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ATTENTIONAL MODULATION OF THE AUDITORY STEADY-STATE RESPONSE ACROSS THE CORTEX

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Introduction

Background Information

- The cocktail party effect is the brain's ability to filter one stimulus out of many. Dichotic listening tests were previously used to study this phenomenon, where different stimuli were presented to each ear;
- Auditory steady state response (ASSR) is an evoked potential produced in phase with an incoming stimulus over the same period;
- Studies on the role of selective attention in increasing ASSR have been inconsistent, and studies showing enhanced ASSR with selective attention have been intermodal.

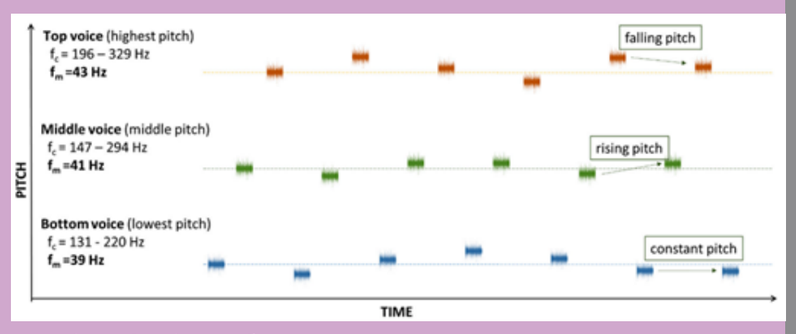
Aims:

- This study aims to use MEG analysis to determine if selective attention increases ASSR power of an attended stimulus, and if other sites beyond the auditory cortex contribute to ASSR expression;
- This study could provide insights on the use of ASSR as a behavioural marker for neurodegenerative disorders or early cognitive decline.

Methods

Participants:

- 27 volunteers aged 18-49;
- With no prior hearing or attention deficits.



Melody development tracking (MDT) task:

- Participants were presented with 3 melody streams of increasing pitch, and were told to direct attention to top or bottom voices;
- Each stream was tagged with a different amplitude frequency to enable ASSR identification on the MEG;
- To ensure alertness and reduce fatigue, participants were allowed to rest every 5 min.

Data acquisition:

- MEG measurements were made using a 306-channel whole-scalp neuromagnetometer system, with millisecond temporal resolution, and millimetre spatial precision;
- Participants' head position, head movement, and cardiac activity were measured to correct for electromagnetic interference.

Data processing:

- MEG data was pre-processed to minimise artefacts from outside the MEG helmet and to compensate for head movement;
- Mean task scores were then calculated to assess response accuracy in the MDT task;
- Sensor-space analysis was carried out to obtain a time-locked ASSR and evoked response field (ERF);
- Source-space analysis was carried out to model the effect of selective attention on ASSR at anatomical level;
- Cluster-based permutation of attentional modulation was carried out to assess if attentional modulation is statistically driven by regions outside the temporal cortex.

Results

- There was a 17% and 11% increase in ASSR power for the bottom voice (blue) and top voice (red) respectively after Fourier transformation when selective attention was applied; (Fig 1)
- Multiple ASSR sources are shown across the entire cortical sheet, with strongest activity in the primary auditory cortex; (Fig 2)
- Region of Interests (ROIs) in the frontal gyrus appear to be most strongly and consistently enhanced by attention, with the left superior frontal gyrus showing up to 54% attentional enhancement. (Table 1)

