SAV – Spatial Audio Virtualization and Gamification for Hearing Assessment and Enhancement

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Investigation of Neural Representations of Auditory Distance Percepts and Cues using MVPA

Vasileios Menikos[1,3], Eleni Vlahou[1], Keerthi Kumar Doreswamy[2], Jyrki Ahveninen[3], Norbert Kopčo[2, 3]

[1] University of Thessaly
[2] P. J. Šafárik University
[3] Athinoula A. Martinos Center for Biomedical Imaging

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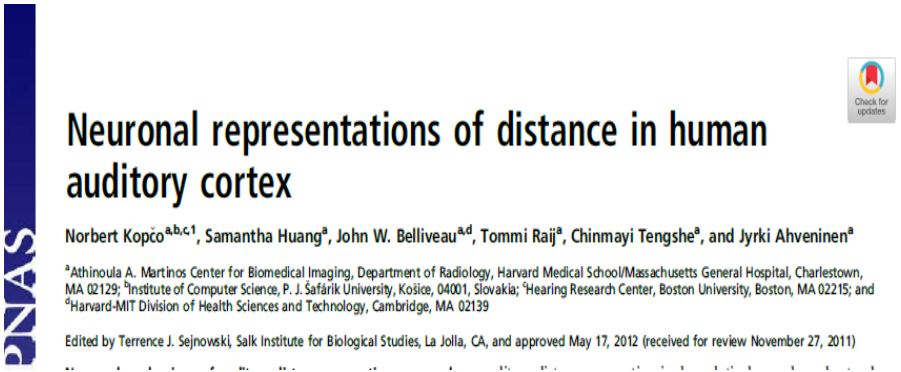
Original Study (Kopčo et al., 2012): Research Questions

Research questions

How does the brain represent the distance of a sound?

Which areas of the auditory cortex (AC) are involved?

How can we distinguish distance-related activity from changes in sound intensity?



PNAS

Neuronal representations of distance in human auditory cortex

Norbert Kopčo[a,b,c,1], Samantha Huang[a], John W. Belliveau[a,d], Tommi Raij[a], Chinmayi Tengshe[a], and Jyrki Ahveninen[a]

[a]Athinoula A. Martinos Center for Biomedical Imaging, Department of Radiology, Harvard Medical School/Massachusetts General Hospital, Charlestown, MA 02129; [b]Institute of Computer Science, P. J. Šafárik University, Košice, 04001, Slovakia; [c]Hearing Research Center, Boston University, Boston, MA 02215; and [d]Harvard-MIT Division of Health Sciences and Technology, Cambridge, MA 02139

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Kopčo et al 2012 experimental design

How we can tell distance apart from loudness?

DRR - Direct to Reverberant Ratio
ILD - Interaural Level Difference

Virtual sound at 15-100 cm to the listeners right side

A: Varying distance
B: Varying intensity
C: Constant sounds

Comparing A vs B: Look for brain responses associated with those cues

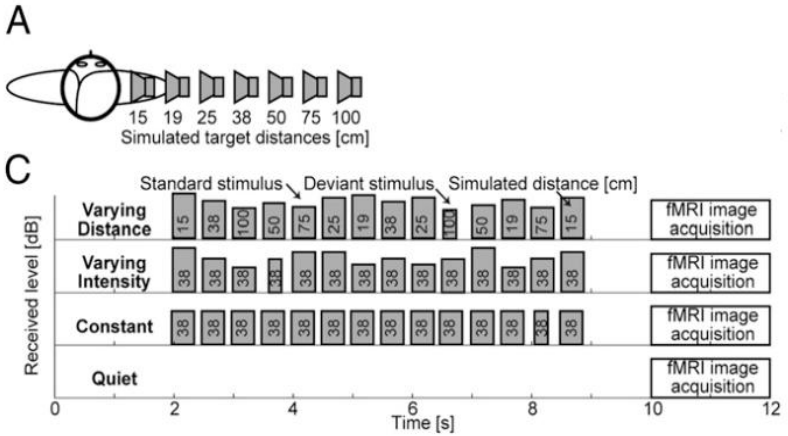


Figure 1(panels A and C). Kopčo et al. (2012)

Original Study (Kopčo et al., 2012): Experimental Conditions and Main Findings

Where in the brain they found this difference?

Sound stimulation activates Auditory Cortex.

Varying sounds produce stronger responses than constant sounds.

Sound varies -> Response increases in surrounding AC

Distance > intensity: Greater response in left Planum Temporale/posterior Superior Temporal Gyrus.

