

# Cortical alpha oscillations as a measure of listening effort in adults with hearing loss

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**Background:** Understanding speech presented against a background of noise can be effortful, especially for older adults with hearing loss (Pichora-Fuller et al., 2016; Alhanbali et al., 2017). Cortical electroencephalography (EEG) is one of the many different objective measures used to index listening effort (Pichora-Fuller et al., 2016; Alhanbali et al., 2019). Changes in the power of EEG oscillations in the alpha frequency band (8-13 Hz) may indicate increased listening effort (Obleser et al., 2012; Petersen et al., 2015; Dimitrijevic et al., 2019; Fiedler et al., 2021), or suppression of irrelevant background noise during effortful listening tasks (McMahon et al., 2016).

**Methods:** Our research focuses on using EEG alpha power to measure listening effort during speech-in-noise listening tasks for older adults who have a hearing loss. We use the Nexus-10 with the BioTrace software (Mind Media B.V. neuro and biofeedback system) to acquire EEG data. We use EEGlab (Delorme & Makeig, 2004) to analyse the EEG data during discrete time periods of interest during a listening task.

**Results:** For older adults with hearing loss, changes in EEG alpha power during listening to, and remembering, speech captures aspects of listening effort that are distinct from those captured by other objective measures of listening effort (Alhanbali et al., 2019). Baseline alpha power can predict performance accuracy on a digits-in-noise task (Alhanbali et al., 2022). The degree of hearing loss modulates EEG alpha power prior to the presentation of a speech stimulus (Alhanbali et al., 2022) and during listening to, and remembering, a speech stimulus (Petersen et al., 2015). Preliminary work from our group suggests that EEG alpha power may be used as an objective marker of when (i.e., at different time periods in a listening task) participants with varying degrees of hearing loss use listening effort to achieve listening success.

**Conclusion:** Changes in EEG alpha power have the potential to provide insight into the temporal dynamics of listening effort throughout the course of a listening task. These temporal changes in EEG alpha power may help to explain individual differences in the experience of listening effort.

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## References:

- Alhanbali, S., Dawes, P., Lloyd, S., and Munro, K.J. 2017. Self-reported listening-related effort and fatigue in hearing-impaired adults. *Ear and Hearing* 38 (1): e39–e48.
- Alhanbali, S., Dawes, P., Millman, R.E., and Munro, K.J. 2019. Measures of listening effort are multidimensional. *Ear and Hearing* 40 (5): 1084–1097.
- Alhanbali, S., Munro, K. J., Dawes, P., Perugia, E., and Millman, R.E. 2022. Associations between pre-stimulus alpha power, hearing level and performance in a digits-in-noise task. *International Journal of Audiology*, 61(3), 197–204.
- Delorme, A., and S. Makeig. 2004. EEGLAB: An open source toolbox for analysis of single-trial EEG dynamics including Independent Component Analysis. *Journal of Neuroscience Methods* 134 (1): 9–21.
- Dimitrijevic, A., Smith, M., Kadis, D., and Moore, D. 2019. Neural indices of listening effort in noisy environments. *Scientific Reports* 9 (1): 1–10.
- Fiedler, L., Seifi Ala, T., Graversen, C., Alickovic, E., Lunner, T., and Wendt, D. 2021. Hearing aid noise reduction lowers the sustained listening effort during continuous speech in noise - A combined pupillometry and EEG study. *Ear and Hearing* 42(6):1590-1601.
- Hart, S.G., and Staveland, L.E. 1988. Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. *Advances in Psychology* 52: 139–183.
- McMahon, C.M., Boisvert, I., de Lissa, P., Granger, L., Ibrahim, R., Lo, C.Y., Yhun, K., and Graham, P.L. 2016. Monitoring alpha oscillations and pupil dilation across a performance-intensity function. *Frontiers in Psychology*, 7.
- Obleser, J., Wöstmann, M., Hellbernd, N., Wilsch, A., and Maess, B. 2012. Adverse listening conditions and memory load drive a common  $\alpha$  oscillatory network." *The Journal of Neuroscience* 32 (36): 12376–12383.
- Petersen, E.B., Wöstmann, M., Obleser, J., Stenfelt, S., and Lunner, T. 2015. Hearing loss impacts neural alpha oscillations under adverse listening conditions. *Frontiers in Psychology* 6: 177.
- Pichora-Fuller, M.K., Kramer, S.E., Eckert, M.A., Edwards, B., Hornsby, B.W.Y., Humes, L.E., Lemke, U., et al. 2016. Hearing impairment and cognitive energy: The Framework for Understanding Effortful Listening (FUEL)." *Ear and Hearing* 37 (1): 5S–27S.