Analyzing the Allocation of Visual Attention in Deaf and Hearing Signers with a Drift-Diffusion Model

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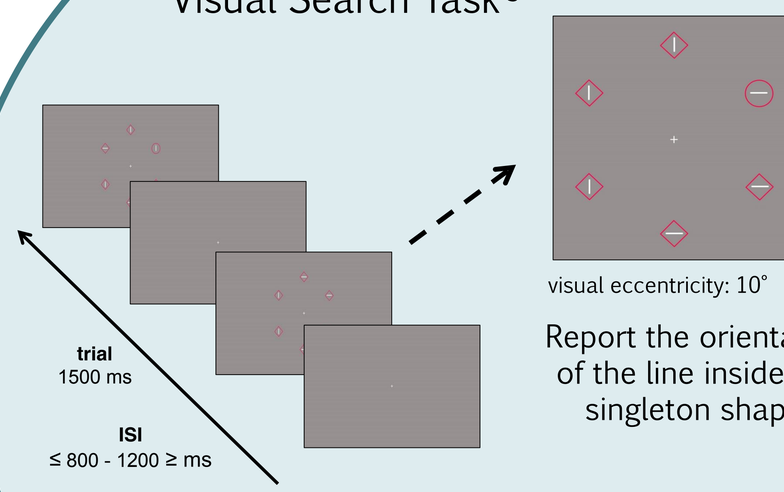
Introduction

- Deaf signers have higher visuo-attentional resources specifically in their peripheral Visual Field (VF)[1]
- The impact of sign language on the allocation of visual attention, and more particularly between upper and lower parts of the VF[2], has not been studied in as much detail
- When signing, signers look at each other face and do not look directly at the hands or at the gestures; the lower VF is therefore the location where the manual components of signs are perceived[3,4]
- Can sign language experience induce a shift in the allocation of visual attention by increasing resources in the lower VF?

If sign language experience affects the distribution of visual attention, both deaf and hearing signers should have a greater attentional bias toward the lower VF than do hearing non-signers

Method

Visual Search Task [5]



Report the orientation of the line inside the singleton shape

Participants

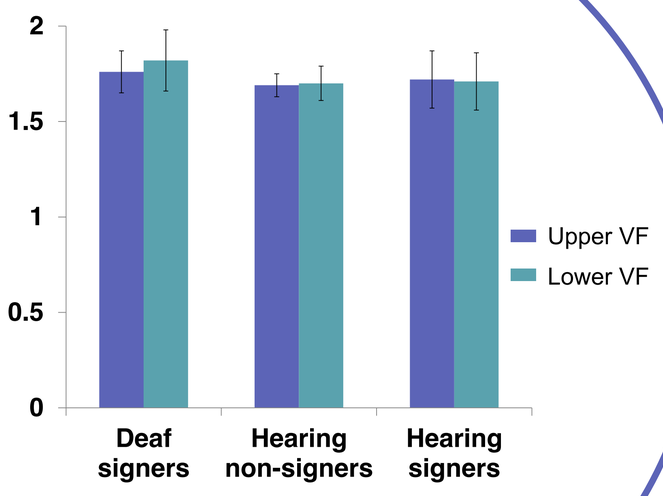
Deaf early signers (n=29)
Hearing non-signers (n=28)
Hearing early signers (n=18)

Data modelling: Hierarchical Drift Diffusion Model

In a 2-AFC decision task, over time individuals accumulate evidence favoring one of two choices until a response is initiated. We applied a Bayesian Hierarchichal Drift Diffusion Model[6] to the data to estimate three decision parameters:

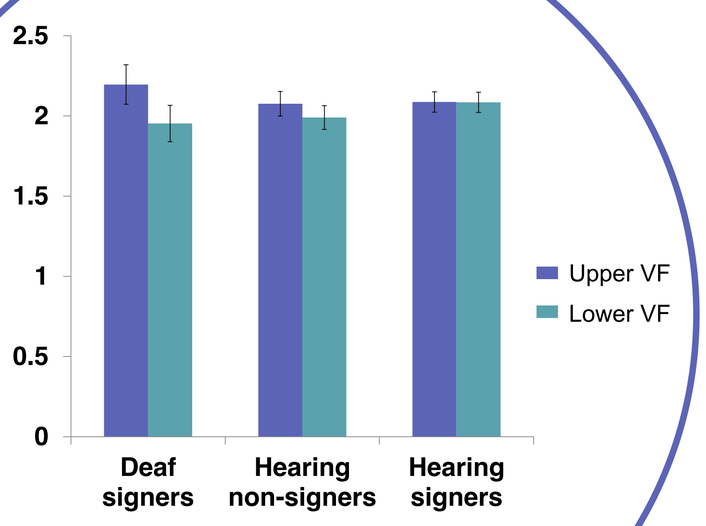
- The threshold: The amount of information necessary to make a decision, e.g. a higher threshold indicates a more cautious but slower response.
- The drift-rate: The speed at which an individual accumulates relevant evidence, e.g. a high drift-rate means a relevant information is extracted from the stimulus display at a faster rate.
- The non-decision time: Non-decisional processes include sensory perception, visual encoding, motor planning, and motor execution…

