



Auditory spatialization approaches ^{don't} differentially recruit sensory-biased prefrontal cortex

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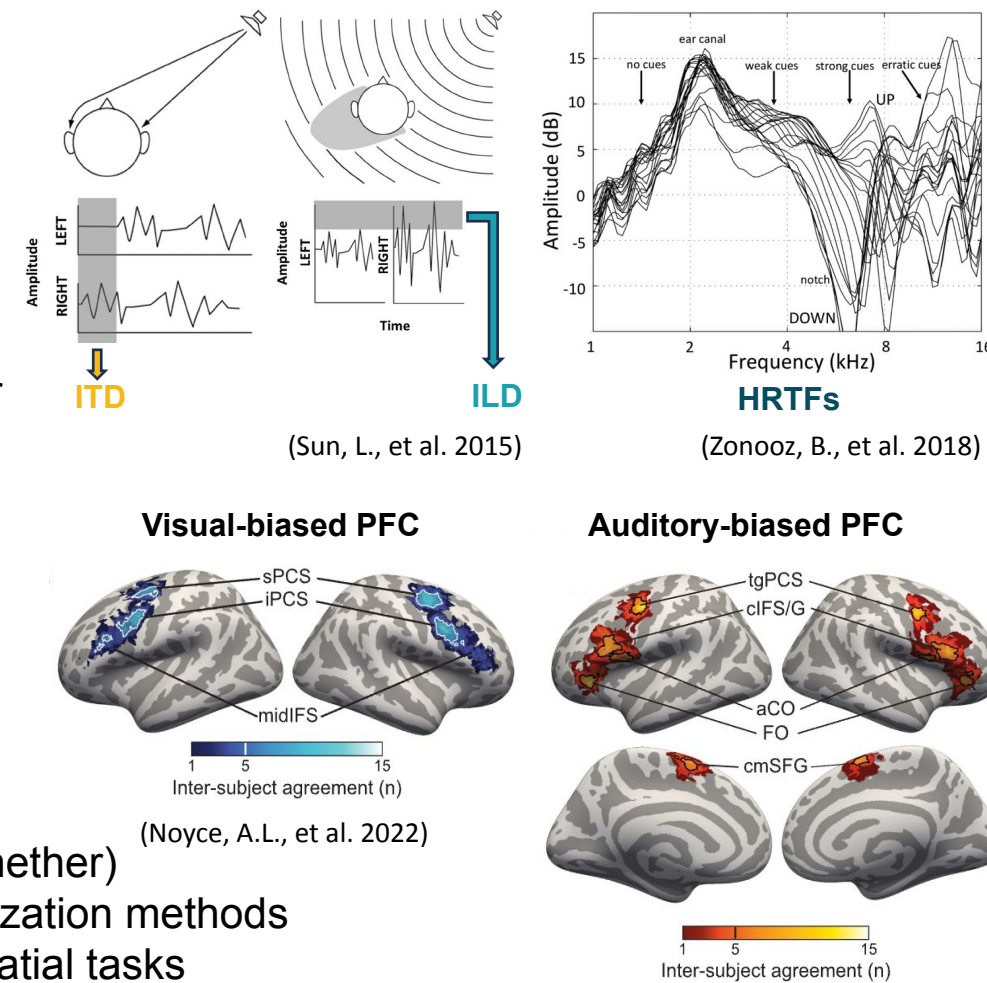
Background

- Different spatialization methods present different types of acoustic cues
 - Head-related transfer functions (HRTFs)
 - Interaural-level differences (ILDs)
 - Interaural-time differences (ITDs)

- EEG brain signatures of auditory attention vary with spatialization methods [1]
- Spatial selectivity in auditory ACx is greater during spatial than non-spatial tasks [2,3]

- Auditory cortex (ACx) may show a contralateral bias for HRTFs and ILDs simply from stimulus differences

- Visually biased prefrontal cortex (PFC) regions show greater activation during auditory spatial than non-spatial tasks [4]



This behavior/fMRI study investigates how (whether)

- spatial selectivity in ACx varies with spatialization methods
- PFC activation differs for spatial vs. non-spatial tasks
- PFC activation varies with spatialization methods
- PFC spatial selectivity varies for spatial vs. non-spatial tasks

Working Memory (WM) Task

In each trial, participants listened to two 4-item sound sequences and determined whether the two sequences were the same in the attended attribute. Simultaneous behavior and fMRI data were collected from 18 subjects.