Important region to investigate

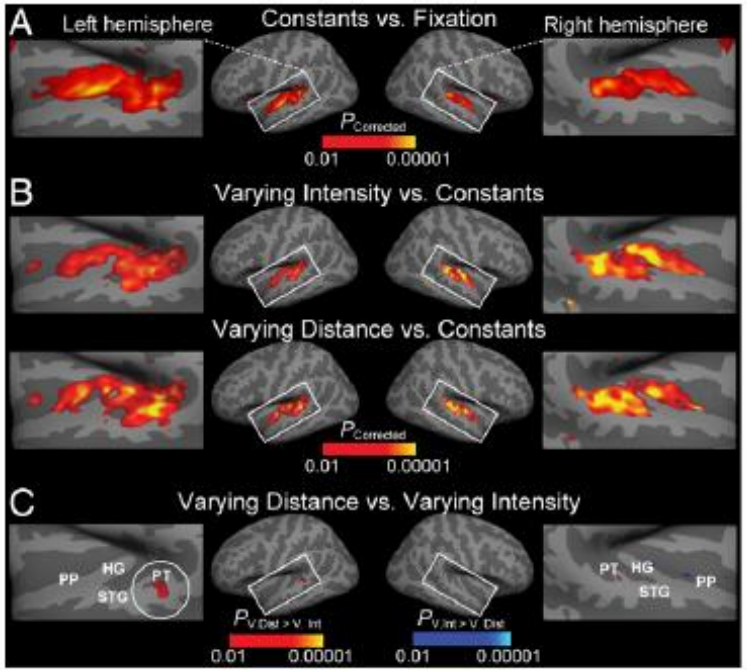


Figure 3. Kopčo et al. (2012)

Kopčo et al. (2020): Is ILD Necessary?

2012: Sounds simulated to the side; DRR and ILD both available.

2020: Sounds simulated in front; distance-varying ILD unavailable.

Distance-related responses were still found bilaterally in posterior auditory cortex.

This supports a role for reverberation related information in distance processing

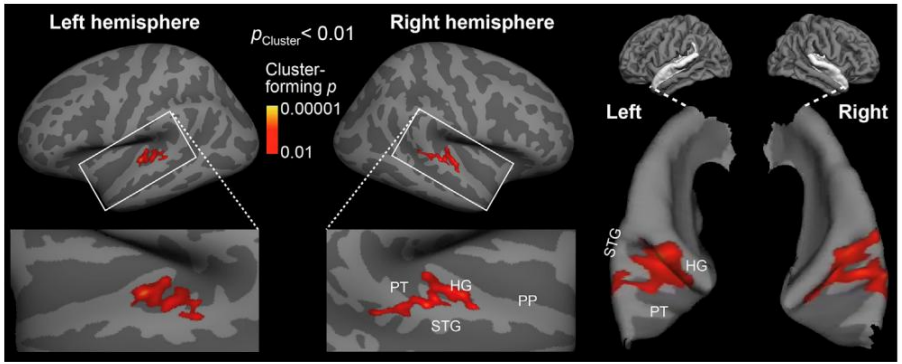


Figure 3. Kopčo et al. (2020).

Doreswamy et al. (2026) : Distance Cues vs. Distance Percepts

Are these AC areas responding to individual acoustic cues or to the perceived distance created by combining them?

Congruent cues: DRR and ILD indicate the same distance; Incongruent cues: they indicate different distances.

Univariate analysis: Revealed responses related to DRR in posterior auditory cortex, similar to 2020 findings.

MVPA: found differences in spatial activity patterns between congruent and incongruent conditions in the right PT/pSTG.

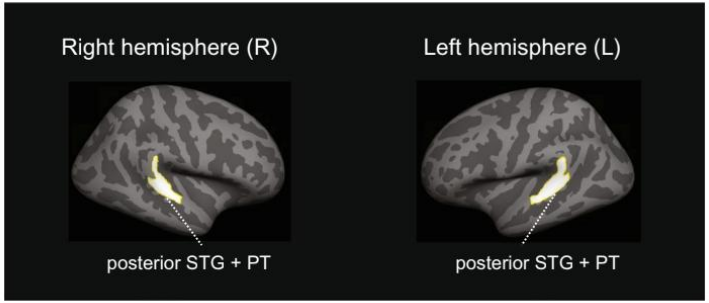
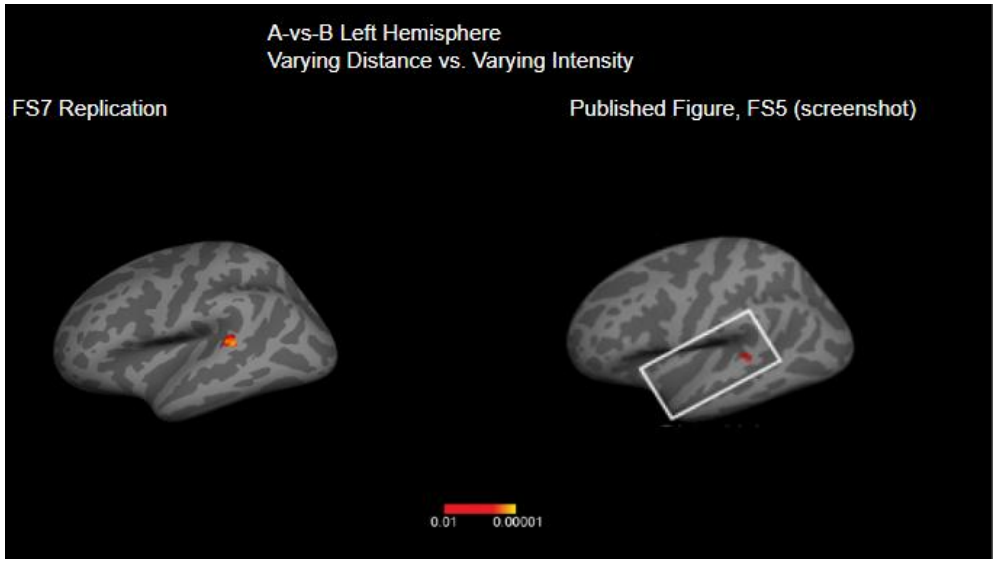


