



# Auditory spatialization approaches differentially recruit sensory-biased prefrontal cortex

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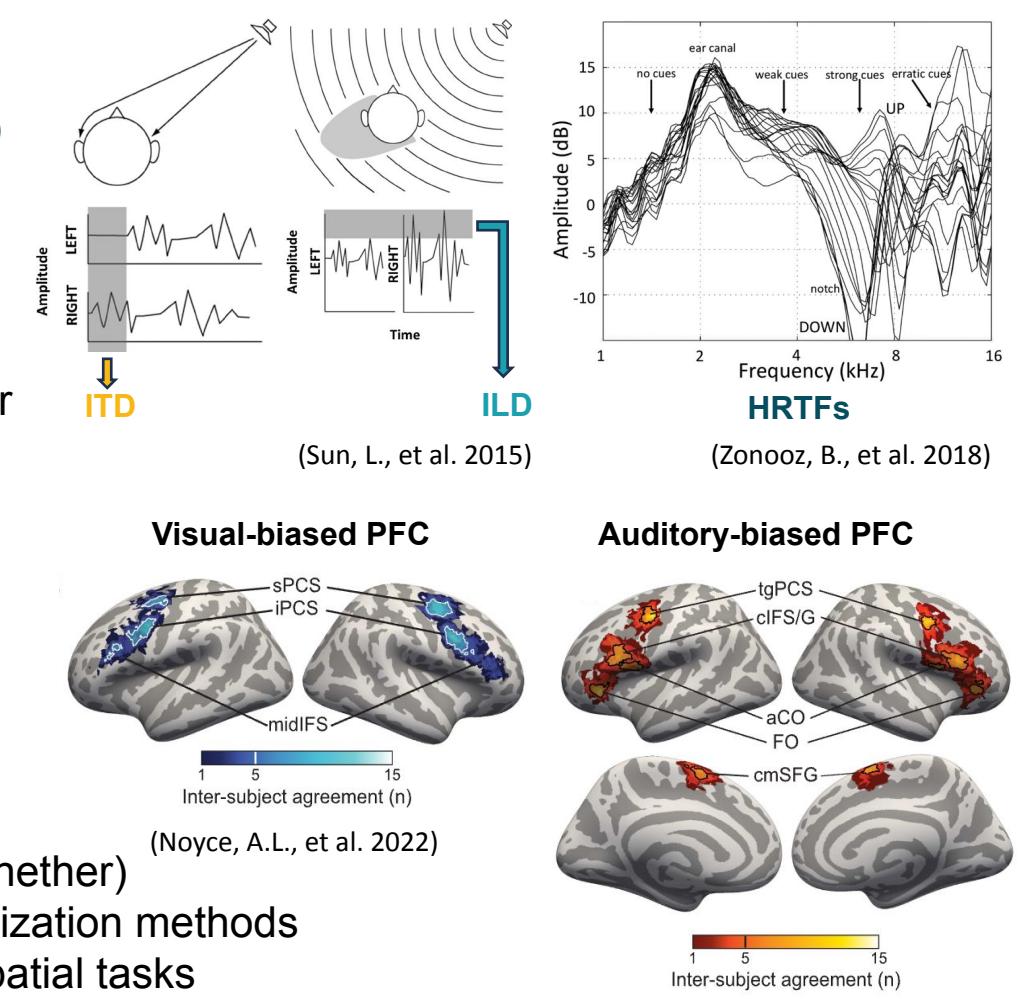
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## Background

- 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.

