

FROM INNATE BIAS TO LEARNED CUES: THE ROLE OF SPATIAL LOCALIZABILITY AND PERCEPTUAL LEARNING IN THE AUDITORY LOOMING BIAS

Tobias Greif^{1,2}, Karolina Ignatiadis¹, Diane Baier¹, Roberto Barumerli¹, Brigitta Tóth³, Robert Baumgartner^{1,*}

¹Acoustics Research Institute, Austrian Academy of Sciences, Vienna, Austria, ²Institute of Computer Science, Faculty of Science, P. J. Safarik University, Kosice, Slovakia, ³Institute of Cognitive Neuroscience and Psychology, Hungarian Academy of Sciences, Budapest, Hungary, * robert.baumgartner@oeaw.ac.at

BACKGROUND

Auditory looming bias

- Prioritized processing of approaching (“looming”) sounds. ⁽¹⁻²⁾
- Elicited in human adults also during passive inattentive listening. ⁽³⁾
- Supports automatic hazard detection in dynamic environments. ⁽⁴⁾

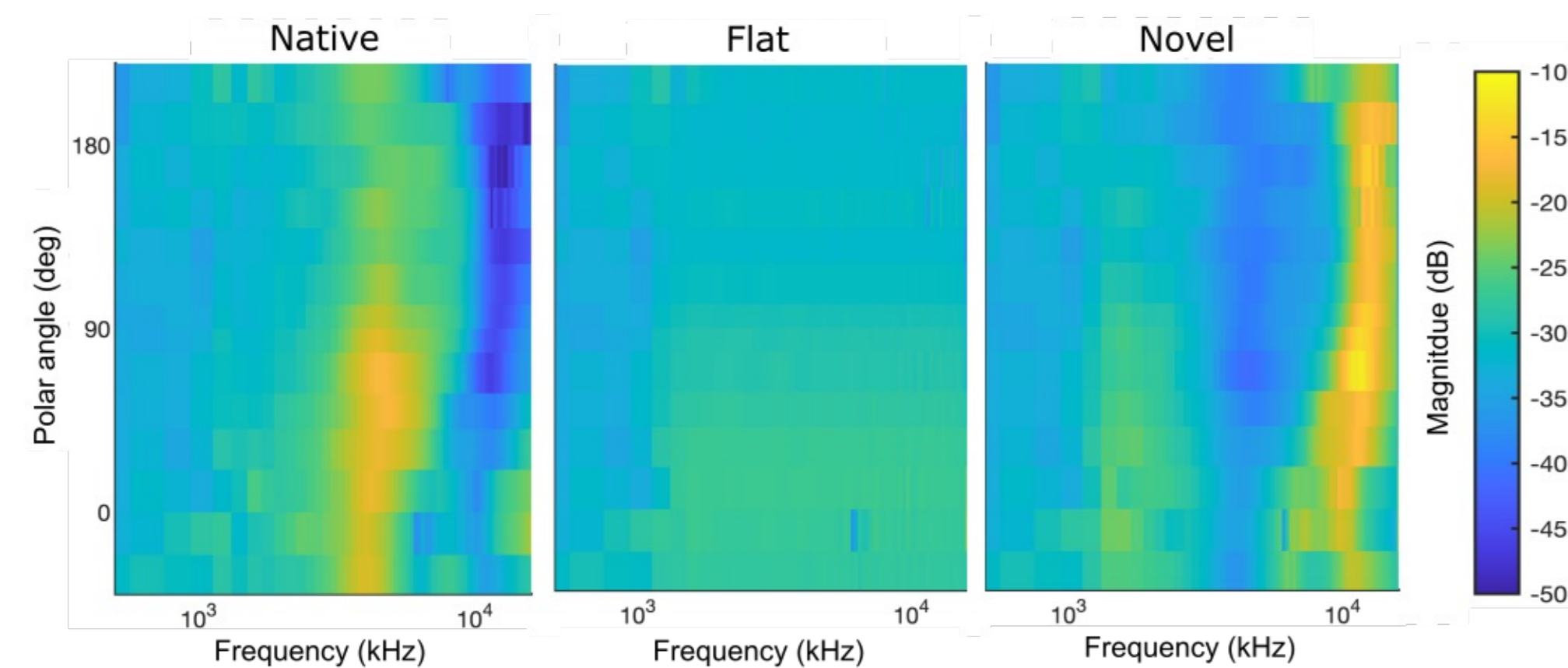
Cue-specific presence in newborns ⁽³⁾

- Intensity cues elicit bias even in sleeping newborns.
- Spectral cues (i.e. acoustic filtering in the spectral domain, mainly induced by the outer ear) elicit bias only in adults.

METHODOLOGY

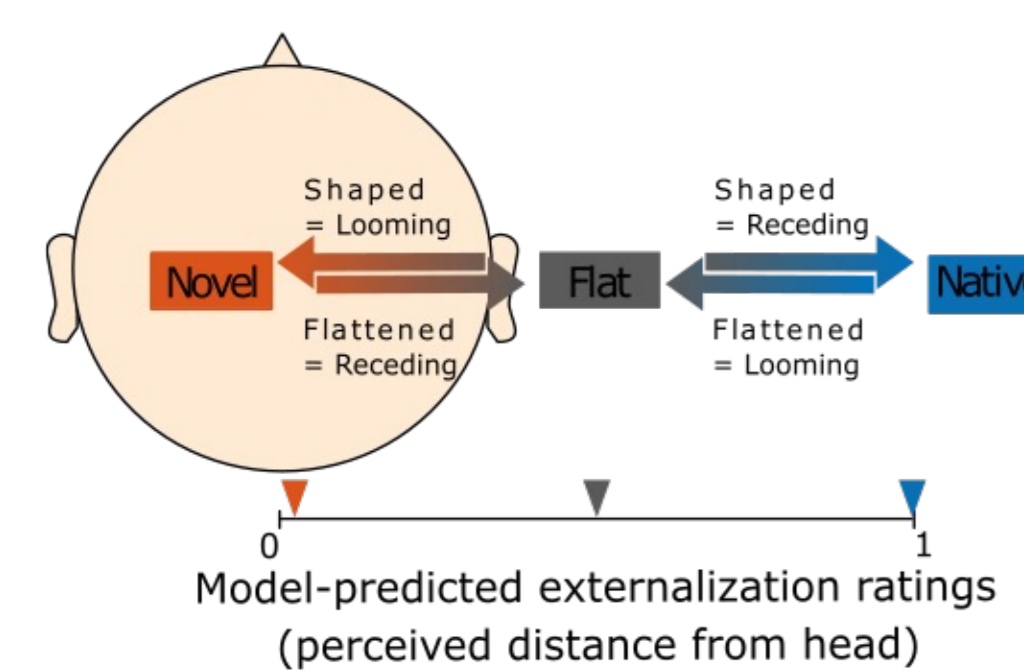
Spectral cue manipulation

- Native: listener-specific HRTFs (DTFs for Exp. 2)
- Flat: flat magnitude spectrum, phase and broadband ILD maintained
- Novel: inverted magnitude spectrum, loudness matched

