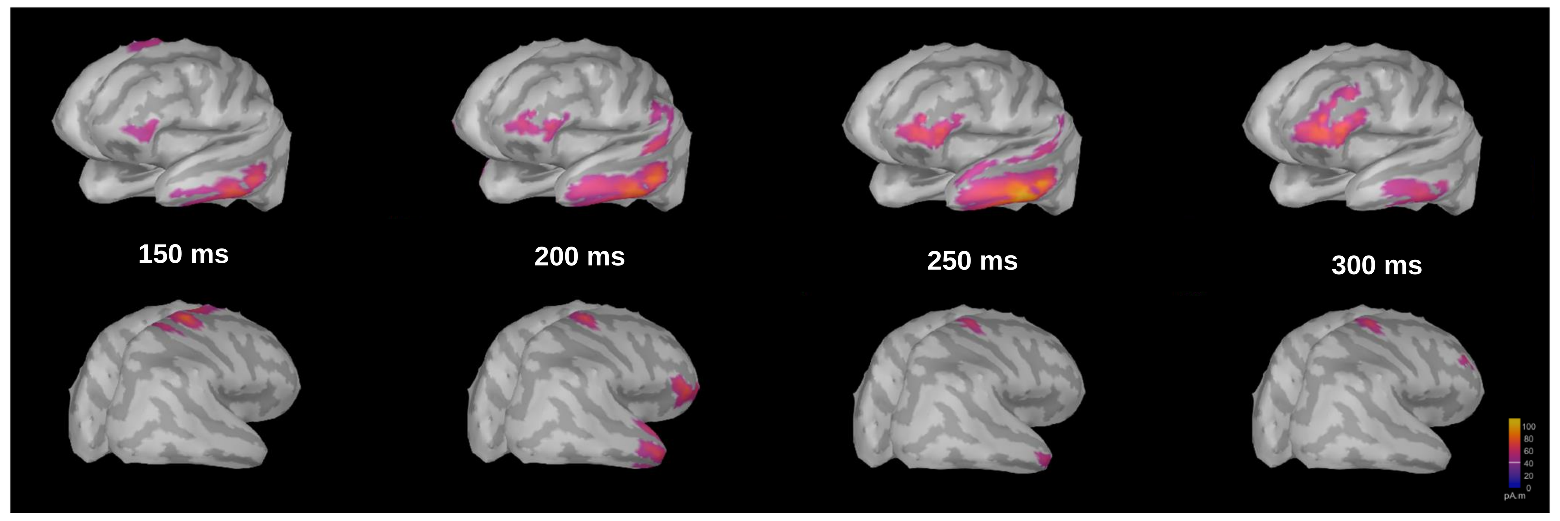
B) LV characterized by higher amplitudes over central electrodes for “asynchronous” responses, 150-300 ms after second stimulus (S2)

Source Localization

Auditory leading condition:
“Asynchronous” trial average – “synchronous” trial average

Minimum norm imaging (unconstrained sources) identified a pattern of regions including the left temporal lobe, left inferior parietal lobule, and bilateral inferior frontal gyrus

Current density maps (150-300 ms after S2):



Conclusions

No evidence that crossmodal phase resetting differentiates bound and unbound percepts

A novel ERP marker of audiovisual binding was identified instead, providing a target for future investigation

Source localization identified a distributed pattern of unisensory and multisensory regions previously implicated in multisensory integration[8-11], corroborating their role in this process

References

1. Keil, J., & Senkowski, D. (2018). Neural Oscillations Orchestrate Multisensory Processing. *The Neuroscientist*, 1–18.
2. Lakatos, P., Connell, M. N. O., Barczak, A., Mills, A., Javitt, D. C., & Schroeder, C. E. (2009). The Leading Sense : Supramodal Control of Neurophysiological Context by Attention. *Neuron*, *64*(3), 419–430.
3. Mercier, M. R., Foxe, J. J., Fiebelkorn, I. C., Butler, J. S., Schwartz, T. H., & Molholm, S. (2013). Auditory-driven phase reset in visual cortex: Human electrocorticography reveals mechanisms of early multisensory integration. *NeuroImage*, *79*, 19–29.
4. van Atteveldt, N., Murray, M. M., Thut, G., & Schroeder, C. E. (2014). Multisensory Integration: Flexible Use of General Operations. *Neuron*, *81*.
5. Kambe, J., Kakimoto, Y., & Araki, O. (2015). Phase reset affects auditory-visual simultaneity judgment. *Cognitive Neurodynamics*, *9*(5), 487–493.
6. Vroomen, J., & Keetels, M. (2010). Perception of intersensory synchrony: A tutorial review. *Attention, Perception & Psychophysics*, *72*(4), 871–884.
7. McIntosh, A. R., & Lobaugh, N. J. (2004). Partial least squares analysis of neuroimaging data: Applications and advances. *NeuroImage*, *23*, 250–263.
8. Bushara, K. O., Grafman, J., & Hallett, M. (2001). Neural correlates of auditory-visual stimulus onset asynchrony detection. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *21*(1), 300–304.
9. Calvert, G. A., Hansen, P. C., Iversen, S. D., & Brammer, M. J. (2001). Detection of audio-visual integration sites in humans by application of electrophysiological criteria to the BOLD effect. *NeuroImage*, *14*(2), 427–438.
10. Noesselt, T., Rieger, J. W., Schoenfeld, M. A., Kanowski, M., Hinrichs, H., Heinze, H.-J., & Driver, J. (2007). Audiovisual Temporal Correspondence Modulates Human Multisensory Superior Temporal Sulcus Plus Primary Sensory Cortices. *Journal of Neuroscience*, *27*(42), 11431–11441.
11. Dhamala, M., Assisi, C. G., Jirsa, V. K., Steinberg, F. L., & Scott Kelso, J. A. (2007). Multisensory integration for timing engages different brain networks. *NeuroImage*, *34*(2), 764–773.

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