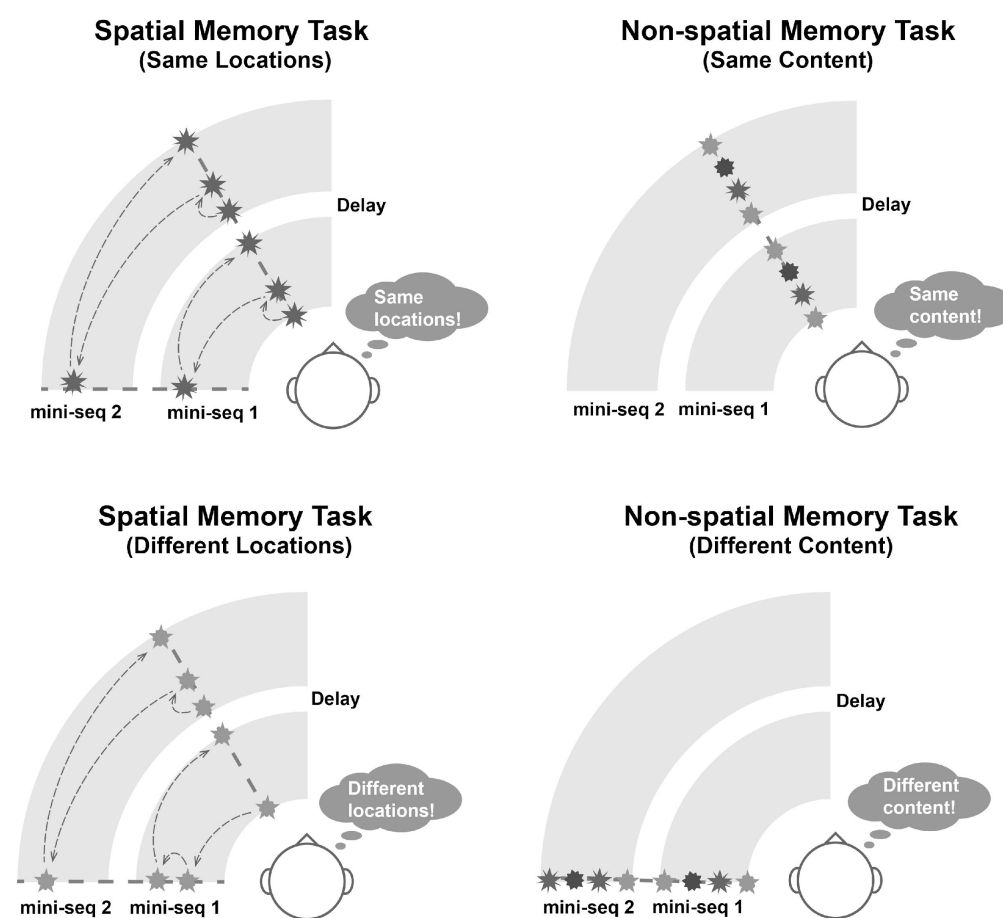
Task types:

- Spatial task (compare locations)
- Non-spatial task (compare content)
- Passive listening

Spatialization methods:

- Generic HRTF (30°, 90°)
- Broadband ILD (10dB, 20dB)
- Broadband ITD (400μs, 800μs)

fMRI data were acquired with 3T Siemens Prisma scanner, preprocessed with fMRIPrep; surface-based analysis was performed with FreeSurfer and NiLearn.