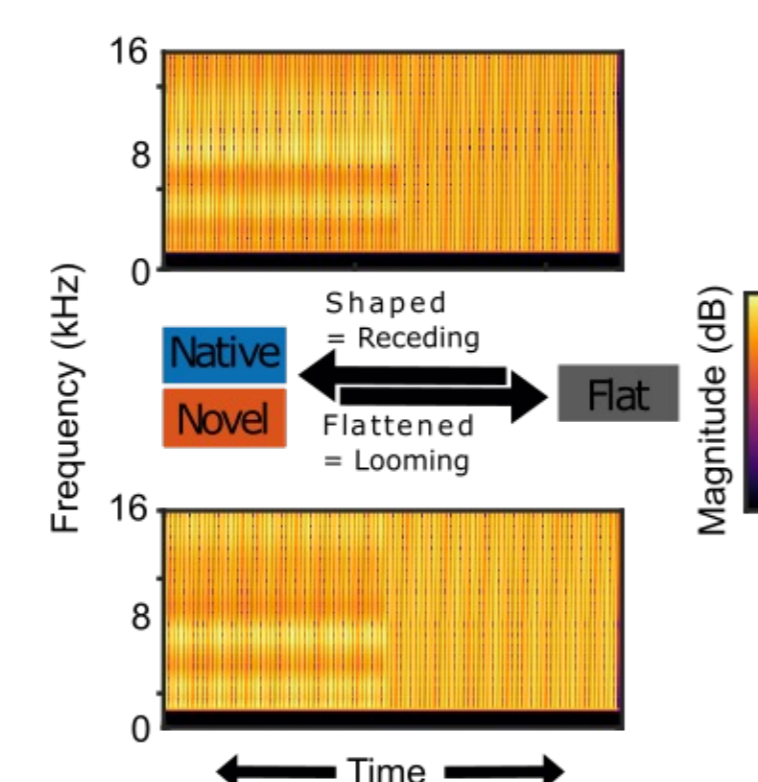


ALTERNATIVE HYPOTHESES

Bias linked to spatial percept ⁽⁵⁾



Bias reflects low-level stimulus characteristics



REFERENCES

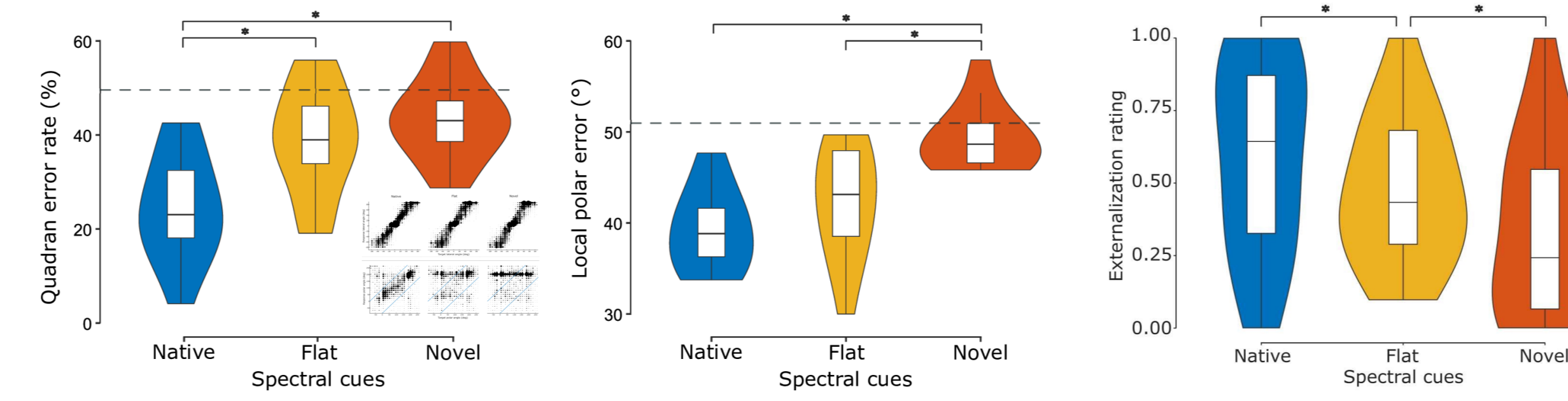
1. Neuhoff, J. G. (1998). Perceptual bias for rising tones. *Nature*, 395(6698), 123–124. <https://doi.org/10.1038/25862>
2. Baumgartner, R., Reed, D. K., Tóth, B., Best, V., Majdak, P., Colburn, H. S., & Shinn-Cunningham, B. (2017). Asymmetries in behavioral and neural responses to spectral cues demonstrate the generality of auditory looming bias. *PNAS*. <https://doi.org/10.1073/pnas.1703247114>
3. Ignatiadis, K., Baier, D., Barumerli, R., Sziller, I., Tóth, B., & Baumgartner, R. (2024). Cortical signatures of auditory looming bias show cue-specific adaptation between newborns and young adults. *Communications Psychology*. <https://doi.org/10.1038/s44271-024-00105-5>
4. Ignatiadis, K., Barumerli, R., Deco, G., Tóth, B., & Baumgartner, R. (2025). Threat-related corticocortical connectivity elicited by rapid auditory looms. *Scientific Reports*. <https://doi.org/10.1038/s41598-025-30552-x>
5. Baumgartner, R., & Majdak, P. (2021). Decision making in auditory externalization perception: Model predictions for static conditions. *Acta Acustica*. <https://doi.org/10.1051/aacus/2021053>
6. Greif, T., Barumerli, R., Ignatiadis, K., Tóth, B., & Baumgartner, R. (2025). The role of spatial perception in auditory looming bias: Neurobehavioral evidence from impossible ears. *Frontiers in Neuroscience*. <https://doi.org/10.3389/fnins.2025.1645936>
7. Greif, T., Ignatiadis, K., Baier, D., Tóth, B., & Baumgartner, R. (2024). From Sound Localization to Hazard Detection: Adaptation to Novel Spectral Cues. *OSF*. <https://doi.org/10.17605/OSF.IO/2Q3MP>

