The impact of asymmetrical hearing loss on multisensory integration: Sensory conflict increases saccade latencies to audiovisual stimuli

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Background

- Asymmetrical hearing loss (AHL) is a common type of hearing loss (14-20%)[1, 2] that heavily distorts sound localization, shifting the perceived location of sounds relative to their actual location[3].
- Multisensory integration (MSI) of auditory (A) and visual (V) input normally greatly enhances perception of AV input when A and V are spatially aligned relative to when they are misaligned in space[4, 5, 6].
- Studies of AHL have heavily focused on impairments in hearing. However, given that AHL distorts auditory spatial perception, AHL should also have large consequences for how the senses work together to improve spatial perception.
- Here, we investigated the impact of (simulated) AHL (i.e. earplug in the right ear) on the benefits of MSI for saccades towards spatially aligned AV targets.
- We expected that AHL disrupts MSI because of the spatial conflict between hearing and vision. If so, the decrease in saccade latency for aligned relative to misaligned AV targets should be reduced due to AHL.

Methods

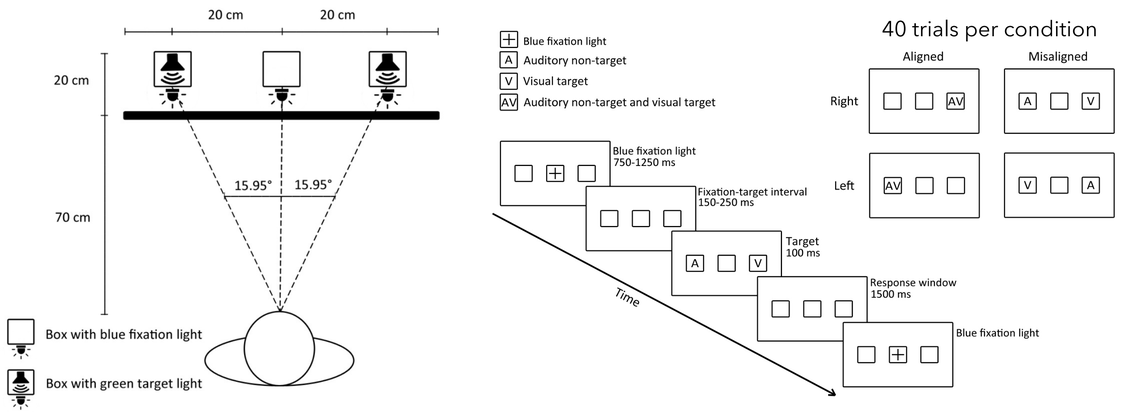
Materials & stimuli

- Fixation: blue LED (13.5 cd/m^2).
- Visual target: green LED (15.9 cd/m^2).
- Auditory non-target: ~68 dB(A) white-noise burst.
- Fixation-Target distance: 15.95°.
- E-audio black 4" Full Range Mini Box Speakers.
- Black sound-transparent screen.
- Eye-tracker: Eyelink 1000.
- Sennheiser HD 201 headphone for the hearing test.
- Ohropax Soft earplugs. Noise reduction: ~32 dB(A).

Task

- An equal loudness test was used to measure the effect of the earplug on hearing.
- Twelve participants were instructed to make saccades towards V targets as fast and as accurate as possible while ignoring the spatially aligned or misaligned A target.

Setup and procedure



Analysis

- The point of subjective equality (PSE) for sound intensity in the left and right ear was compared between the no earplug and the earplug condition using a paired t-test.
- Saccade latency, amplitude, and landing points were analyzed using a repeated measures ANOVA.

Results

Equal loudness test
The earplug caused a PSE shift of 29 dB(A) (SE=3.57, $t(11)=-8.162$, $p<.001$) resulting in ~34 dB(A) hearing loss in the right ear (see Fig. 1A).

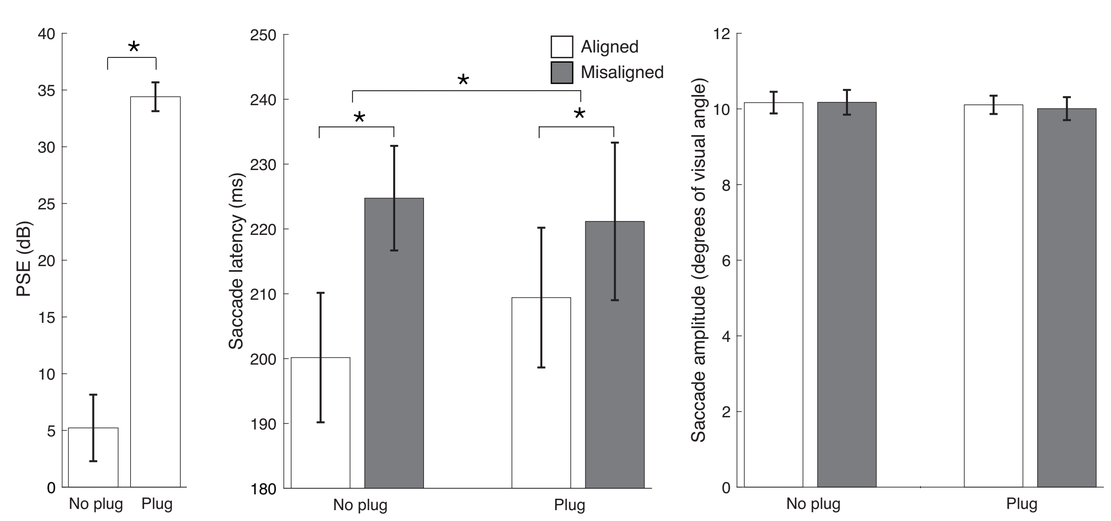


Fig. 1 PSE without and with earplug (A). Saccade latency (B) and saccade amplitude (C) for spatially aligned and misaligned AV targets without and with earplug. Error bars indicate standard errors. * $p<0.05$

Saccade latency
There was a main effect of Spatial Alignment ($F(1,11)=28.914$, $p<0.001$). Saccade latencies were shorter for aligned than for misaligned AV targets. There was no main effect of the plug on saccade latency ($F(1,11)=0.312$, $p=0.588$). Importantly, there was an interaction between Spatial Alignment and No plug/Plug ($F(1,11)=6.588$, $p=0.26$, see Fig. 1B). The Spatial Alignment effect was reduced when participants wore an earplug in the right ear.

Saccade amplitude and landing position
Neither spatial alignment, nor the earplug affected saccade amplitude or saccade landing position (see Fig. 1C and Fig. 2).

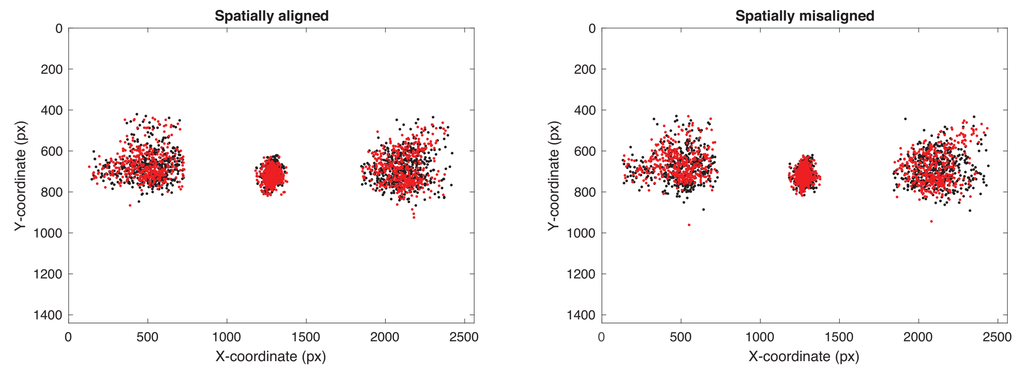


Fig. 2 Saccade start and landing positions in the spatially aligned (left) and misaligned (right) condition before (black) and after earplug insertion in the right ear (red).

Conclusion & Discussion

- This study is the first to show that AHL specifically increases saccade latencies of saccades towards spatially aligned AV targets, indicating that MSI is disrupted by AHL.
- Saccade landing point and amplitude were not affected by AHL, likely due to the high reliability of visual input.
- We are now investigating how AHL affects the integration process by manipulating stimulus intensity and reliability and using race model and optimal cue integration analyses.

References

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