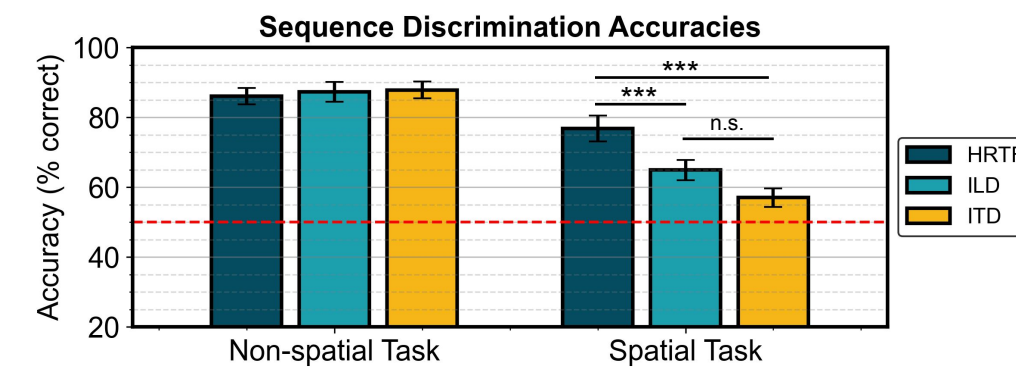


References

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WM Behavioral Results

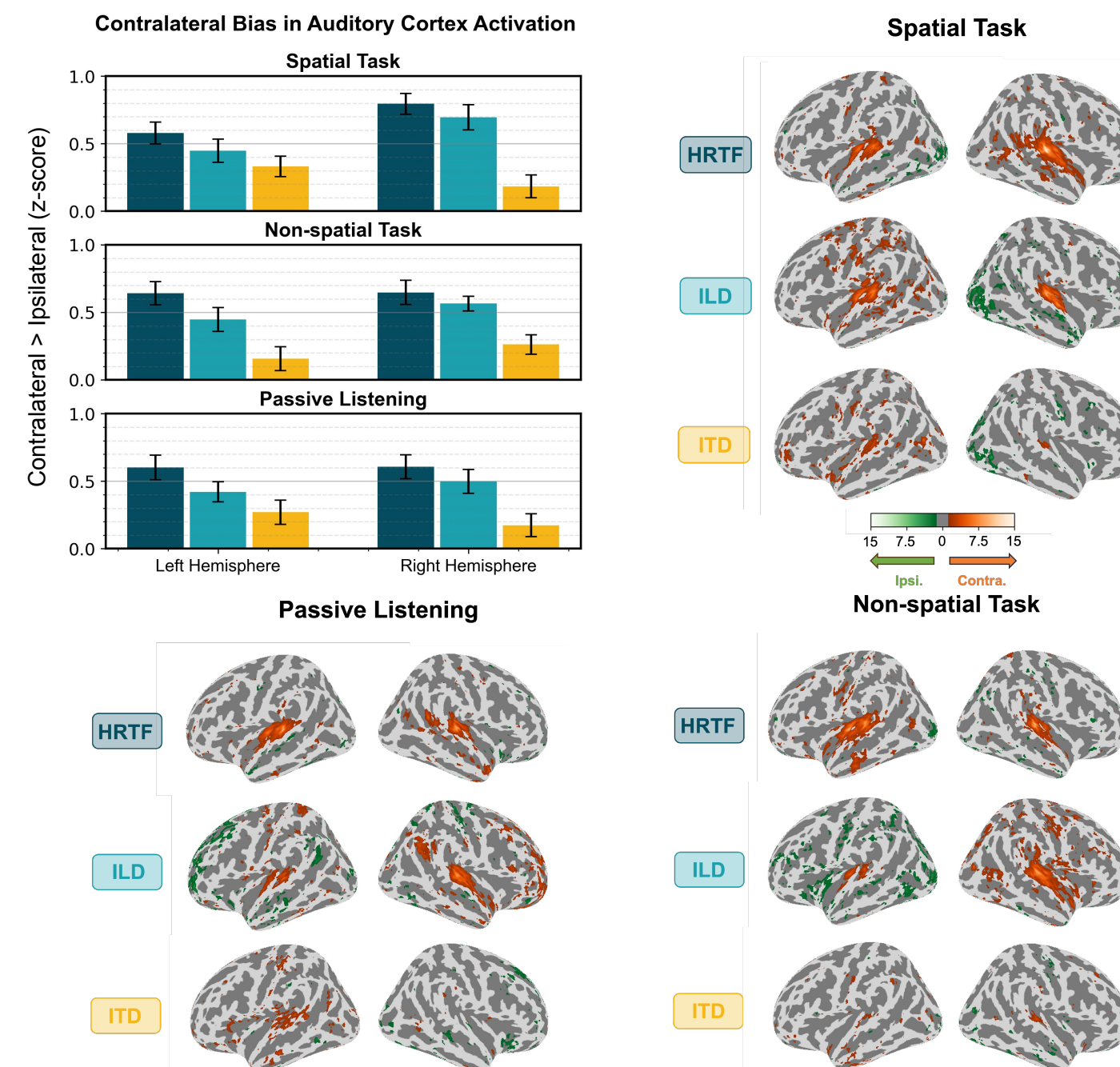
In non-spatial task, no differences across spatialization methods ($p > 0.9$ for all). In spatial task, performance best for HRTFs, worse for ILDs and ITDs.