Lobe	Label #	Regions of interest	Localizer Power (A^2m^2)			% AU Change	
			BH	LH	RH	LH	RH
Temporal	7	Superior temporal gyrus	1.74E-25	1.24E-25	2.25E-25	19%*	15%
Temporal	8	Middle temporal gyrus	1.29E-25	1.14E-25	1.43E-25	18%*	11%
Temporal	12	Posterior superior temporal sulcus	1.27E-25	1.06E-25	1.48E-25	13%*	14%
Frontal	3	Inferior frontal gyrus	8.36E-26	6.42E-26	1.03E-25	15%	18%*
Temporal	9	Inferior temporal gyrus	5.33E-26	5.87E-26	4.79E-26	13%	14%
Parietal	16	Postcentral gyrus	4.79E-26	3.84E-26	5.74E-26	17%*	11%*
Insular	17	Insular gyrus	3.77E-26	2.23E-26	5.32E-26	14%*	15%*
Frontal	5	Precentral gyrus	3.50E-26	2.79E-26	4.21E-26	15%	25%*
Temporal	10	Fusiform gyrus	3.09E-26	2.72E-26	3.46E-26	27%	9%
Temporal	11	Parahippocampal gyrus	2.96E-26	2.74E-26	3.17E-26	-14%	10%
Frontal	4	Orbital gyrus	2.87E-26	2.53E-26	3.21E-26	-8%	15%*
Parietal	14	Inferior parietal lobule	1.61E-26	9.93E-27	2.23E-26	13%*	14%*
Frontal	6	Paracentral lobule	1.40E-26	1.52E-26	1.28E-26	-5%	59%
Frontal	2	Middle frontal gyrus	1.15E-26	8.79E-27	1.41E-26	18%	25%*
Parietal	15	Precuneus	1.02E-26	1.12E-26	9.25E-27	-3%	35%
Frontal	1	Superior frontal gyrus	8.96E-27	6.67E-27	1.13E-26	54%	32%
Occipital	20	Lateral occipital cortex	8.18E-27	8.01E-27	8.35E-27	20%	36%
Parietal	13	Superior parietal lobule	8.12E-27	6.74E-27	9.49E-27	-6%	0%
Occipital	19	MedioVentral occipital cortex	6.4448E-27	6.23E-27	6.74E-27	9%	20%
Limbic	18	Cingulate gyrus	6.20E-27	5.12E-27	7.28E-27	12%	14%

Table 1 shows the %AU (attended condition to unattend condition) change in various ROIs. Asterisks denote ROIs containing vertices that belong to clusters with $p < 0.05$ that drive attentional deficit. However, noise or field spread could contribute to high %AU changes.

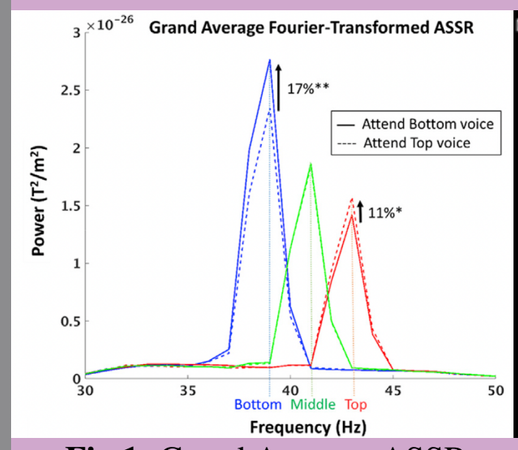


Fig 1: Grand Average ASSR power spectra for all conditions.

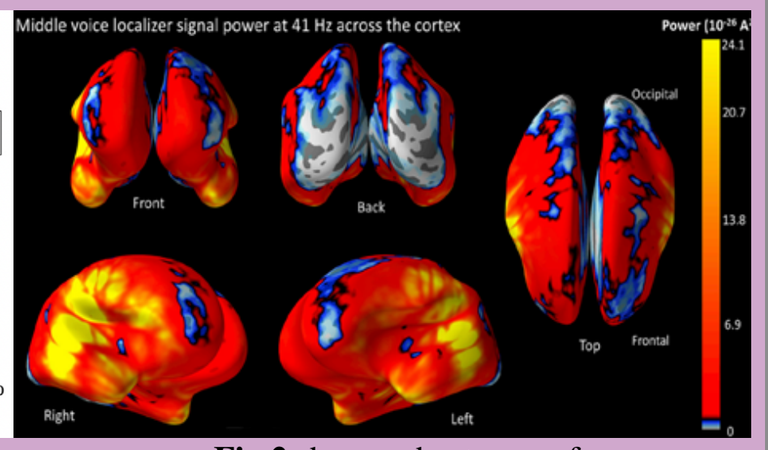


Fig 2 shows a heat map of ASSR power.

Discussion

- Selective attention has been shown to increase ASSR power of an attended stimulus even when presented diotically;
- Other areas outside the auditory cortex have been shown to contribute to ASSR and attentional modulation, such as the frontal, temporal and parietal regions, which is consistent with previous EEG (Farahani et al) and PET (Reyes et al) studies;
- Further research questions include the use of ASSR to assess selective attention for early diagnosis and detection of attention deficit disorders (e.g. ADHD) and neurodegenerative disorders such as Alzheimer's disease.

References

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To watch the presentation, please click on the video below: