Naturalistic auditory narratives synchronize "visual" cortices of congenitally but not late blind or sighted people

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Introduction

- In individuals who are born blind, the brain regions that would otherwise process vision undergo significant reorganization. For example, in blindness the "visual" cortices are active during non-visual tasks like braille reading (1), sound localization (2), and auditory sentence comprehension. (3,4)
- Moreover, this reorganization is consistent across people: across congenitally blind individuals, responses in "visual" cortices" synchronize while participants listen to sound clips of naturalistic audio-movies and narratives, but not during shuffled sentences or backwards speech. (5)
- Is there a sensitive period to this systematic re-purposing of the "visual" cortices in blindness? Or, can this neuroplasticity also emerge later in life? To address these questions, we measured brain activity in individuals who lost their vision as adults. Does visual cortex activity synchronize in these individuals as well? And if so, what kind of auditory stimuli induce synchronization?

Subjects

- Subject groups: Congenitally Blind (CB, n=18), Late Blind (LB, n=15) & Sighted (S, n=18)
- Blindness caused by pathologies in or anterior to optic chiasm, not due to brain damage
- CB subjects were born blind and LB subjects had functional vision until age 18 or older
- Average ages: 41.9 CB; 54.5 LB; 41.2 S, all subjects blindfolded during scanning

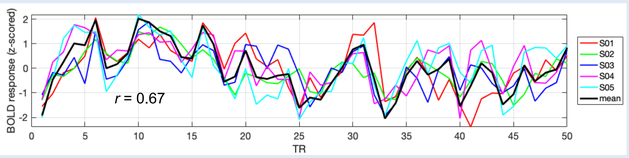
Methods

To test visual cortex responses in blind individuals: naturalistic auditory stimuli that parametrically vary in degree of low-level sensory vs. high-level content

Stimuli: backward speech | shuffled sentences | comedic story | movie clips

- Participants listened to six sound clips, each 5-7 minutes long (one per scanning run)
- Narrative stimuli included a comedic story ("Pie-man") and excerpts from three movies
- fMRI acquisition parameters: TR = 2000ms, voxels resampled to 3mm^3

To test for synchronized activity across individuals: inter-subject correlation analysis (ISC)[6]



How correlated are the activity timecourses across subjects?

- Within group: correlate each member's timecourse with their rest-of-group average
- Between groups: correlate each Group1 member's timecourse with the Group2 average

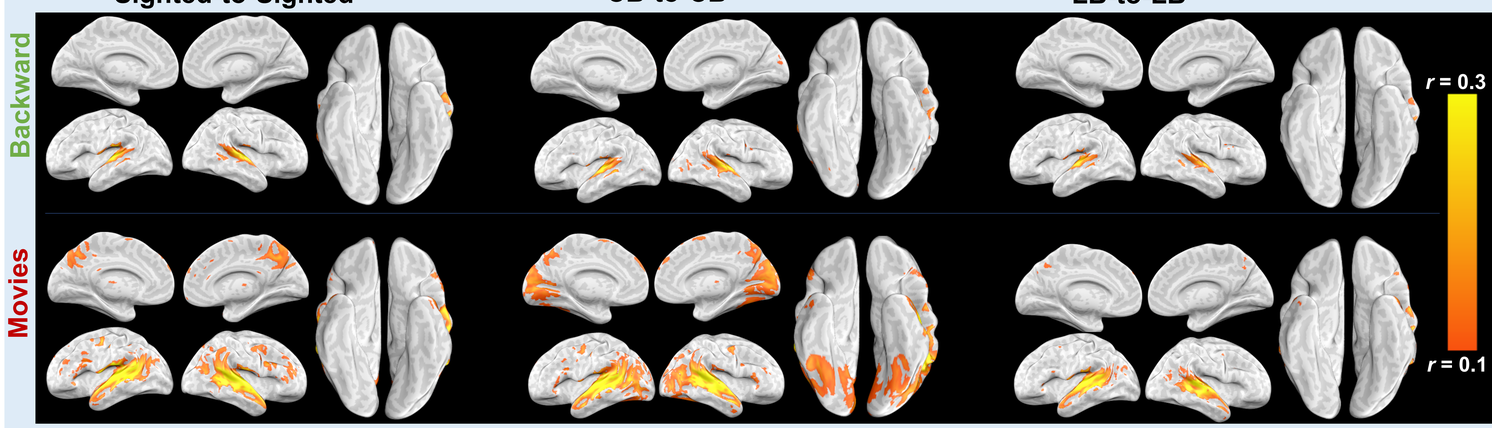
Predictions

- High ISC (synchronized responses) within each subject group: (1) for all stimuli, in auditory cortex and (2) for meaningful stimuli, in higher-cognitive areas (precuneus & frontotemporal cortex)