Auditory Cortex fMRI Results

Contrast Contralateral vs. Ipsilateral Stimuli

Spatial selectivity in ACx greatest for HRTFs, mid for ILDs, least for ITDs ($p < 0.001$ for all).

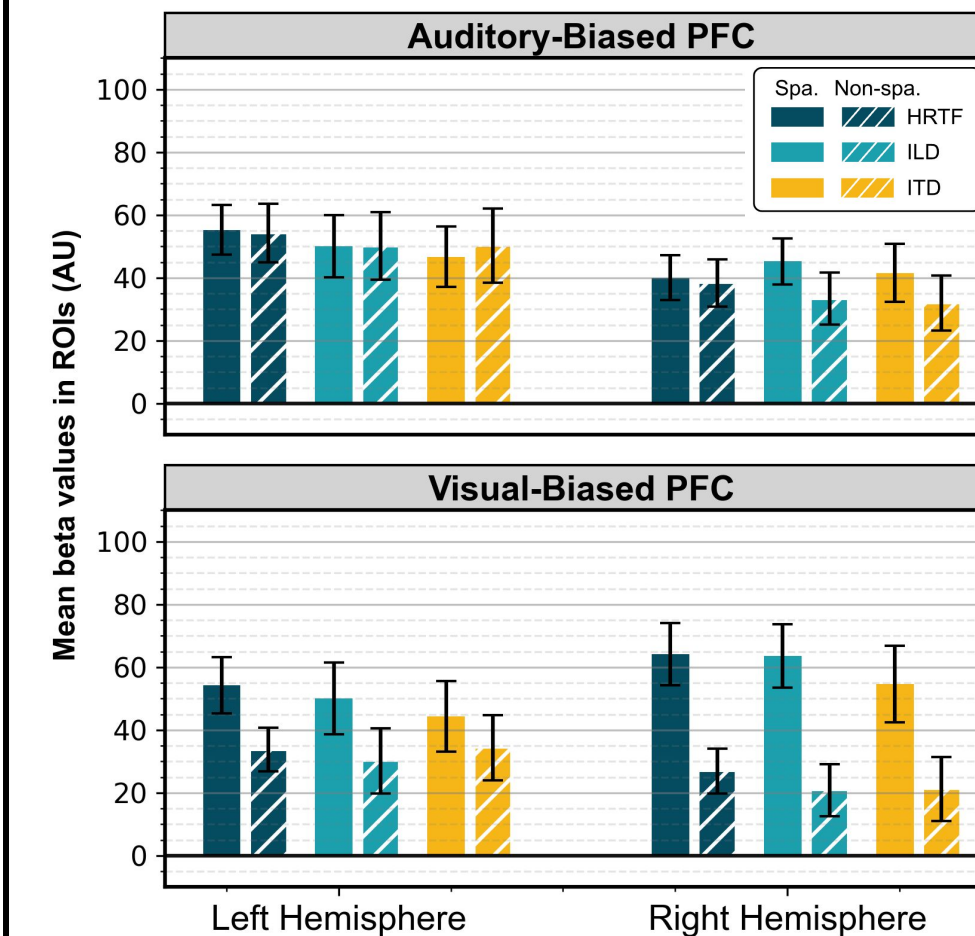


Results

PFC fMRI Results

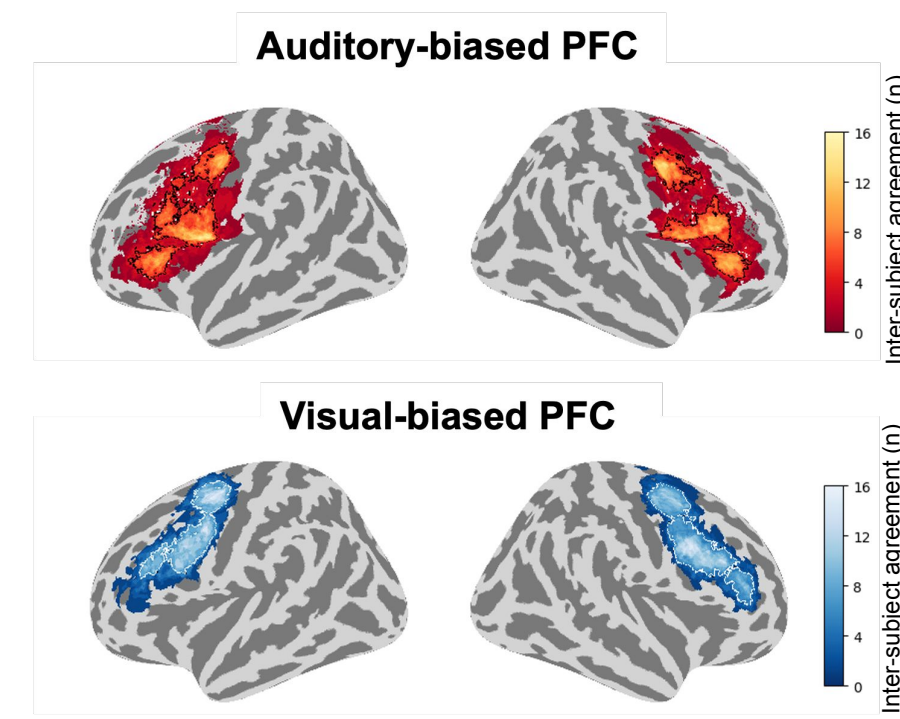
Spatial vs. Non-spatial Tasks

