Brain Changes in Mild to Moderate Hearing Loss after Hearing Aid Use

Carly Schimmel; Emily Lee; Hannah Glick, AuD, PhD; Don Bell-Souder; Anu Sharma, PhD
Speech, Language and Hearing Sciences Department, The University of Colorado at Boulder

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. In this study, we examined EEG spectral bands in older adults with mild to 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.

RESULTS (PRE/POST HEARING AID USE)

SPECTRAL POWER AFTER HEARING AID USE

<table>
<thead>
<tr>
<th>Spectral Band</th>
<th>Aspect of Cognition</th>
<th>ROI</th>
<th>Average Post-Pre change</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha (8-12 Hz)</td>
<td>Listening Effort</td>
<td>E33, E36</td>
<td>0.36</td>
<td>0.179</td>
</tr>
<tr>
<td>Theta (4-8 Hz)</td>
<td>Working memory capacitya</td>
<td>E35, E36, E41</td>
<td>0.32</td>
<td>0.23</td>
</tr>
<tr>
<td>Gamma (30-79 Hz)</td>
<td>Learningb</td>
<td>E45, E46</td>
<td>0.044</td>
<td>0.035*</td>
</tr>
<tr>
<td>Theta/Alpha Ratio</td>
<td>Cognitive capacityc</td>
<td>E35, E36, E41</td>
<td>0.23</td>
<td>0.075**</td>
</tr>
<tr>
<td>Theta/Beta Ratio</td>
<td>Cognitive capacityc</td>
<td>E62, E72</td>
<td>1.59</td>
<td>0.096</td>
</tr>
</tbody>
</table>

Table 1. Spectral band definitions, aspect of cognition reflected, regions of interest (ROI) tested, average difference of spectral power measured post-hearing aid minus pre-hearing aid, and significance. *significant at p<0.05; ** trending towards significance.

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 hearing aids (Post-hearing aid).

Average Audiogram
Subjects had normal hearing (defined as ≤ 25 dB HL) through 1000 Hz, sloping to moderate hearing loss (>60 dB HL).

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

Speech in noise testing
Clinically used sentence-level measure, QuickSin2

Cognitive Test Battery
- Reading Span Test (RST) - visual working memory
- Behavioral Discontrol Scale II (BDS-2) - executive function
- Symbol Digits Modalities Test (SDMT) - processing speed
- Montreal Cognitive Assessment (MoCA) - global cognition

High Density EEG Data Collection Protocol (Cortical Visual Evoked Potentials)
- Recorded from a 128-channel EGI cap
- Artifacts and noisy channels removed manually and through Independent Components Analysis
- Spectral analysis completed by:
  - 1. Spectral sum average calculated per subject per channel per spectral band
  - 2. For each spectral band, average spectral power calculated per electrode per subject and averaged across all subjects in each group
  - 3. Average spectral power plotted by electrode on a scalp map

DISCUSSION AND CONCLUSIONS

In this study we sought to identify neural correlates from EEG spectral bands analyses which may serve as a clinically relevant marker of early candidacy for hearing aid, and a marker of neurocognitive improvement after hearing aid use.

Overall, we find that adults with age-related hearing loss show an improvement in speech in noise perception (QuickSin), global cognition (MoCA), executive functioning (BDS), visual working memory (Reading Span) and processing speed (SDMT) after 6 months of hearing aid use.

In addition, we have identified two possible EEG spectral markers of neurocognitive outcome.

1. The Theta/Alpha ratio (TAR) showed an increase after 6 months of hearing aid use and this increase was significantly positively correlated with improvement in speech in noise perception (p<0.05). Changes seen in TAR may be a sign of healthy cognition, and may increase the likelihood of better performance in speech in noise.

2. We saw a significant increase in gamma power post-hearing aid use (p<0.05), which may reflect enhanced ability for learning to process restored auditory information with hearing aids.

These results provide overall evidence for improved neurocognitive functioning with hearing aid use in individuals with mild to moderate age-related hearing loss.

Future Directions
In future research our aim is to further understand TAR, Gamma and other clinically relevant and feasible markers of improved neurocognitive outcomes to better determine who would receive early intervention with hearing aids and to monitor outcomes after hearing aid use in adults with age-related hearing loss.

REFERENCES


ACKNOWLEDGMENTS

We acknowledge funding from the Hearing Industry Research Consortium.