Eye responses reflect spatial congruency and perceptual bias in audiovisual interaction

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Introduction

Ventriloquism

The ventriloquist illusion indicates a perceptual illusion, in which the localization of an auditory stimulus is influenced by the position of a spatially offset visual stimulus [1]. The ventriloquist effect reflects the degree of the binding between auditory and visual stimuli.

Eye responses in audiovisual interaction

Eye responses such as pupillometry and microsaccades reflect audiovisual interaction. Enhanced pupil dilation and microsaccade inhibition are associated with improved behavior in the bisensory over unisensory conditions [2].

The aims of the study

As spatially displaced visual stimulus induces the ventriloquism, we investigated whether the ventriloquist effect and eye responses reflect the difference in audiovisual interaction caused by spatial congruency of audiovisual stimuli.

Methods

Stimuli

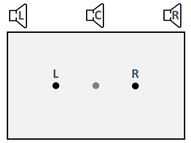
- Visual (V): a single filled circle (0.6° diameter, 6cd/m²)
- Auditory (A): a simple beep sound (1000Hz, 48.0k sampling rate).

A and V stimuli were presented simultaneously in the AV condition.

Spatial Congruence in the AV condition

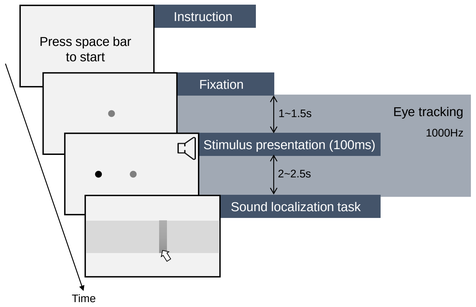
- **Congruent (SC):** LL, RR
- **Incongruent (SI):** LR, CL, CR, RL

Ex) **CL** = A: **C**enter V: **L**eft



Procedure

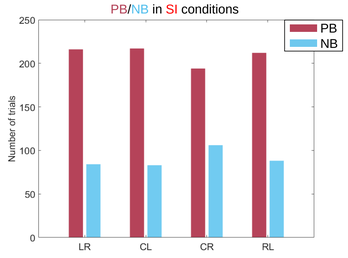
15 participants



Analyses

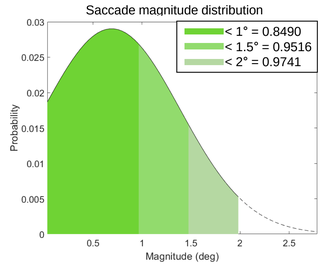
Classification for perceptual experience

All trials in the SI were classified as follows: responses significantly biased toward V stimulus relative to A stimulus were considered as perceptually biased (PB), and the others as not biased (NB).



Microsaccades detection

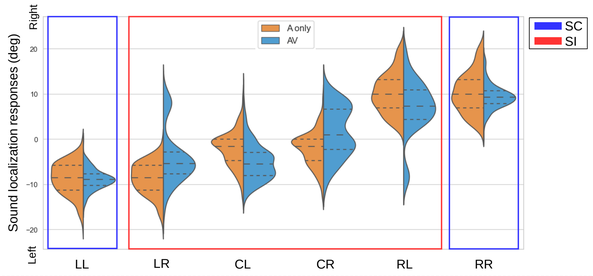
Microsaccades were detected using the algorithm by Otero-Millan et al [3]. All subsequent analyses concern microsaccades with magnitudes < 2°.



Results: Behavior

Sound Localization performance

- Enhanced consistency of responses in the bisensory over unisensory condition.
- Significant response bias toward V stimulus in the SI



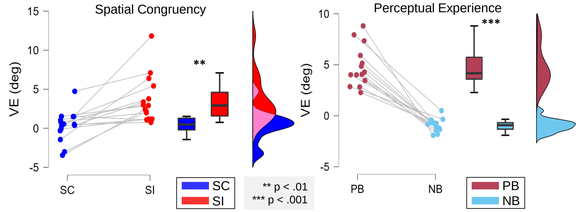
Ventriloquist Effect (VE)

Spatial congruency and perceptual experience of visual bias modulate the VE.