Auditory-biased PFC regions similarly engaged in spatial and nonspatial tasks ($p = 0.54$, uncorrected); visual-biased PFC regions more strongly engaged in spatial tasks ($p = 0.002$, Bonferroni-corrected for 2 ROIs).



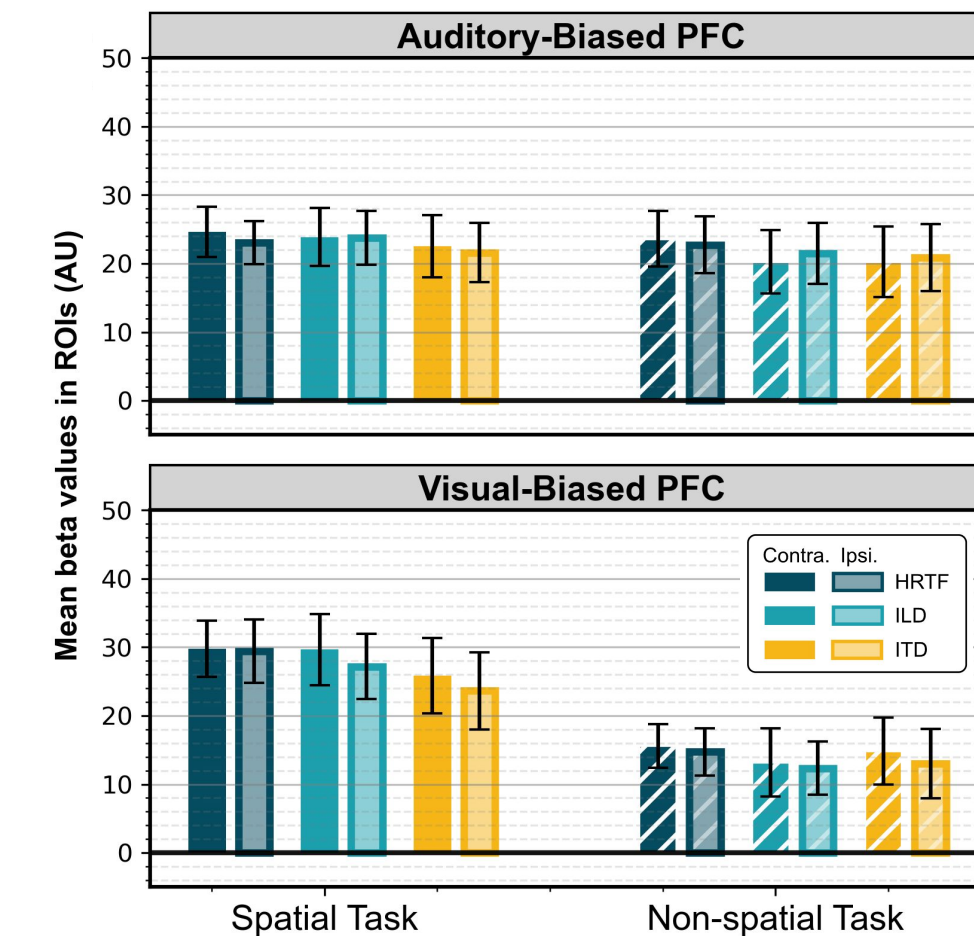
Auditory- and visual-biased regions

Contrast of auditory vs. visual WM; ROI labels drawn in individual subjects from an independent dataset.

