The Role of Auditory Experience in Patient Reported Outcomes and Task Performance for Effortful Listening

Bradley E. White[1,3,5], Poorna Kushalnagar[2,4,5], Clifton Langdon[1,3,5]

[1]Language and Educational Neuroscience Laboratory, [2]Deaf Health Communication and Quality of Life Center, [3]PhD in Educational Neuroscience Program, [4]Department of Psychology, [5]Gallaudet University

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INTRODUCTION

Everyday conversation frequently occurs under a wide range of suboptimal and adverse listening conditions.[1] Behavioral and neuroimaging research suggest that processing degraded acoustic information creates a cascading effect on the mechanisms underlying speech comprehension, indicating that our cognitive resources are limited and causing a trade-off between effort and comprehension.[2-6] Here, using patient-reported outcomes, a plausibility judgment task, and functional near-infrared spectroscopy (fNIRS), we aim to dissociate motivated listening and its modulation of language processing networks in response to increasing demands on executive functioning in listeners with typical hearing acuity and experienced, early-deafened hearing aid and cochlear implant users.

QUESTIONS AND HYPOTHESES

Does experience (i.e., naïve vs. early, life-long) with acoustically degraded speech modulate language processing in response to increased demands on cognitive executive functions (e.g., short-term verbal working memory, attention)?

H1. Early, chronic exposure yields adapted language systems.
P1. Increased demands will yield dissimilar behavioral and neural patterns compared to naïve listeners of simulations.
H2. Early, chronic exposure yields constraints on language systems.
P2. Increased demands will yield similar behavioral and neural patterns compared to naïve listeners of simulations.

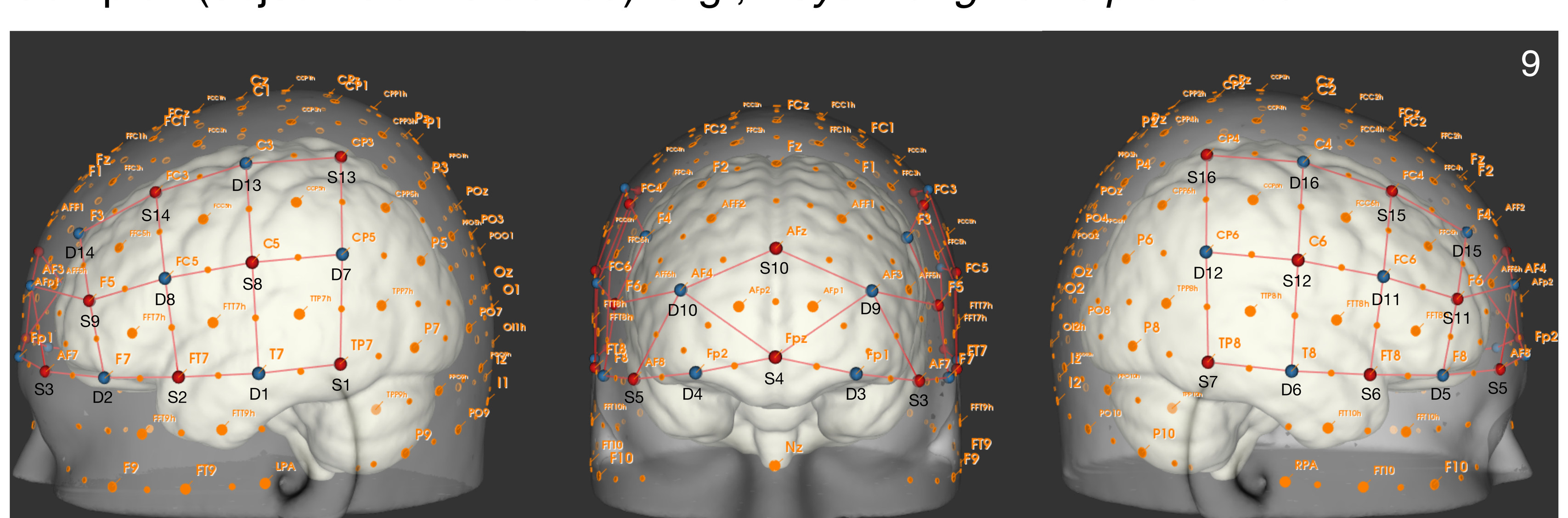
METHODOLOGY

Participants. Healthy, monolingual, English-speaking adults (N=24).
*CI Users** (N=4, F=0, Age range=18;0 to 19;7, Mean age=18;8)
*HA Users** (N=5, F=1, Age range=18;1 to 20;10, Mean age=19;2)
Typical hearing (N=15, F=11, Age range=19;1 to 37;9; Mean age=28;6)
*Used since before age 5;0

Task. PROMIS Global Health; English sentence plausibility judgment task.[7,8]

Stimuli. 288 sentences presented at various speech rates and with or without distortions (i.e., computer-generated hearing aid and cochlear implant simulations [8 channel noise-vocoded]). Equal number of plausible and implausible sentences.

Simple (subject-relative clause): e.g., *Boys that help girls are nice.*
Complex (object-relative clause): e.g., *Boys that girls help are nice.*



Corresponding author: clifton.langdon@gallaudet.edu

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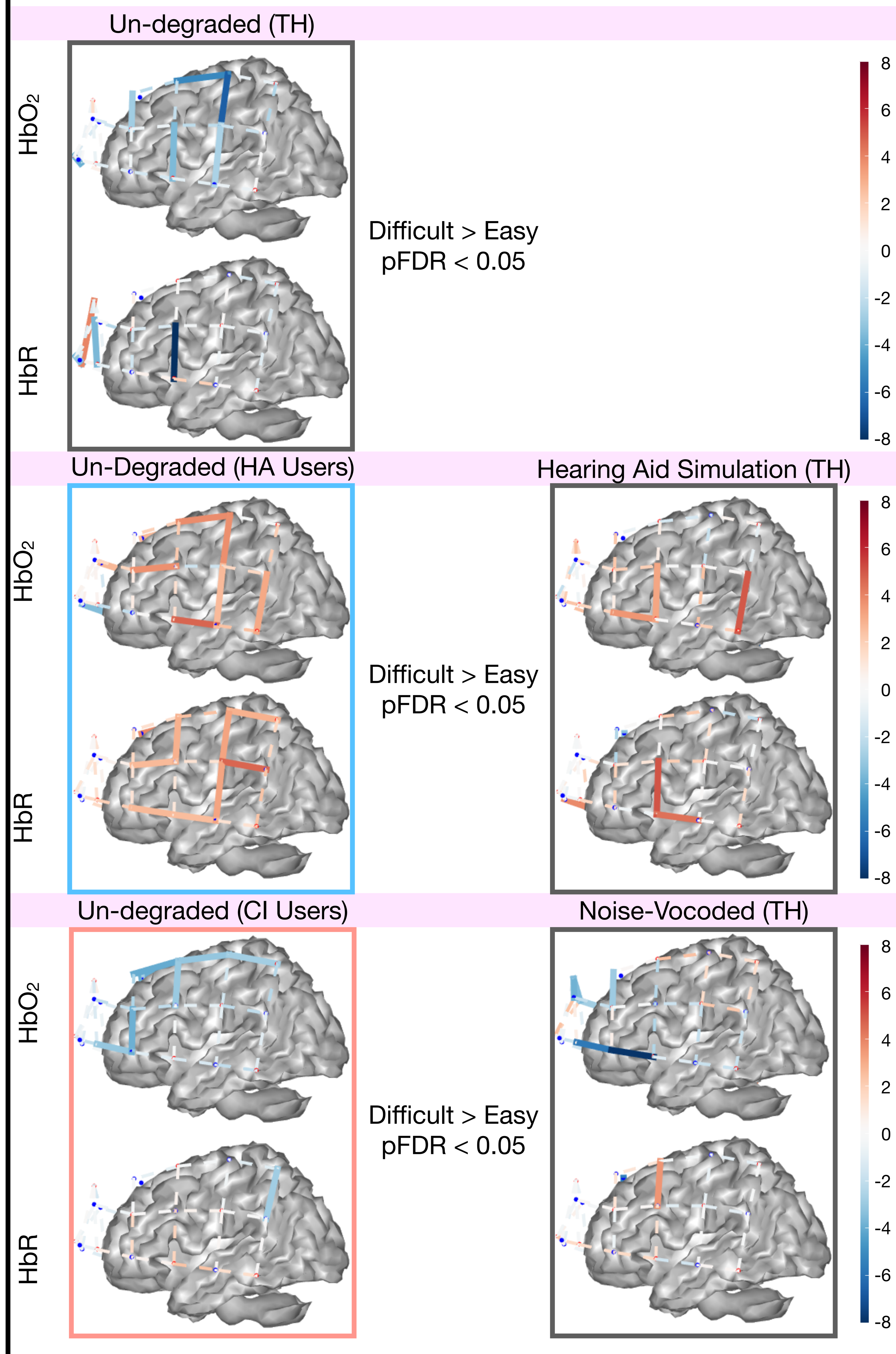
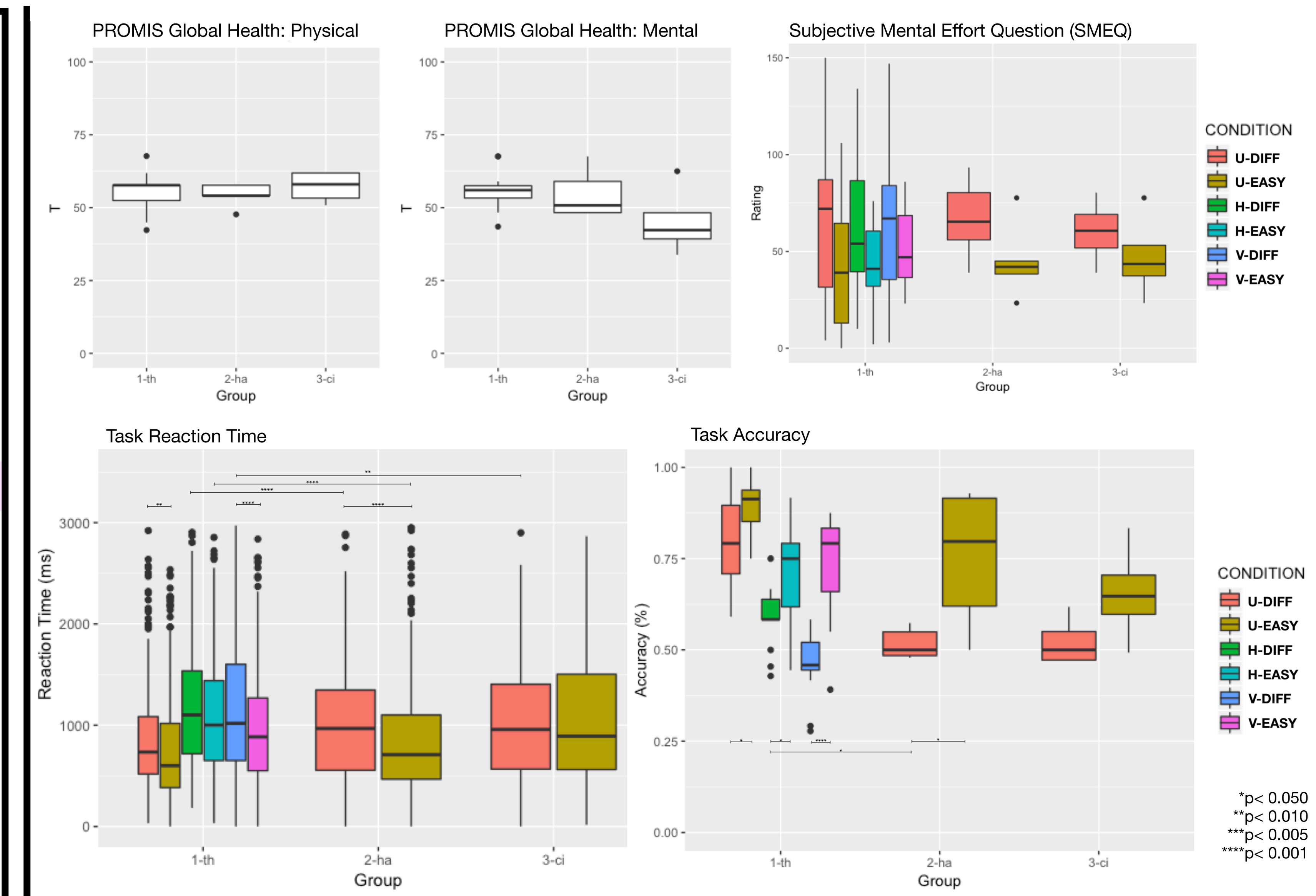
ANALYSES

Behavioral analyses were conducted using R and Welch t-tests.
Functional NIRS data were preprocessed and analyzed using the NIRS Brain AnalyzIR Toolbox.[10] *Individual Analysis***:** We used linear regression modeling with an autoregressive iterative re-weighted least squares (AR-IRLS)[11] pre-whitening method. *Group Analysis***:** Group-level comparisons were made using mixed-effects statistical models.

fNIRS AND BEHAVIORAL RESULTS





DISCUSSION

Patient-reported outcomes and Task Performance:

- *PROMIS Global Health* measures suggest that all participants are healthy. No differences between groups was observed, possibly indicating that the measures are not sensitive or that the sample size is too small.
- *SMEQ (mental effort)* ratings show distinctions, though not significant, in perceived effort between easy and difficult speech listening.
- *Task Performance (accuracy and reaction time)* reflect that, overall, participants respond significantly faster and more accurately to easy speech compared to difficult speech. Significant differences were also observed between early, life-long hearing aid users listening to normal speech and listeners with typical hearing (naïve) listening to hearing aid and cochlear implant simulations.

fNIRS:

- Listeners with typical hearing and early, long-term cochlear implant users activate language regions in the left hemisphere more for processing easy compared to difficult speech.
- Early, long-term hearing aid users show the opposite pattern and activate language regions in the left hemisphere more for difficult compared to easy speech.
- Listeners with typical hearing (naïve) show similar activation patterns as early, long-term hearing aid and cochlear implant users for language processing.

H1 Language Processing. Here, we find that auditory experience does in fact modulate the neural systems for language processing. Crucially, the nature of one's listening experience may predict this modulation.

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