Frequency- Following Response (FFR) may detect auditory spatial processing

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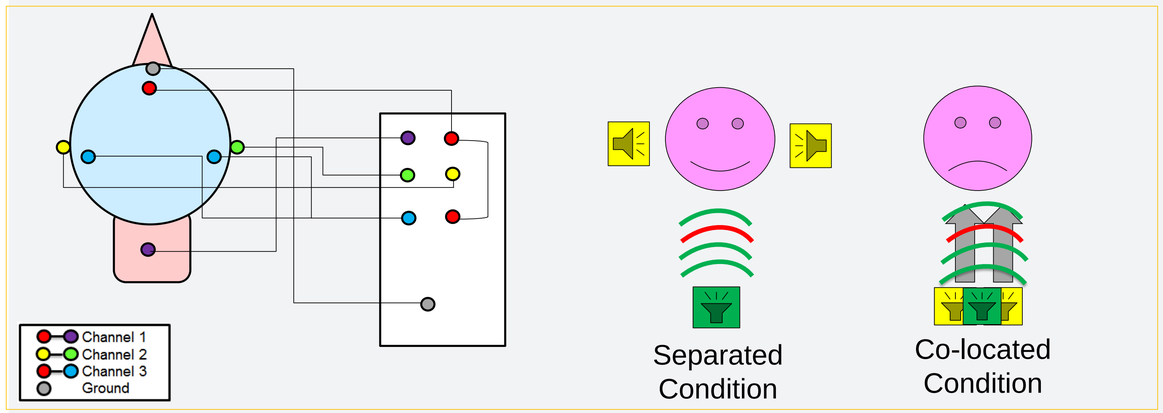
Introduction

Perceiving and determining an acoustic signal in the presence of background noise, as different streams, relies on its spatial cues including interaural intensity and time differences (IID and ITD) along with other spectral information.

Spatial processing or spatial release from masking refers to the improvement in the detection threshold of a signal when spatially separated from competing sounds compared to when it is co-located. Here we examine whether phase-locked neural activity, reflected in the brainstem frequency following response (FFR), exhibits spatial release from masking for a signal presented with spatially separated competing sounds, and the effect of attention on this process. This technique could potentially be used for detection of spatial processing disorders at an early age.

Methods

- Eighteen normal-hearing adults (≤ 20 dBHL in 125 - 4000 Hz)
- Target & deviant stimuli:
  - Vowel /u/
  - F_0 : 110 Hz
  - Duration: 250 ms
  - Rate: 2.85/s (SOA: 350 ms)
  - Number of stimuli: 1100 (10% artefact rejected)
  - Intensity: 60 dB SPL (target) and 52 dB SPL (deviant)
  - Convolved with head-related transfer functions (HRTFs) corresponding to 0 degrees
- Distracting (competing) stimuli:
  - Two discourses narrated by one male talker
  - Convolved with HRTFs corresponding to 0 degrees (co-located) and +/- 90 degrees (separated)
  - SNR (in dB): (-5 ~ low, 0 ~ medium, +5 ~high)
  - Electrode montage: F_p-C_7 (channel 1); A_1-A_2 (channel 2); F_p-M_1& M_2 (mastoids)(channel 3) and F_{pz} (Ground)
  - Attention task: participants detected the number of deviant stimuli



Results

- ✓ Significant interaction was found between the different SNRs and spatial separation (p=0.01) (Figure 1).

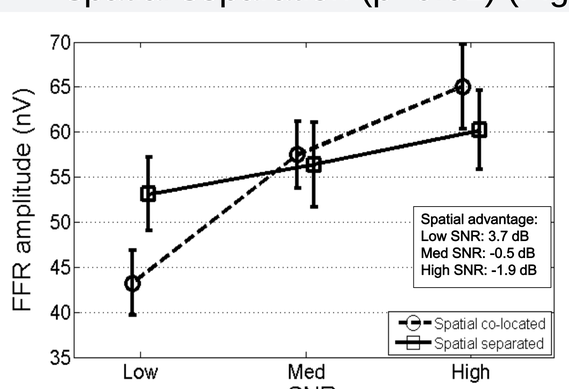


Figure 1. FFR amplitudes for spatially co-located and separated conditions at different SNRs, collapsed over attention and channels one and three.

