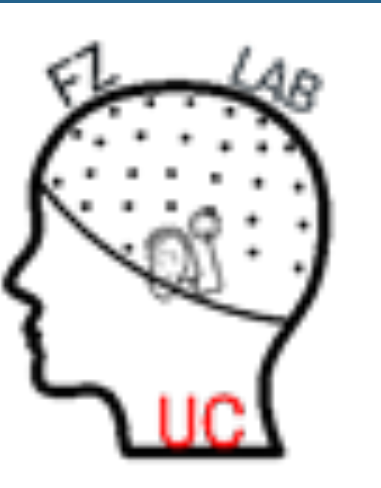


Cortical Processing of Location and Feature Changes of Sounds in Normal Hearing Listeners

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INTRODUCTION

- Sounds we hear in our daily life contain changes in the acoustic features (e.g., frequency, intensity, and duration) and/or changes in location.
- The auditory system needs to automatically process these changes before selectively attending to the “what” and “where” information of the sounds in order to perceive target sounds in complex listening situations, such as parties and restaurants (Altmann et al., 2007).
- In non-primate vertebrates, the “what” and “where” dimensions of sounds may be processed separately in the auditory cortex. Such distinctions are less elucidated in humans (De Santis et al., 2007; Ahveninen et al., 2014; Rettsa et al., 2018).
- This study aims to examine the cortical auditory evoked potentials (CAEPs) to the change in frequency and location of the sound in normal hearing listeners.
- The data will be used to compare those from patients with abnormal hearing in order to identify the nature of abnormality in these patients.

METHODS

- Subjects: Fifteen normal hearing adults (age range: 20-30 years) participated. They were right-handed, and did not have any history of hearing and neurological disorders, or brain injuries.
- Electroencephalographic (EEG) stimuli: The acoustic stimuli were pure tones of 1 sec, with a perceivable change in frequency (F), location (L), or both location + frequency (L+F) in the middle of the tone. The first segment of the stimulus was a 250 Hz pure tone presented from the left speaker. The two sound segments before and after the change occurred were equalized in terms of the root mean square energy. Additionally, the 250 Hz tone of 1 sec without any change was used as a reference.

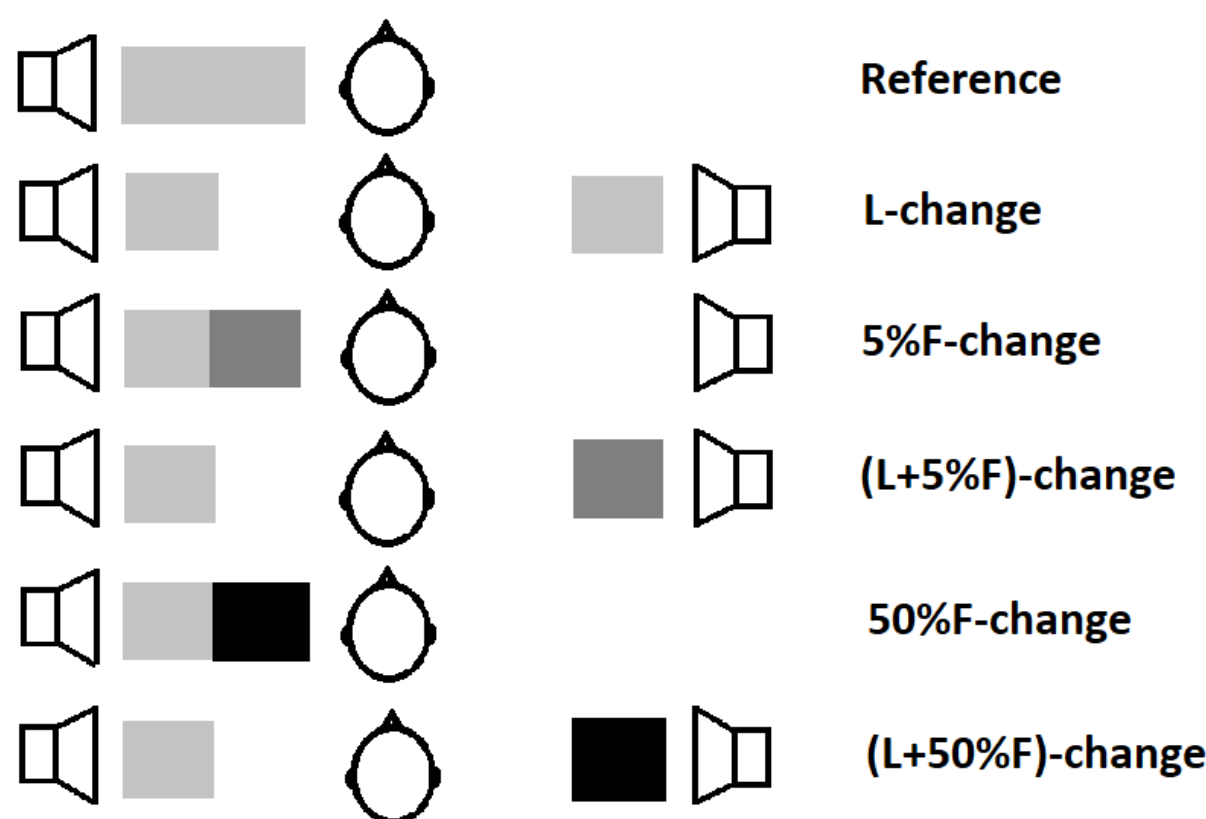


Figure 1. Schematic illustrations of the stimuli used for EEG recordings. For the stimuli containing a change in the middle, the first segments were presented from the left speaker and the second segment representing a frequency (F) change, a location (L) change, or a (L+F) change.

- Procedures:
 - 1) Prior to the EEG experiment, all participants were able to reliably detect the location and frequency changes.
 - 2) During EEG testing, participants read self-selected magazines or watched a captioned movie to keep alert and were asked to ignore the acoustic stimuli. They were also instructed not to move their heads during the EEG testing.
- Data analysis:
 - 1) EEG data were segmented, filtered, and baseline corrected. The averaged event-related potential (ERP) was derived for each stimulus.
 - 2) sLORETA was used for ERP and current source density comparisons.

RESULTS

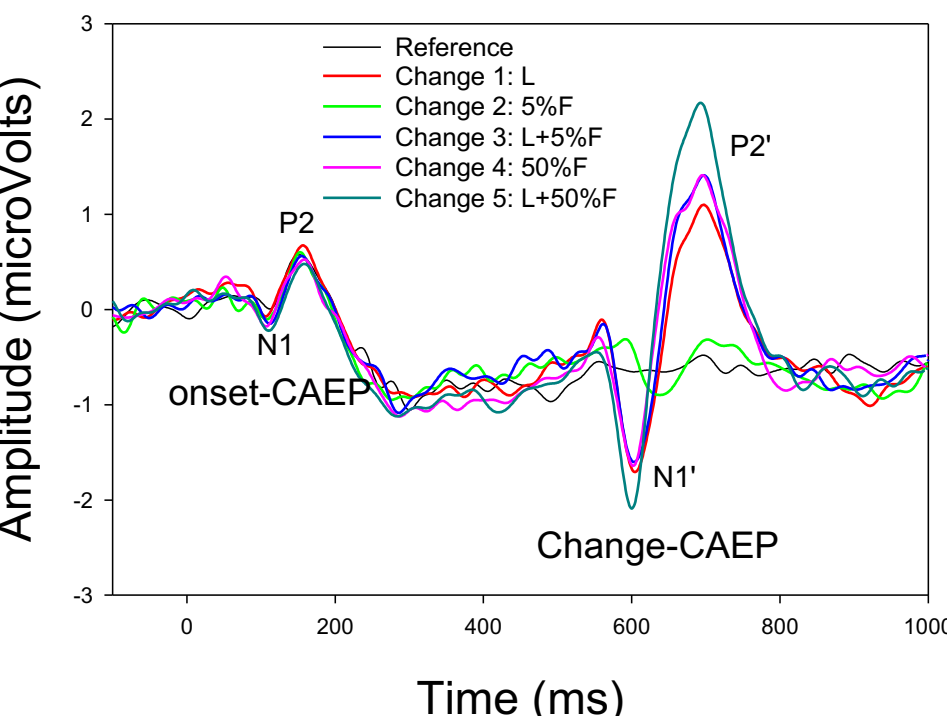


Figure 2. Grand-average event-related potentials (ERPs) at the Cz electrode evoked by different stimuli, plotted with traces of different colors.

Comparisons	The time windows showing Significant differences in ERPs ($p < 0.01$)	Current source density comparisons
L-change vs. 5%F-change	151-204ms after the change occurs	Significant at $p < 0.05$ level
L-change vs. 50%F-change	208-215ms after the change occurs	NS
(L+5%F) change vs. L-change	NS	
(L+5%F) change vs. 5%F-change	173-203ms after the change occurs	Significant at $p < 0.01$ level
(L+50%F) change vs. L-change	NS	
(L+50%F) change vs. 50%F-change	NS	
(L+50%F) change vs. (L+5%F)-change	NS	
50%F-change vs. 5%F-change	153-163ms & 163-203ms after the change occurs	Significant at $p < 0.01$ level

Table 1. Comparisons in event-related potentials (ERPs) and current source densities using sLORETA. NS: no statistical difference.

