Spectral Changes in the Brain After Hearing Aid Use

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BACKGROUND

Research suggests that hearing loss is associated with incident cognitive impairment, as well as faster rates of cognitive decline, with conflicting evidence regarding effects of hearing aid use.[1] Spectral EEG changes in the brain have been studied as indices of cognitive and listening effort, with some an increase in alpha modulation associated with listening effort in more challenging environments such as speech in noise.[2,3] Additionally, evidence suggests that an increase in theta/alpha ratio power is considered a sign of healthy cognition.[5]

Aim: In this study, we examined EEG spectral bands in older adults with mild-moderate hearing loss before and after 6 months of hearing aid use.

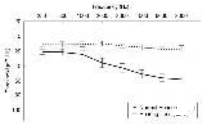
Results can give us insight into neurocognitive changes associated with age-related hearing loss (ARHL), and how intervention with hearing aids may improve outcomes.

METHODS

Participants

Retrospective analysis of data was analyzed from 21 participants with age-related hearing loss (mean age = 64.4 years), prior to hearing aid use (Pre-hearing aid), and 6 months after being fit with state-of-the-art hearing aids fit to NAL-NL2 targets (Post-hearing aid).

Average Audiogram



Subjects had normal hearing (defined as ≤ 25 dB HL) through 1000 Hz, sloping to a mild to moderate hearing loss (~60 dB HL)[5].

Methods:

The following tests were administered (see Glick and Sharma 2020 for details)

Speech in noise testing

Clinically used sentence-level measure, QuickSIN[6]

High Density EEG Data Collection Protocol (Resting State Eyes Open):

- Recorded from a 128-channel EGI cap
- Artifacts and noisy channels removed manually and through Independent Components Analysis
- For spectral analysis, a spectral sum average was calculated per subject per channel per spectral band. For each spectral band, average spectral power was calculated per electrode per subject and averaged across all subjects in each group. Average spectral power was plotted by electrode on a scalp map.

RESULTS

REGIONS OF INTEREST

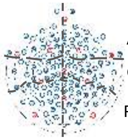
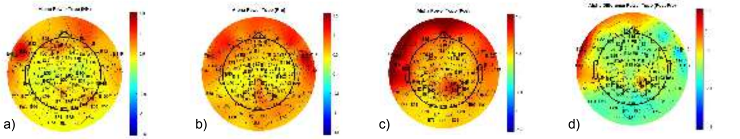


Figure 1. Regions of interest chosen for data analyses shown on the 128-channel EGI cap. Regions were divided into left and right anterior, central, and posterior regions.

ALPHA POWER



THETA/ALPHA RATIO (TAR) POWER

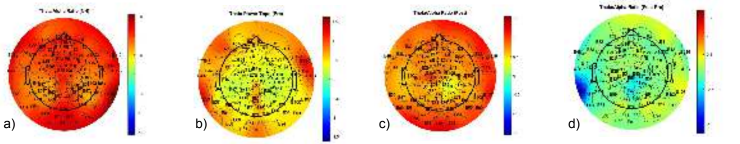


Figure 2. Scalp maps of alpha power (first row) and TAR (second row), averaged across all subjects for a) typical hearing controls b) pre hearing aid use c) post hearing aid use, and d) the difference result. As shown on the scale on the right, the more positive value (or increase in the difference map) is shown in red. As can be seen, alpha power trends towards decreasing and TAR increases ($p<.05$) in the posterior region of interest pre- to post-hearing aid usage.

POSTERIOR ALPHA POWER AND SPEECH PERCEPTION IN NOISE

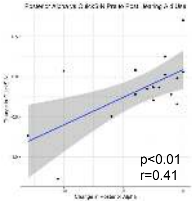


Figure 3. Posterior alpha change versus change in QuickSIN scores from pre- to post- hearing aid use. Decrease in posterior alpha power is correlated with the improvement in speech perception in noise with hearing aids, suggesting that amplification results in both improved speech perception and cognitive load.

DISCUSSION and CONCLUSIONS

In this analysis, we found that alpha power, which has been considered a biomarker of listening effort, decreases after 6 months of hearing aid use, and is correlated with improved speech perception in noise ($p<.01$) post-hearing aid use. This result aligns with previous studies finding an increase in alpha with increased listening effort in speech in noise testing.[2,3]

Additionally, we found a significant increase in posterior Theta/Alpha Ratio (TAR) power ($p<.05$) after hearing aid use. Changes seen in TAR may be a sign of healthy cognition.[4] We found an increase in TAR in this group of subjects in visually-evoked potential data as well, consistent with resting state findings.

Both alpha power and TAR patterns in hearing loss participants after 6 months of hearing aid use tended to be more similar to age-matched NH controls than pre-hearing aid use, suggesting that well-fitted amplification may reverse alterations in cortical processes that occur due to age-related hearing loss. This is consistent with our previous study showing reversal of cross-modal re-organization from vision and neurocognitive improvement in executive function, processing speed and working memory after 6 months of hearing aid use.[5]

Finally, the current study showed cortical changes during resting state (i.e., not evoked by stimulation) suggesting that there is a fundamental alteration in cortical processes as a result of age-related hearing loss, which could be important information to share with patients. Overall, our results suggest that neural correlates from EEG spectral bands analyses may serve as fundamental biomarkers of early candidacy for hearing aid fitting, and markers of neurocognitive improvement after intervention.

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