EXPERIMENT 1: ACUTE EFFECTS

Does looming bias depend on localizability? ⁽⁶⁾

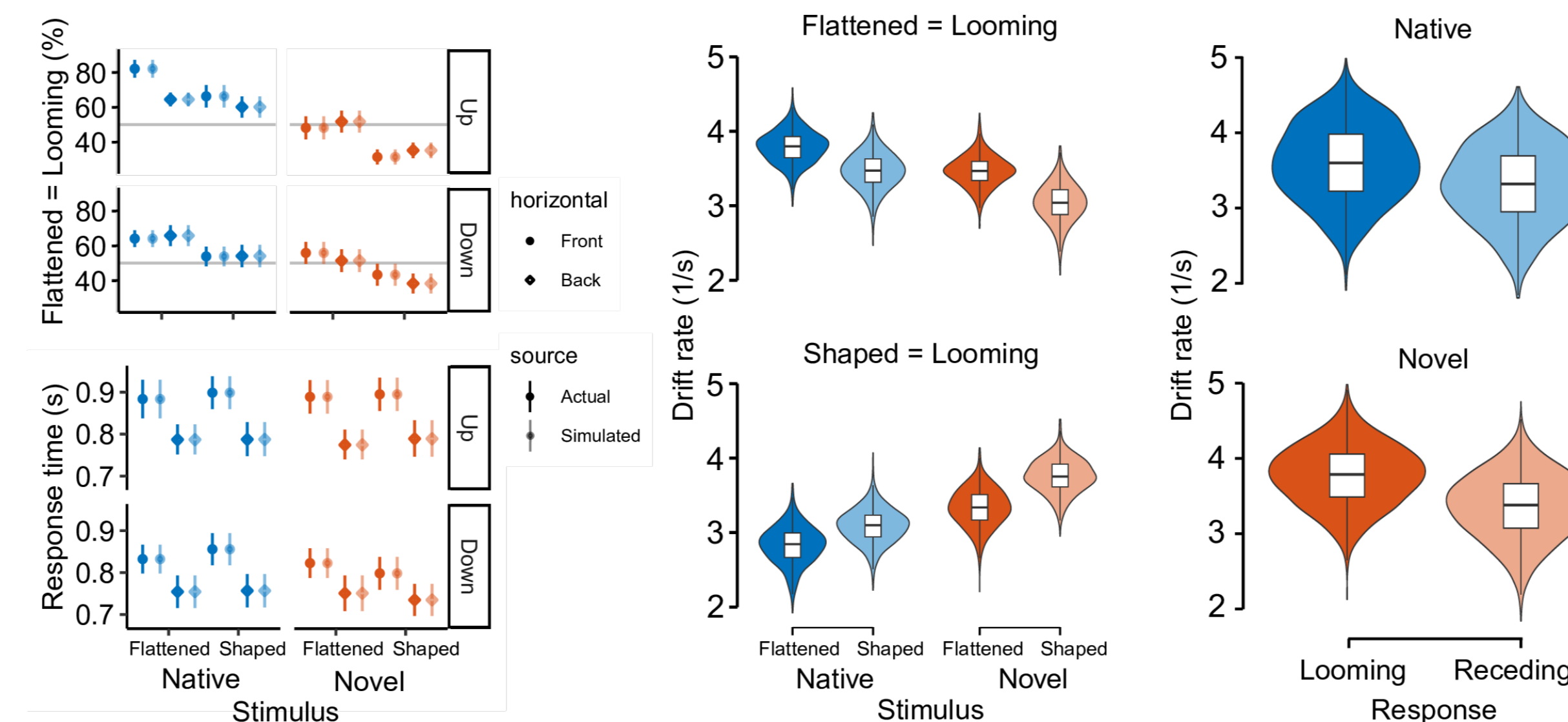
Directional localization and externalization ratings (N = 14)