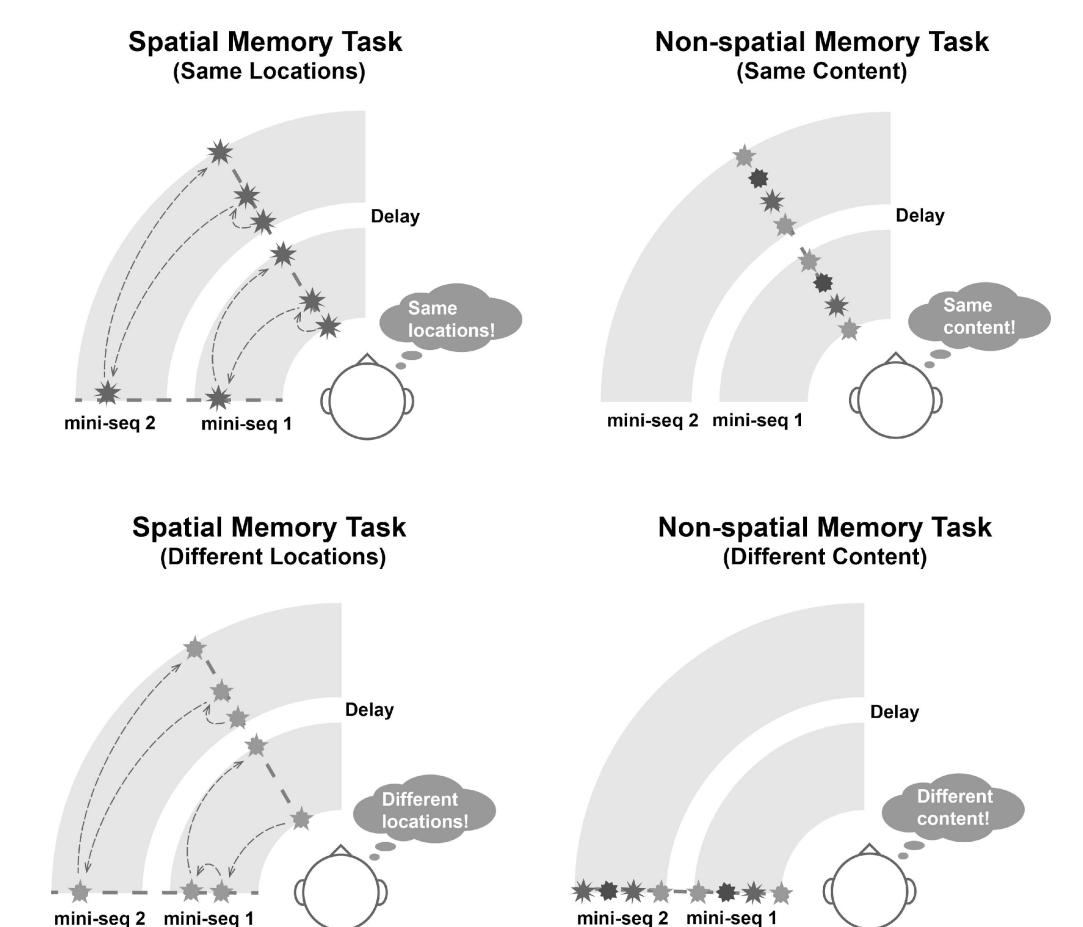
### Task types:

- 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.



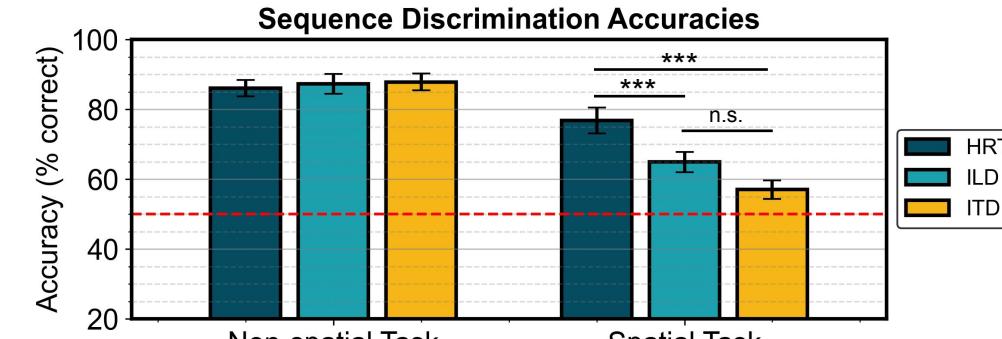
## References

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2. Lee, Chen-Chung, and John C. Middlebrooks. "Auditory cortex spatial sensitivity sharpens during task performance." *Nature neuroscience* 14.1 (2011): 108-114.
3. van der Heijden, Kiki, et al. "Active sound localization sharpens spatial tuning in human primary auditory cortex." *Journal of Neuroscience* 38.40 (2018): 8574-8587.
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5. Sun, Liang, Xuan Zhong, and William Yost. "Dynamic binaural sound source localization with interaural time difference cues: Artificial listeners." *Journal of the Acoustical Society of America* 137.4\_Supplement (2015): 2226-2226.
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## Results

### WM Behavioral Results

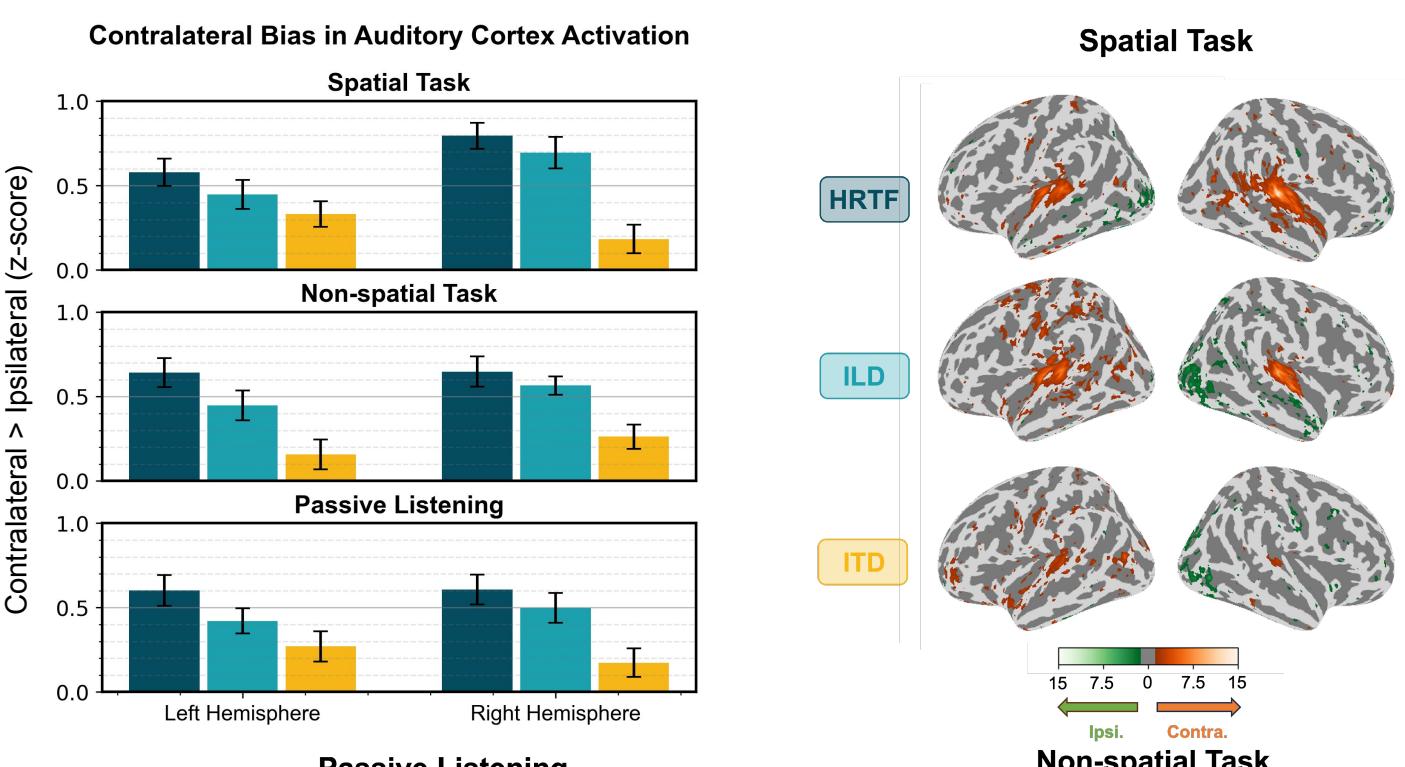
In non-spatial task, no differences across spatialization methods ( $p>0.9$  for all). In spatial task, performance best for **HRTFs**, worse for **ILDs** and **ITDs**.