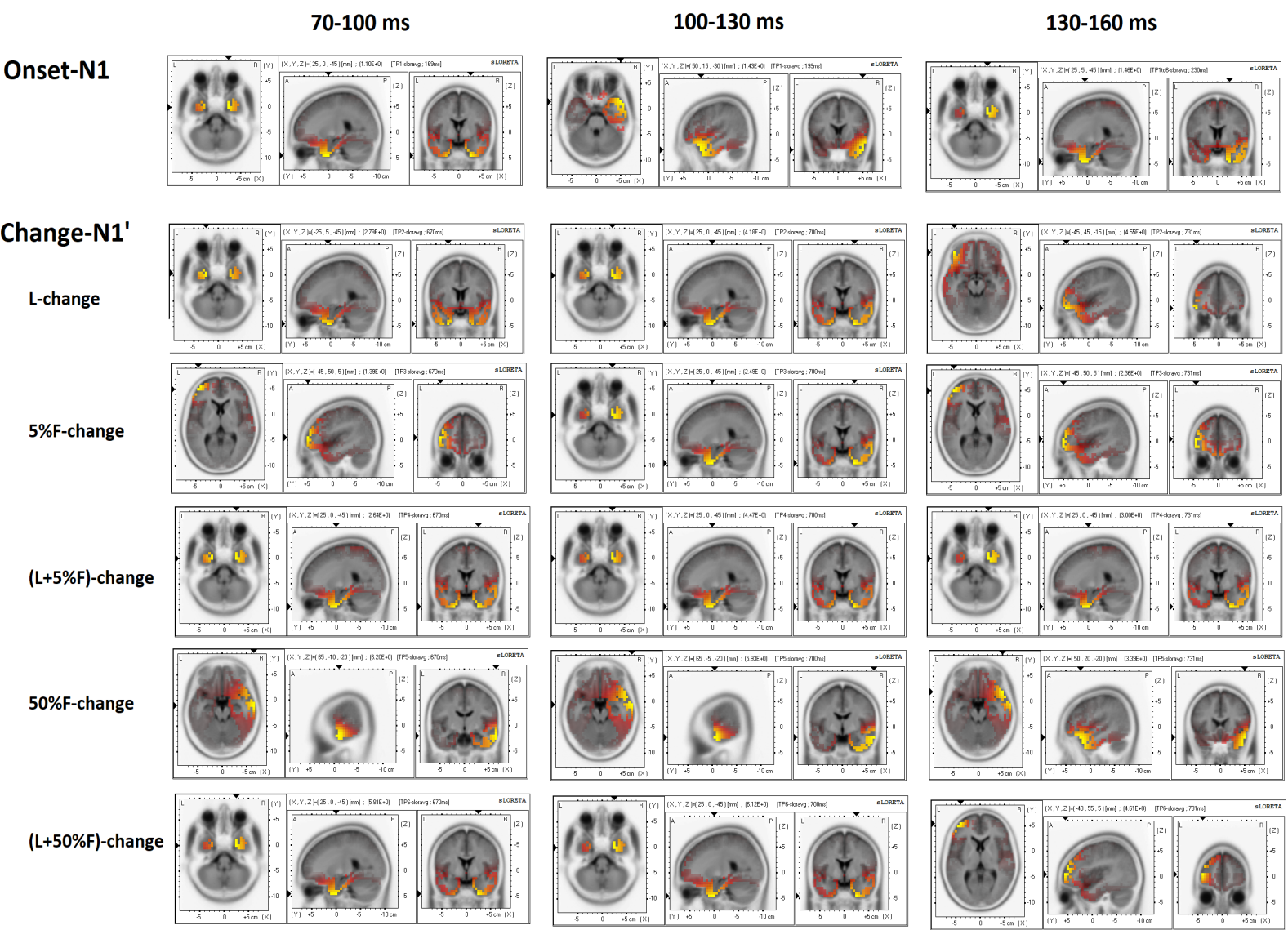


Figure 3. Grand-average of sLORETA current density activation for the onset-CAEP and change-CAEPs within the latency ranges of 70-100, 100-130, and 130-160 ms after stimulus onset or after the change occurs, respectively. Current sources of the onset-CAEP N1 were located in the temporal lobes. In contrast, current sources of the change-CAEP N1' showed different patterns.