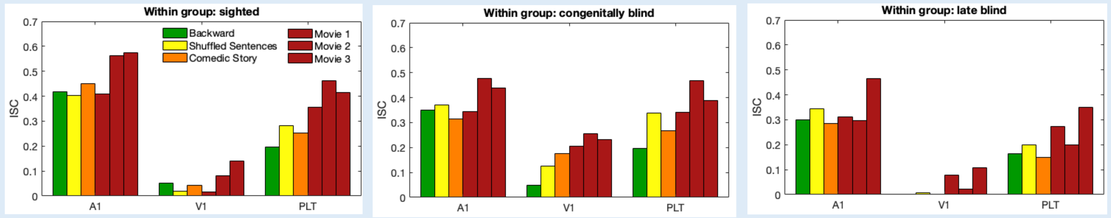
➔ **Does visual cortex synchrony emerge in individuals who lost vision as adults? If so, does this synchrony reflect high-level or low-level stimulus content?**

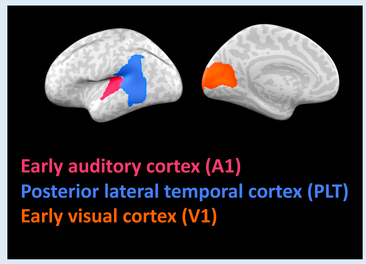
➔ **Between groups: is visual cortex activity synchronized across congenitally blind and adult-onset blind individuals?**

Synchrony within vision groups



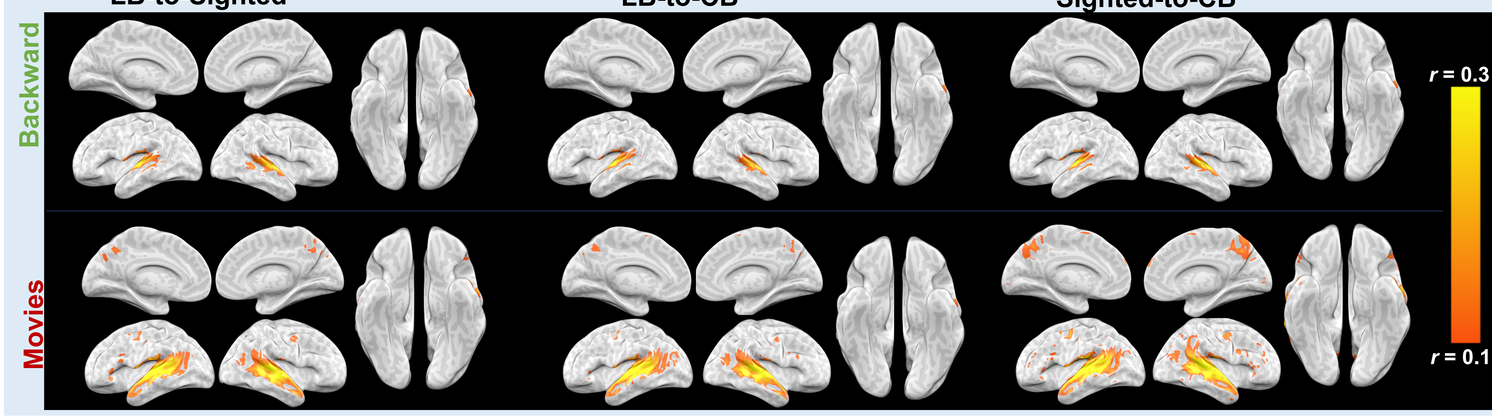
ROI Results





- In A1, inter-subject correlations are high for all stimuli in all subject groups.
- In PLT, inter-subject correlations are greater for meaningful stimuli vs. backward speech.
- In V1, responses synchronize during for meaningful stimuli, but only across individuals who were born blind.

Synchrony across vision groups



Discussion

- In blindness, the "visual" cortices synchronize in response to auditory stimuli. However, this effect only emerges across congenitally blind individuals, and only for high-level stimuli. This synchronization demonstrates a dramatic and systematic repurposing of the visual cortices in the absence of vision.
- In the adult-onset blind individuals (and in the sighted group), neither the high-level nor low-level auditory stimuli induced synchrony in visual cortex. This lack of systematic neuroplasticity across people who lost their vision as adults suggests that the functional reorganization of "visual" cortices is limited to a sensitive period during development.

References & Acknowledgements

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