Classifying simultaneous auditory steady-state responses: associations between attention, performance, & musicality

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Introduction to Frequency-tagging

- Stimultaneous sounds elicit mixed neural responses that are difficult to disentangle & distinguish from one another
- Frequency-tagging can be used to label, identify & separate these neural signals (Auditory Steady-State Responses; ASSRs) according to the respective stimuli modulation frequencies (f_m)
- ♪ ASSRs are modulated by selective attention

Support Vector Machine (SVM) classification of ASSRs





AM Frequency Tagging of sounds Sine tone before amplitude modulation

(i) Frequency-tagged auditory streams trigger (ii) ASSR power \uparrow with selective ASSRs at f_m = 39 & 43 Hz attention



Figure 1. Modulation of ASSRs by selective attention.

(i) Two frequency-tagged auditory streams elicit neural ASSRs at 39 & 43 Hz corresponding to f_m of each stream, as seen by the spectral peaks in (ii). The 39 Hz ASSR power increased when the subject attended selectively to the 39 Hz (red) stream while the 43 Hz ASSR power increased when the subject focused on



• time

Support vector machine classifiers demonstrated above-chance (50%) area-under-curve (AUC) values for both top-down & bottom-up attention at sensor level



the other (blue) stream.

Melody Tracking task

- 2 simultaneous frequency-tagged melody streams
- Subjects attended selectively to either one via top-down attention (TDA) while pitch changes draw bottom-up attention (BUA).

Strong correlations between subjects' task accuracy & musicality

(MSI) Expt 3 -- Alternate falling pitch ha daha din su kaning bara di akawa ha mada kuma dia t **High voice** trees, he dile the relation day down in the second days. In t بر والما والله السالية ال f_c = 329 – 523 Hz , Alexandre and a Alexandre and a strain decremental design and f_=43 Hz **1**S Low voice Did the pitch end rising, f_c =131 – 220 Hz *falling, or constant?* f_m=39 Hz rising pitch > time Expt 4 – Overlap free, Healthalls, ashe backet, ft. Asian half scale line, the fi a hall in which is the day has said from the . Anna haddaath, mis shallan da daar hadaa dha dharaha bara dha dhara dha dh High voice f_=43 Hz 2s detailed and probably to have been been determine an determine to the termine المراجع والمراجع والمتحد والمتحد والمراجع والمراجع

Source-level

Right top: In Exp 3, TDA correlated positivity with task performance at the left inferior parietal lobe (IPL) but BUA correlated negatively at the right IPL.

- Right bottom: In Exp 4, correlations between attention & performance were negative in the right IPL & orbital gyrus (OrG).
- Bottom: TDA correlated positivity with individual musicality (MSI) in Exp 3.





Expt 3: AUC vs Musicality correlation

Low voice f_m=39 Hz

Figure 2. **Variations of melody tracking task.** Subjects attended to one out of two simultaneous melody streams that differed in pitch (f_c), and answered if the melody ended with a falling, rising or constant pitch.

Future Work

More complex & natural sounds for frequency-tagging
Multimodal MEG-MRS neuroimaging

Relevant Publications:

- Manting, C. L.; Gulyas, B.; Ullén, F.; Lundqvist, D., Steady-state responses to concurrent melodies: source distribution, top-down, and bottom-up attention. *Cerebral cortex* 2023, 33(6), 3053–3066.
- Manting, C. L.; Gulyas, B.; Ullén, F.; Lundqvist, D., Auditory steady-state responses during and after a stimulus: Cortical sources, and the influence of attention and musicality. *NeuroImage* 2021, 233, 117962.
- Manting, C. L.; Andersen, L. M.; Gulyas, B.; Ullén, F.; Lundqvist, D., Attentional modulation of the auditory steady-state response across the cortex. *NeuroImage* 2020, 217, 116930.