### Auditory Cortex fMRI Results

#### Contrast Contralateral vs. Ipsilateral Stimuli

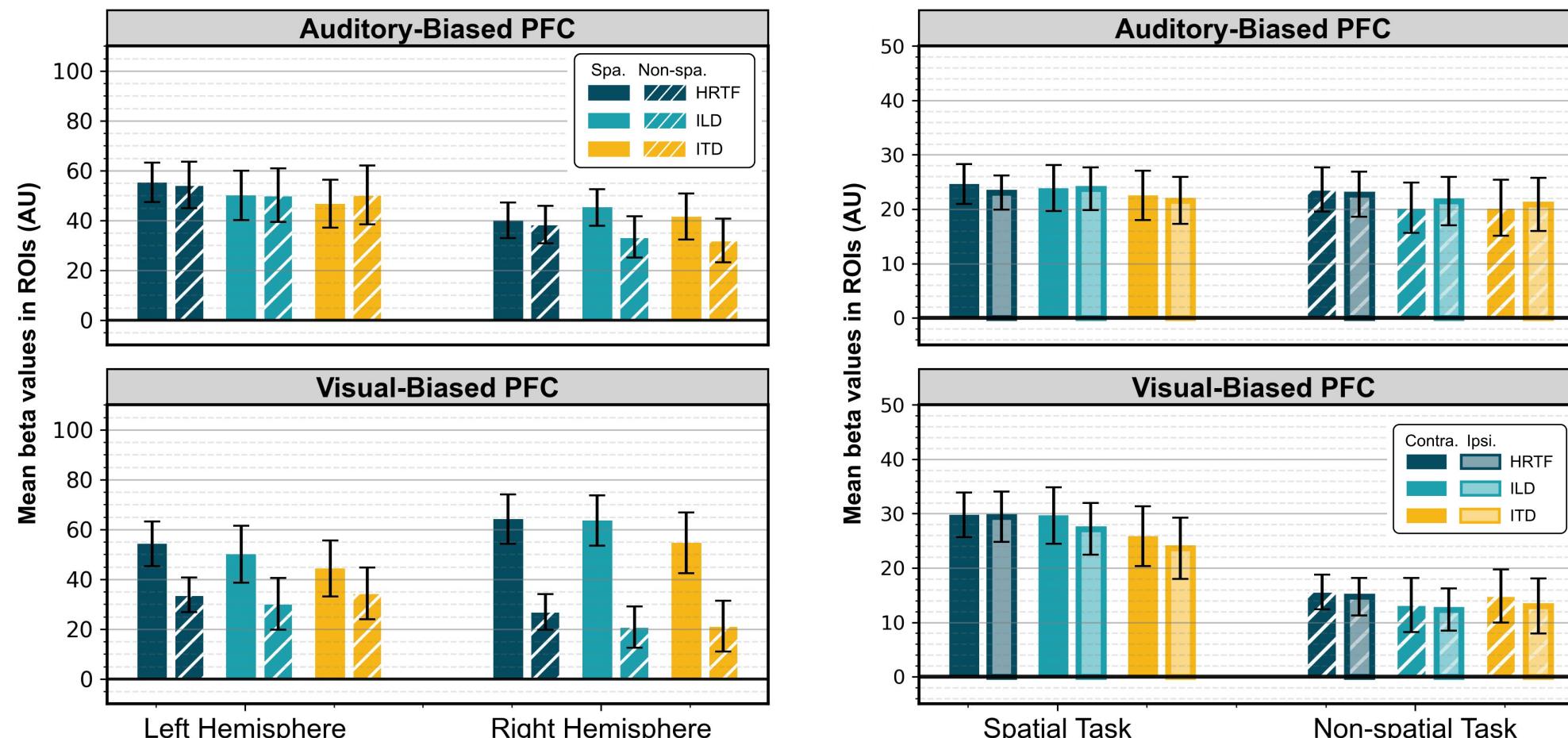
Spatial selectivity in ACx greatest for **HRTFs**, mid for **ILDs**, least for **ITDs** ( $p<0.001$  for all).