- Greater VE in SI than SC
- Greater VE in PB than NB

VE = AV – A only (When V presented right to A)

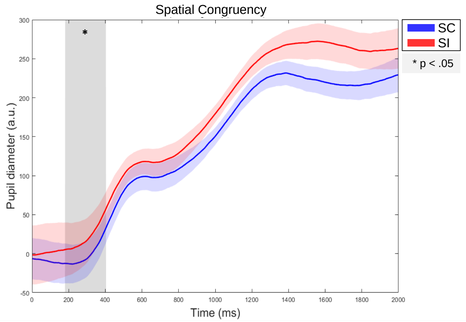
VE = A only – AV (When V presented left to A)

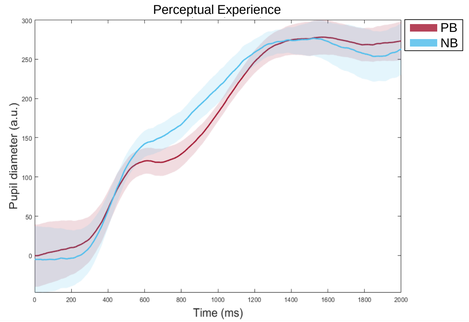


Results: Pupillometry

Temporal dynamics of pupil dilation

- Pupil dilation tend to be greater for SI than SC, significant between182ms and 404ms from the stimulus onset
- No statistically significant difference of pupil dilation between PB and NB





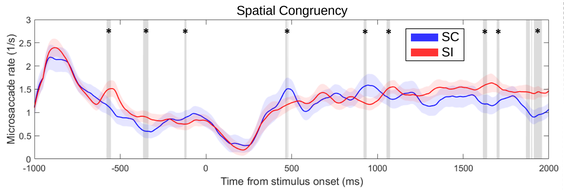
Results: Microsaccades

Microsaccade rate

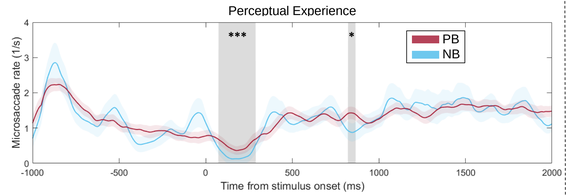
Microsaccade rate was computed using the algorithm by Rolf and Engbert [4]. Decay parameter was set to α = 1/20ms.

For all conditions, microsaccade inhibition appeared shortly after stimulus onset (100~200ms).

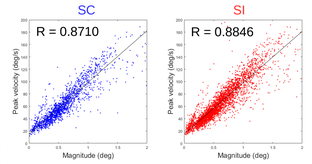
- Microsaccade rate during inhibition: No statistically significant difference between SC and SI.
- Microsaccade rate during rebound: Microsaccade rate for SC greater than SI, significant between 463ms and 473ms from stimulus onset.

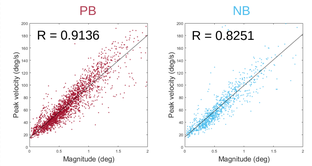


- Microsaccade rate during inhibition: Microsaccade rate for PB greater than NB, significant between 96ms and 228ms from stimulus onset.



- Significant positive correlation between magnitude and peak velocity in all conditions





Conclusion

Eye results indicate that pupillometry is a reliable marker for spatial congruency and microsaccades reflect the perceptual experience of visual bias. These results suggest that pupil dilation reflects the stimulus aspects whereas microsaccade reflects the perceptual aspects of audiovisual integration.

References

[1] Alais, D., & Burr, D. (2004). *Current Biology*, *14*(3), 257-262.
[2] Wang, C. A. et al. (2017). *Biological Psychology*, 129, 36-44.
[3] Otero-Millan et al. (2014). *Journal of Vision*, 14(2), 18-18.
[4] Rolfs, M. et al. (2008). *Journal of Vision*, 8(11), 5-5.