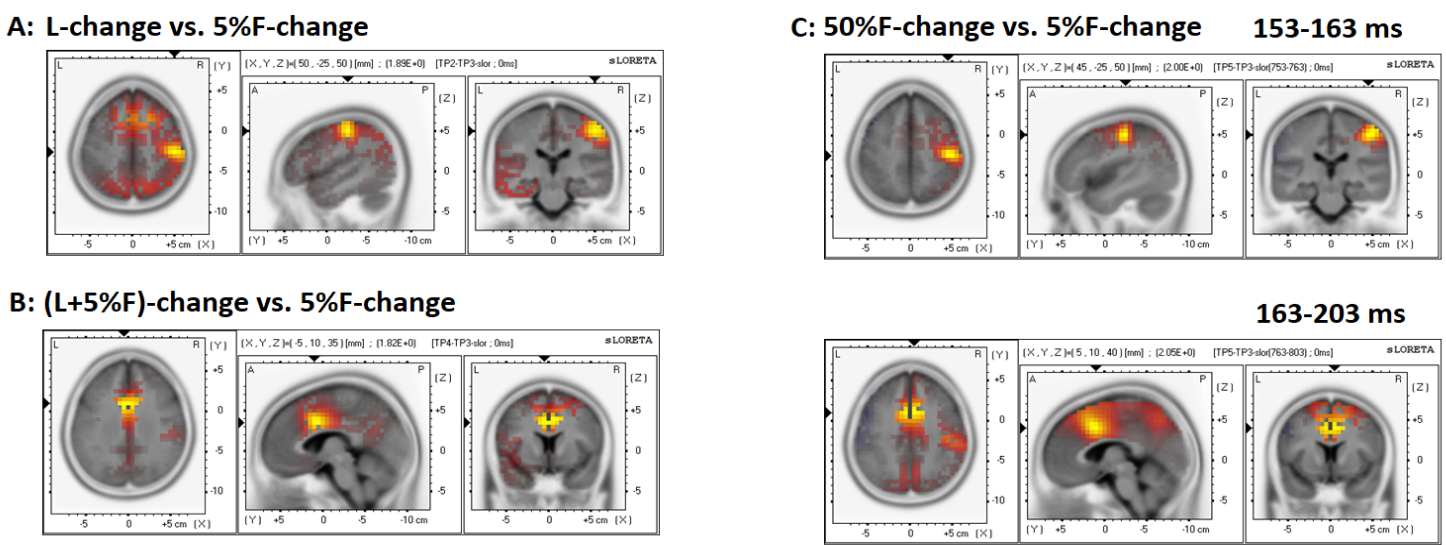


Figure 4. Horizontal, sagittal and coronal slices of sLORETA statistical images (voxel-by-voxel t-tests, $p < 0.05$) for the current density comparisons between different change-CAEPs over time windows where the ERPs showed statistical differences.

CONCLUSIONS

- The change-CAEP is the smallest for 5%F-change and the largest for (L+50%F)-change. The change-CAEPs for other changes have a similar amplitude that is between the smallest and the largest. Such findings suggested that the change-CAEP amplitude is related to the physical magnitude or the corresponding perceptual salience of the change (e.g., 50%F > 5%F).
- The current density patterns show differences between processing L-change vs. F-change, supporting different cortical processing mechanisms for “where” and “what” information of sound (Rettsa et al., 2018); L-change dominates over F-change in cortical processing (e.g., the pattern for L-change is similar to that for (L+F)-change).
- The time course of the current density suggested that there is a common mechanism for detecting sound changes, regardless of L- or F-change, in which the temporal lobes detect the sound differences and then submit to the frontal lobe for discrimination. Compared to small changes, large changes evoke a stronger activation in the postcentral gyrus and cingulate gyrus, suggesting the involvement of auditory working memory (Alain et al., 2008).

REFERENCES

Ahveninen, J., Kopco, N., & Jaaskelainen, I. P. (2014). Psychophysics and neuronal bases of sound localization in humans. *Hearing Research*, 307, 86-97. doi:10.1016/j.heares.2013.07.008 [doi]

Alain, C., He, Y., & Grady, C. (2008). The contribution of the inferior parietal lobe to auditory spatial working memory. *Journal of Cognitive Neuroscience*, 20(2), 285-295. doi:10.1162/jocn.2008.20014 [doi]

Altmann, C. F., Bledowski, C., Wibral, M., & Kaiser, J. (2007). Processing of location and pattern changes of natural sounds in the human auditory cortex. *NeuroImage*, 35(3), 1192-1200. doi:10.1016/j.neuroimage.2007.03.053 [doi]

De Santis, L., Clarke, S., & Murray, M. M. (2007). Automatic and intrinsic auditory “what” and “where” processing in humans revealed by electrical neuroimaging. *Cerebral Cortex (New York, N.Y.: 1991)*, 17(1), 9-17. doi:bhj119 [pii]

Rettsa, C., Matusz, P. J., Schnupp, J. W. H., & Murray, M. M. (2018). What's what in auditory cortices? *NeuroImage*, 176, 29-40. es.2010.11.005 [doi]

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