- Novel spectral cues degrade directional localization performance and perceptual externalization using headphones

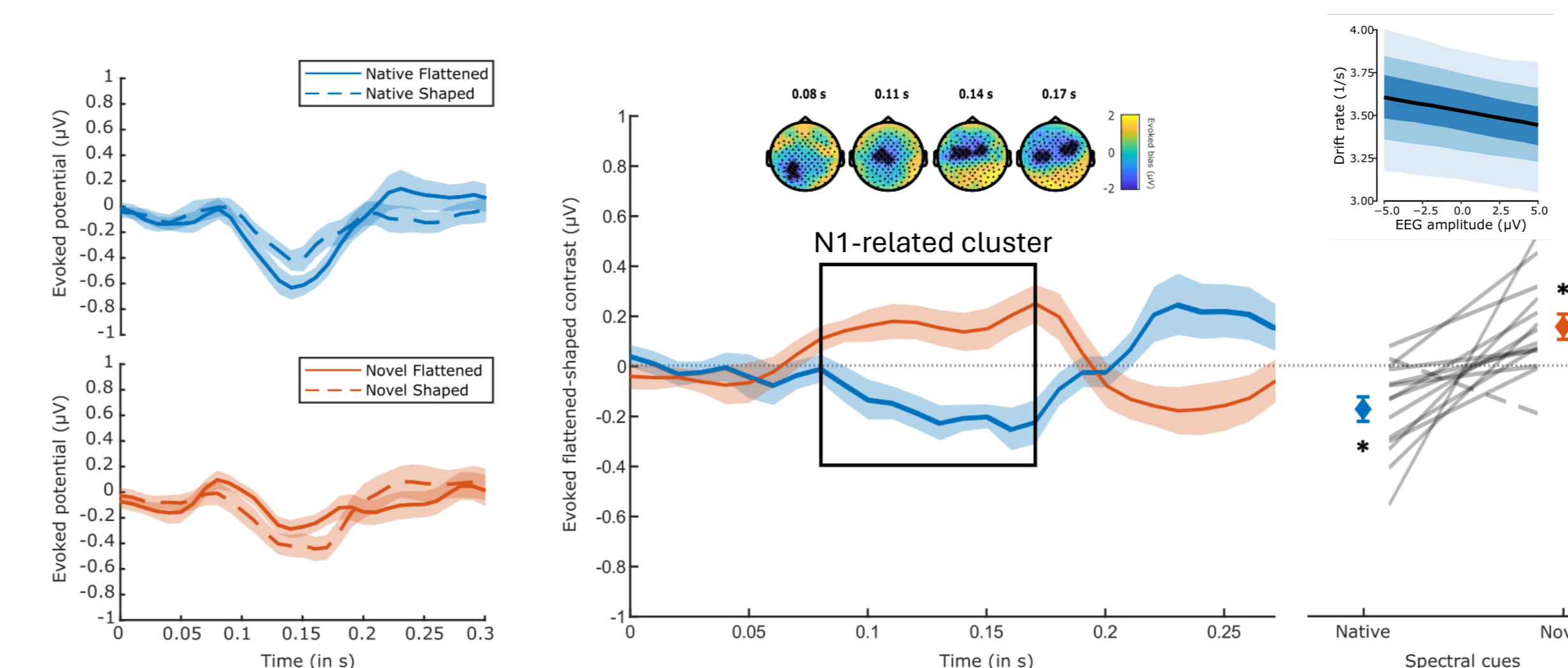


Looming/receding discrimination (N = 14)

- Linear ballistic accumulator model fits show increased speed of evidence accumulation for looming responses