Threshold



No significant effect

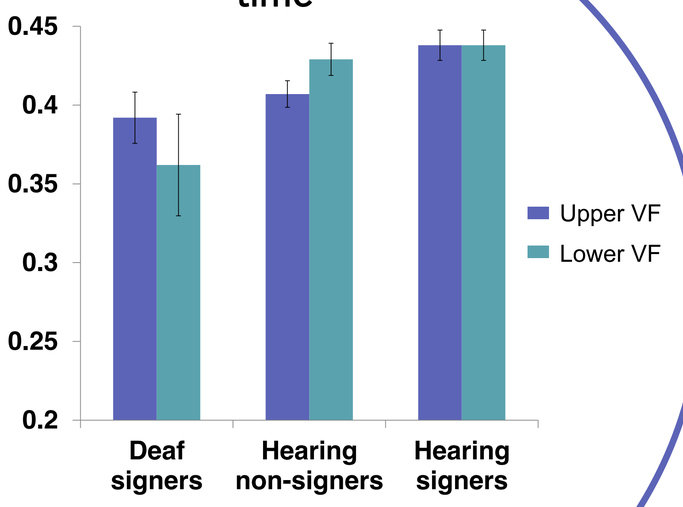
Drift-rate



Group x VF: $F(2,66)=8.09$, $p<0.001$

Deaf *vs* Hearing $t(66)=3.83$, $p<0.001$

Non-decision time



Group : $F(2,66)=6.12$, $p= 0.004$

Deaf *vs* Hearing $t(66)=3.44$, $p=0.001$

References

1. Bavelier, D., Dye, M., & Hauser, P. C. (2006). Do deaf individuals see better? *Trends in Cognitive Sciences*
2. Dye, M., Seymour, J. L., & Hauser, P. C. (2015). Response bias reveals enhanced attention to inferior visual field in signers of American Sign Language. *Experimental Brain Research*, *234*(4), 1–10
3. Emmorey, K., Thompson, R., & Colvin, R. (2009). Eye gaze during comprehension of American Sign Language by native and beginning signers. *Journal of Deaf Studies and Deaf Education*
4. Muir, L. J., & Richardson, I. E. G. (2005). Perception of sign language and its application to visual communications for deaf people. *Journal of Deaf Studies and Deaf Education*, *10*(4), 390–401.
5. Carlei, C., & Kerzel, D. (2017). Stronger interference from distractors in the right hemifield during visual search. *Laterality*, 1–21.
6. Wiecki, T. V, Sofer, I., & Frank, M. J. (2013). HDDM: Hierarchical Bayesian estimation of the Drift-Diffusion Model in Python. *Frontiers in Neuroinformatics*, *7*(August), 14.
7. Loke, H. W., & Song, S. (1991). Central and peripheral visual processing in hearing and nonhearing individuals. *Bulletin of the Psychonomic Society*, *29*(5), 437–440.

Conclusion

- All groups had a similar threshold, meaning they needed the same amount of information to make their decision. Only deaf signers exhibited a lower VF advantage in the speed of information extraction (i.e., drift-rate). This difference cannot be attributed to sign language experience because they are not common between deaf and hearing signers.
- Overall performance in a visual search task in the peripheral VF is not improved by deafness. However deafness changes the way information is extracted -- the distribution of visual attention across VF is changed as a result of deafness.
- In addition, deaf signers were overall faster than the hearing in their non-decision time processes. This enhancement is more likely due to faster visual low-level processing than faster motor planning and execution since deaf signers are faster to detect target onset in their peripheral VF. [7]
- This study is the first to apply the drift-diffusion model to deaf and/or signers' data and provides new insights about deaf and signers cognition.