Figure 4 (panel A). Doreswamy et al. (2026).

Replication: Varying Distance vs. Varying Intensity

Measure	FS5	FS7
Peak statistic	2.67	2.64
Cluster size	202.6 mm²	200.9 mm²
Vertices	449	450



From Univariate Results to MVPA

Supplementary experiment (2012):

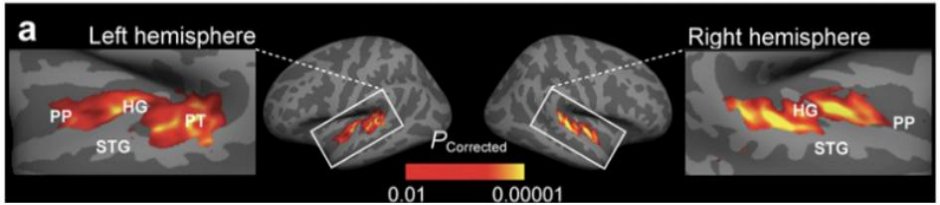


Figure S3A. Kopčo et al. (2012), Supplementary Information.

B (varying distance) vs C (constant sound).

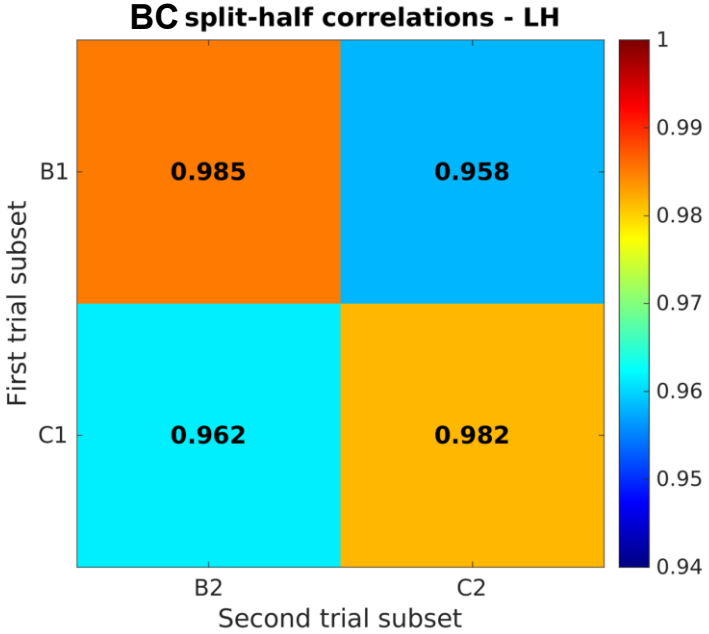
Sound level: Controlled at the nearer ear during B.

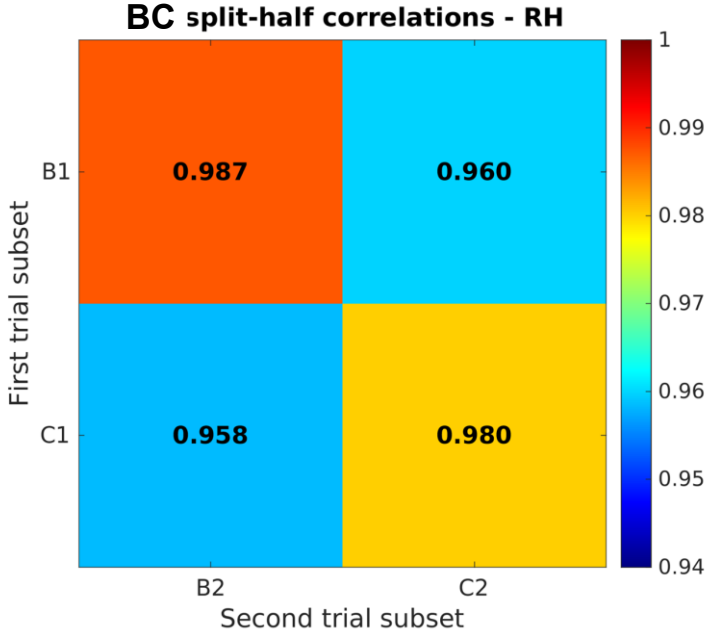
Univariate result: Widespread activation across auditory cortex, without clear localization.