- Larger early negativity for native flattened and novel shaped sounds, consistent with externalization and associated with larger drift rates



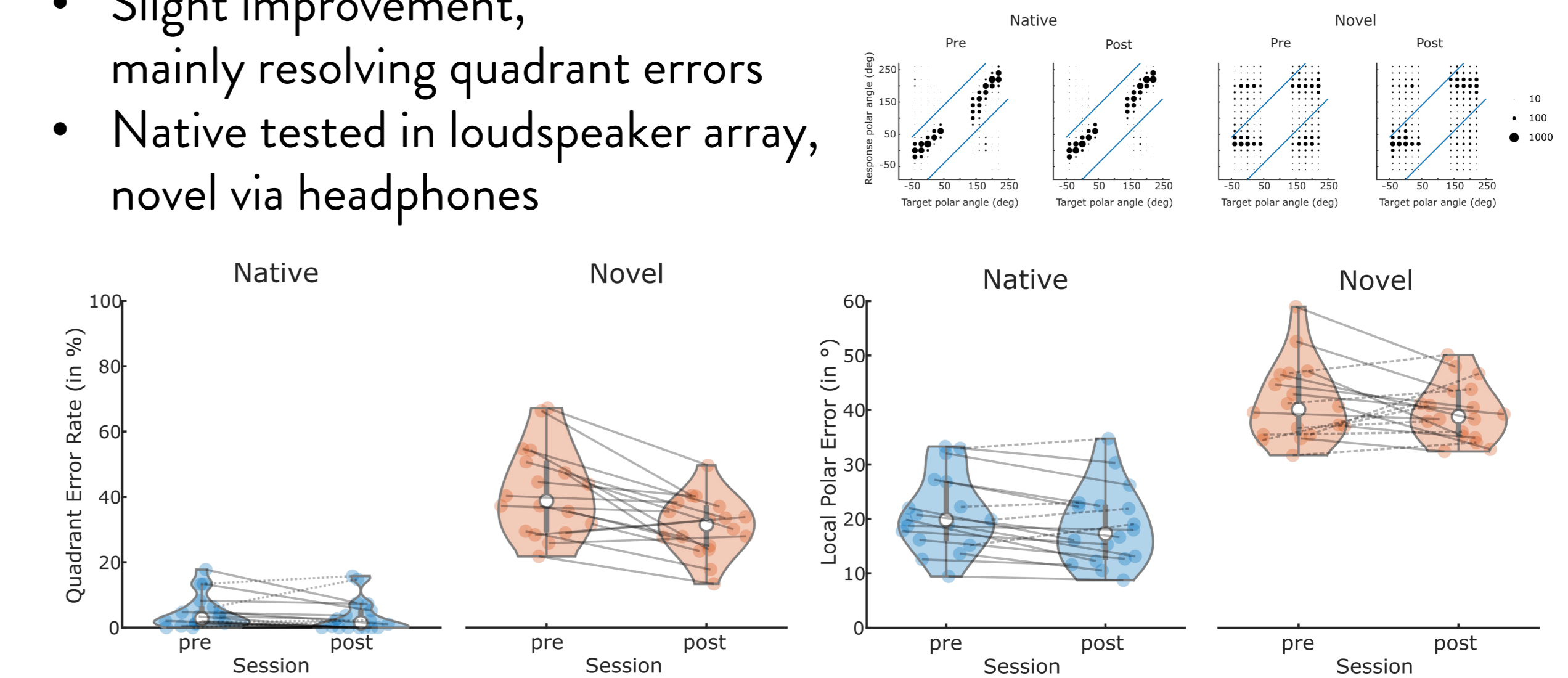
Early sensory cortical boost and speed-up of evidence accumulation align with conscious spatial percept and localizability of sound sources.