### PFC fMRI Results

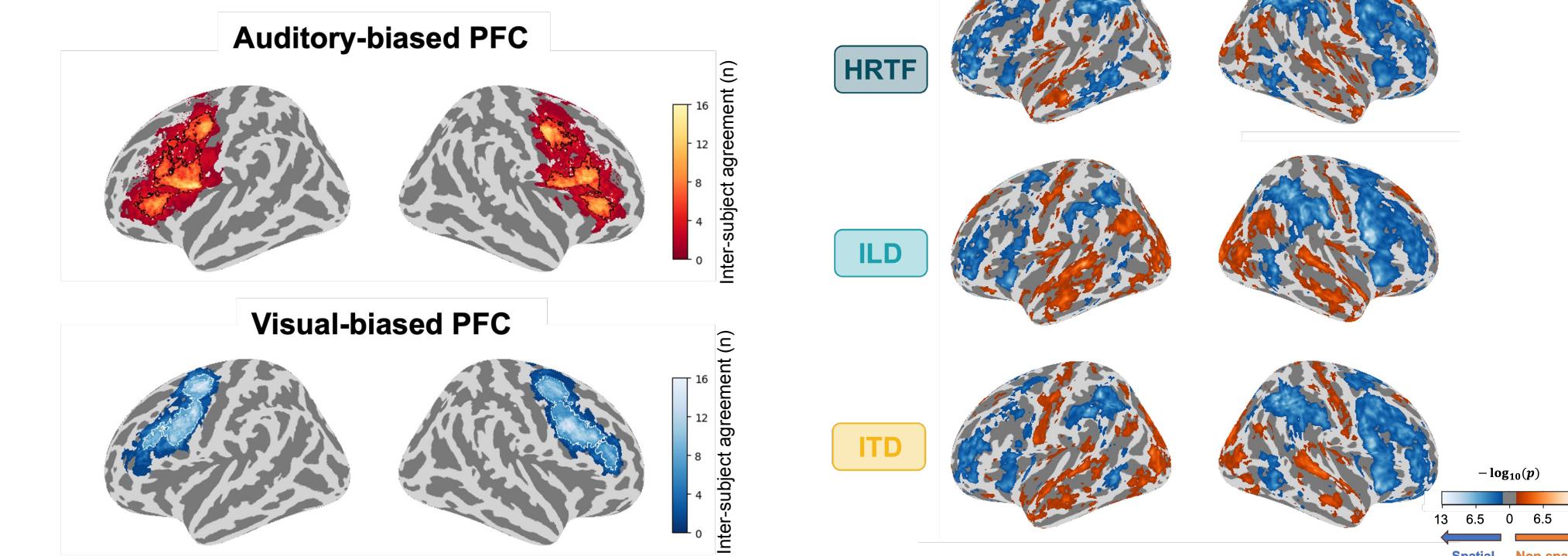
#### Spatial vs. Non-spatial Tasks

Auditory-biased PFC regions similarly engaged in spatial and non-spatial 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.

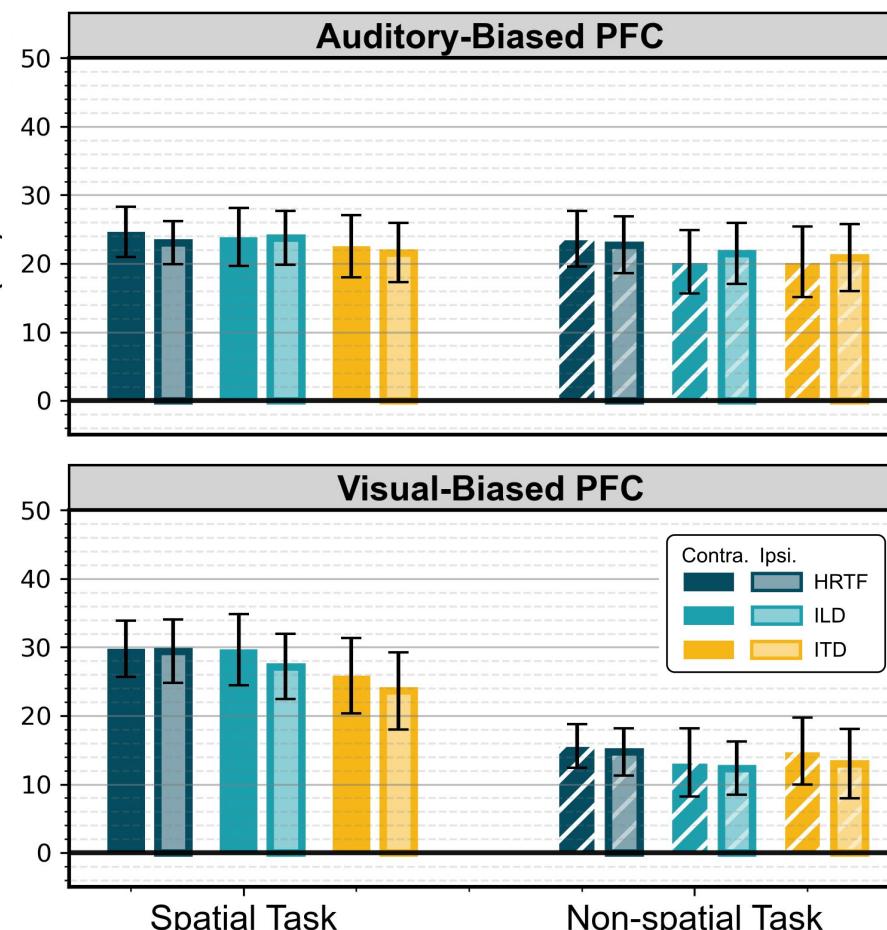


## Summary

- 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.

#### 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