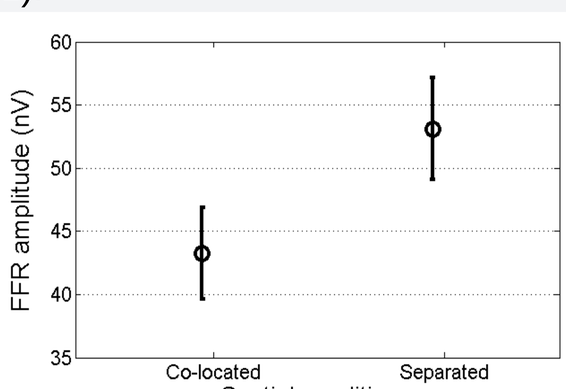


Figure 2. FFR amplitude for two spatial conditions at low SNR across participations and two channels..

- ✓ Significant effect of the spatial separation on F0 FFR amplitude at low SNR (p=0.03) (Figure 2).

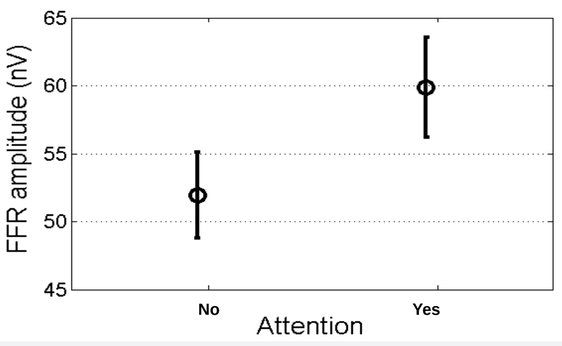


Figure 3. FFR amplitude for factor attention across spatial co-located and separated conditions collapsed over all SNRs and two channels

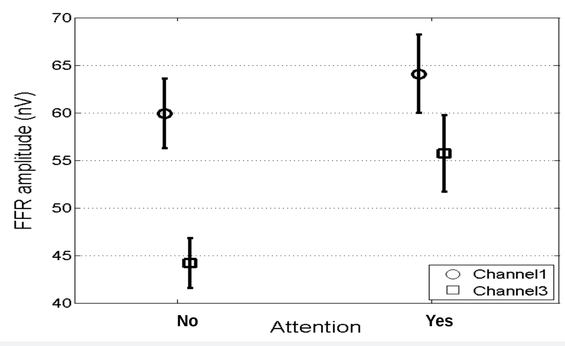


Figure 4. FFR amplitude for attention and channel across spatial conditions and all SNRs.

- ✓ Attention significantly increased F0 amplitude(p=0.008) (Figure 3).
- ✓ Analysing the channels separately showed a significant effect of attention only at channel three and not in channel one (Figure 4).
- ✓ Between attention and spatial separation, no significant interaction was found (Figure 5).

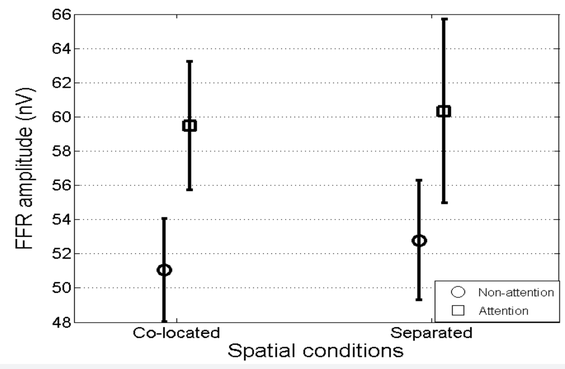


Figure 5. FFR amplitude for factors spatial conditions and attention averaged across channels and SNRs.

Conclusions

- ❖ Binaural processing relevant to spatial release from masking possibly reflected in the phase-locked neural activity in the brainstem and if this the case, it was more effective in the noisiest condition
- ❖ Attending to the target might not play a role at this level, which is an important conclusion when testing children. However, the different attention effect in different EEG channels might suggest there are different neural sources with only some affected by attention.
- ❖ The estimated benefit from separation (in equivalent input SNR dB) is smaller than commonly measured behavioural spatial release from masking. This suggests that the main effect of spatial separation must lie higher in the auditory system than the brainstem, OR it is possible that the remaining part is not measurable electrophysiologically. This question will hopefully be answered in subsequent studies.

Future work

- ❑ Concurrent recording of ABR, FFR, and CAEPs to determine the location(s) of spatial separation on the auditory pathways (In progress)
- ❑ Is the results different for people with Spatial Processing Disorder?
- ❑ Can the effect of training (with LiSN & LEARN) be measured and monitored objectively?

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