EXPERIMENT 2: TRAINING EFFECTS

Does localization training transfer to looming bias? ⁽⁷⁾

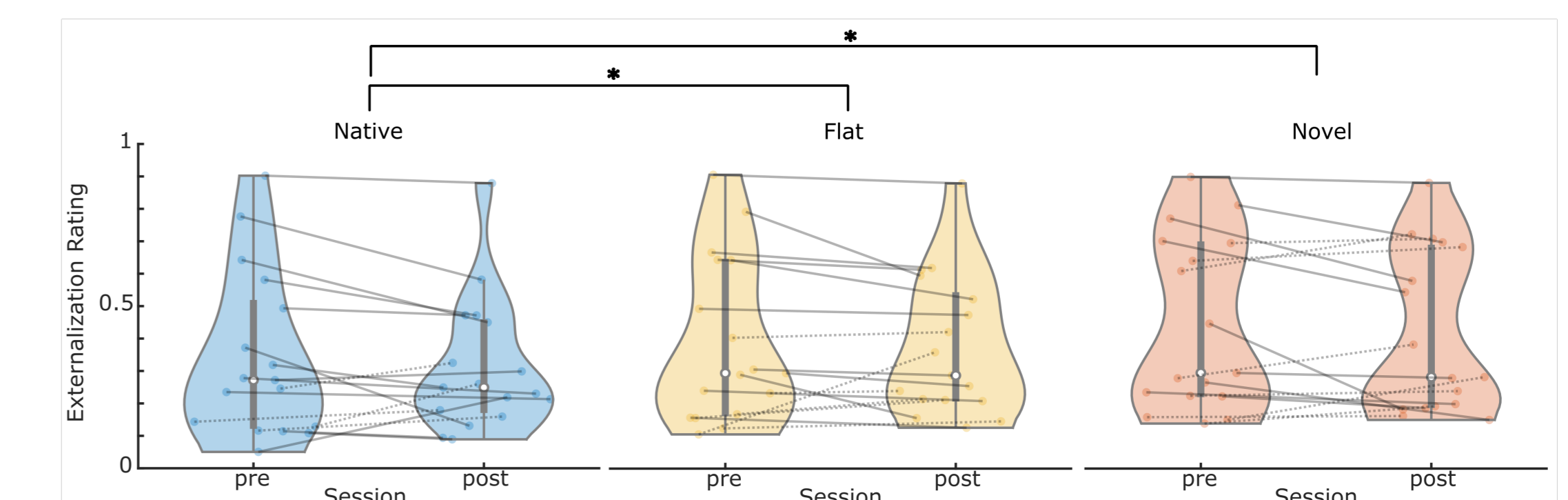
Directional localization training (N = 18)

- Trained 4 days, 90 min each, visual and sensorimotor feedback
- Slight improvement, mainly resolving quadrant errors
- Native tested in loudspeaker array, novel via headphones