Our MVPA: Look for differences in spatial activity patterns between B and C.

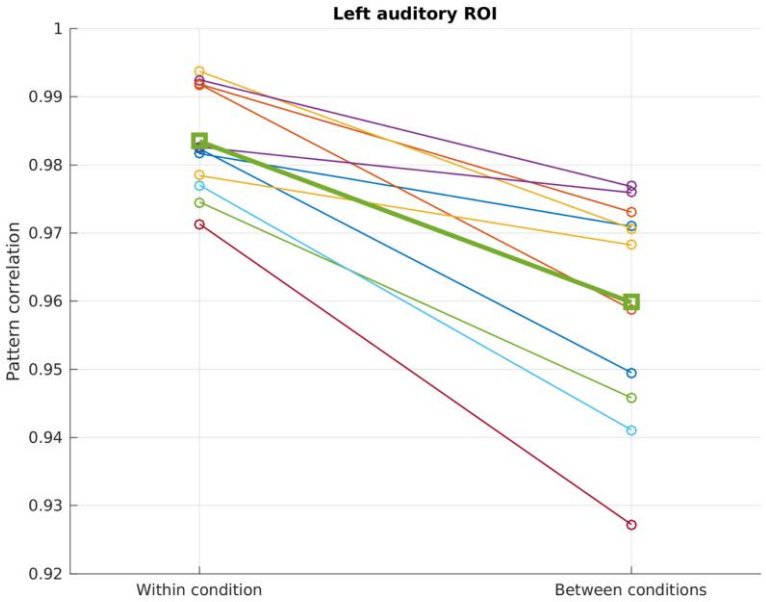
Preliminary B(distance) C(constant) MVPA: Pattern Similarity

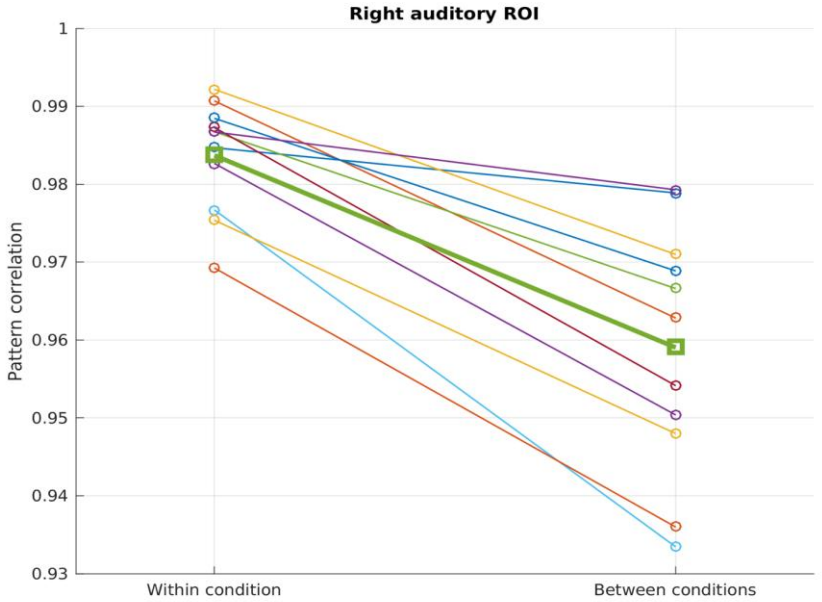
Vertical: Subset 1 Horizontal: Subset 2





B(distance) C(constant): Group results





LH: $\Delta r = 0.0236$, $p < 0.001$

RH: $\Delta r = 0.0247$, $p < 0.001$

Δr = mean within-condition correlation − mean between-condition correlation (n = 11).

Summary

Univariate replication: We reproduced the original distance-related fMRI findings.

Preliminary MVPA: Within-condition pattern correlations were higher than between-condition correlations in both hemispheres.

Next Steps: MVPA in the main experiment

Focus on distance vs intensity: The contrast that identified distance-related activity in left PT/pSTG.

Analyze three independent fMRI runs to test whether condition-related spatial patterns are reproducible across runs.

Examine both hemispheres: Look for distributed pattern differences in left PT/pSTG and the corresponding right auditory region.