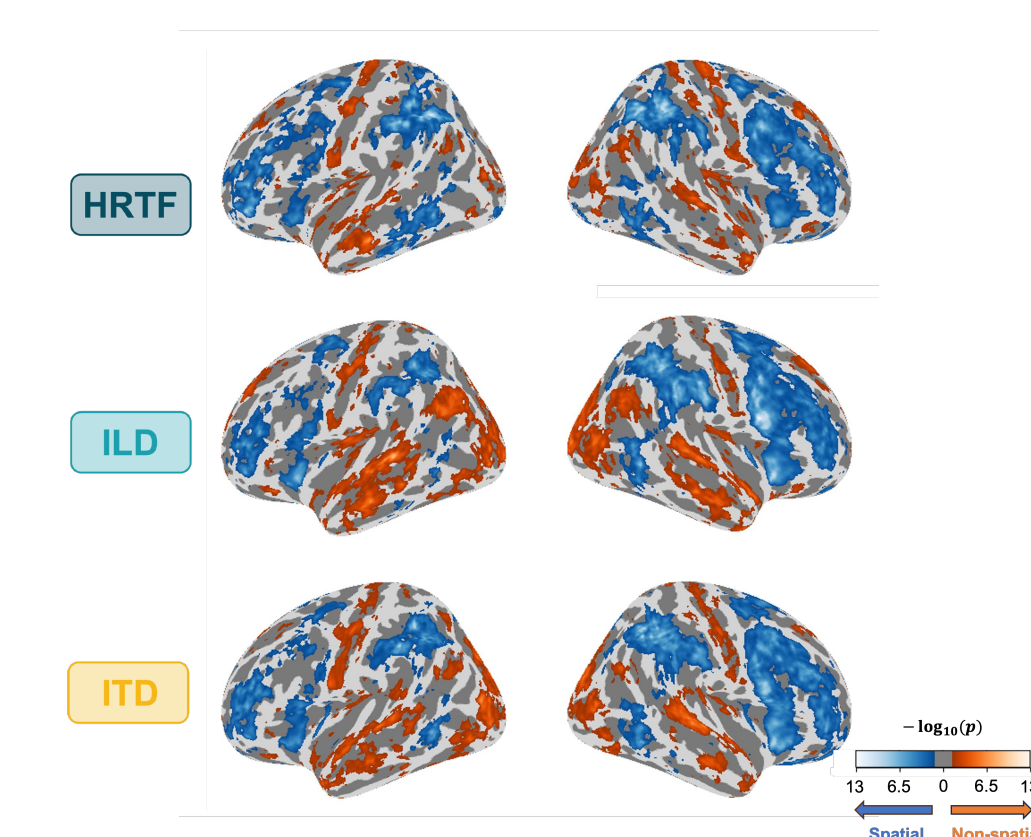


Attend Contralateral vs. Ipsilateral

During spatial tasks, neither auditory nor visual PFC regions show stronger engagement for contralateral compared to ipsilateral sources (aud: $p = 0.76$, vis: $p = 0.12$, uncorrected).



Spatial vs. Non-spatial task activation



Summary

- Performance on non-spatial WM does not depend on spatialization method.
- In spatial WM, performance varies with spatialization method, decreasing from most natural cues (HRTFs) to level differences alone (ILDs) to temporal differences alone (ITDs).
- Spatial selectivity (contralateral bias) in auditory cortex during both active tasks and passive listening is strongest for HRTFs, intermediate for ILDs, and weakest for ITDs.
- Visual-biased regions (but not auditory biased regions) in prefrontal cortex show greater activation during auditory spatial tasks than non-spatial tasks.
- Prefrontal cortex activation does not vary with spatialization method and shows no spatial selectivity (contralateral bias) during auditory spatial tasks.