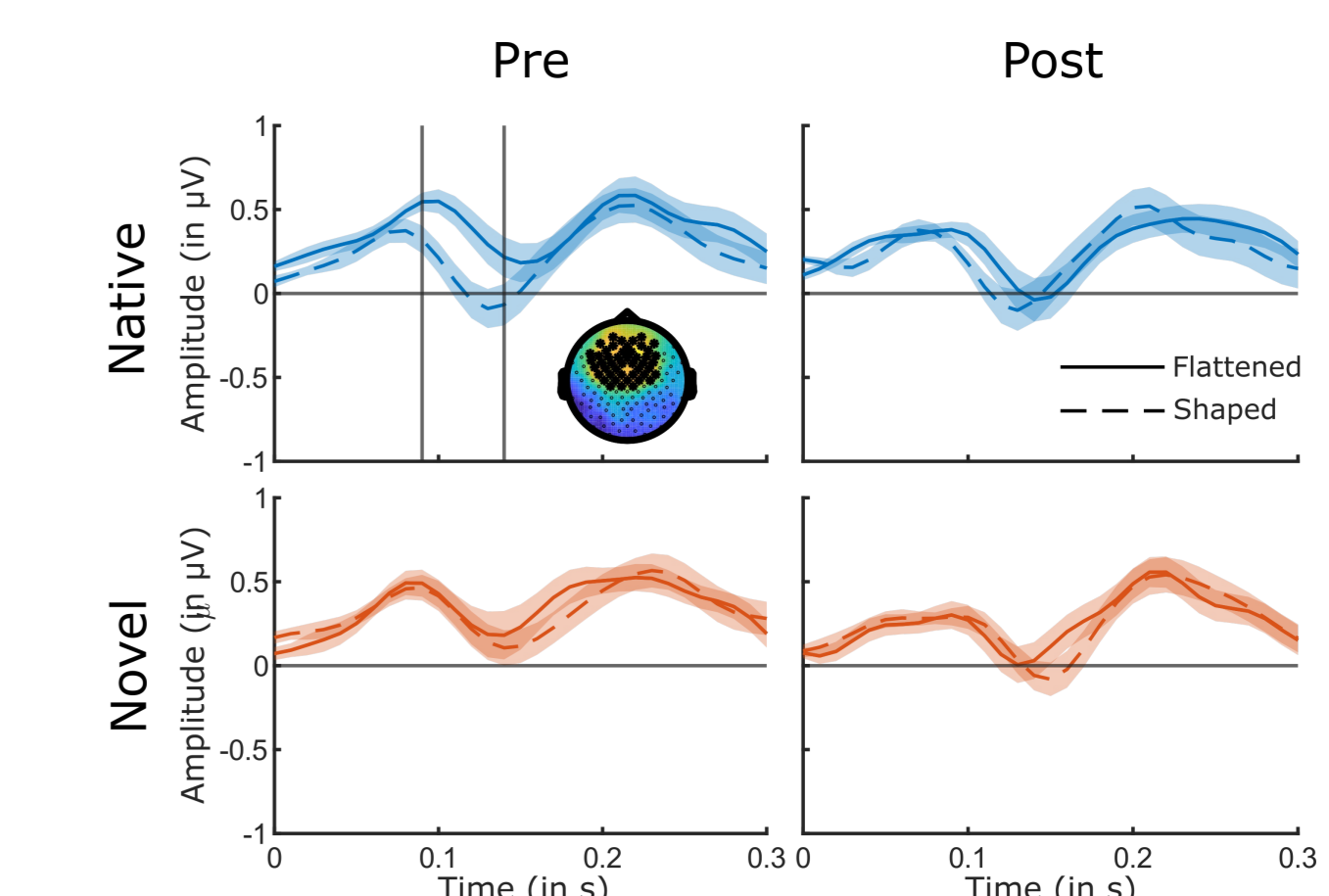
Externalization ratings (N = 17)

- Surprisingly low externalization ratings for DTF-rendered sounds, inverted pattern compared to Exp. 1
- No sig. effect of directional localization training



Inattentive looming paradigm (N = 15)

- Listening while watching silent movie with subtitles
- Smaller early negativity for native flattened sounds during pre-test, consistent with externalization
- No sig. clusters for any other conditions



Looming bias seems to operate as a deeply rooted, early-warning mechanism that does not easily adapt through conscious learning.