Neural Activity in AC during Memory Formation of Auditory Patterns

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1. Introduction

- Learning and memory processes through a repetitive exposure to target sounds are one of key factors for efficient auditory perception.
- Recent human behavioural and neuro-imaging studies have demonstrated the fast process of auditory perceptual learning (Agus et al., 2010; Andrillon et al., 2015; Kumar et al., 2014; Luo et al., 2013).
- However, further in-depth neural recordings are required to identify neural mechanisms underlying the memory process.
- Here we aim at investigating neural basis of learning and memory for random auditory patterns in the auditory cortex by recording neural activities of rodents using electrocorticography (ECoG).

2. Experimental Settings

- ***Stimuli:*** Dynamic Random Chords (DRC) with high saliency (20 dB) and low saliency (5 dB), and white noise (WN), presenting a spectro-temporal structure.

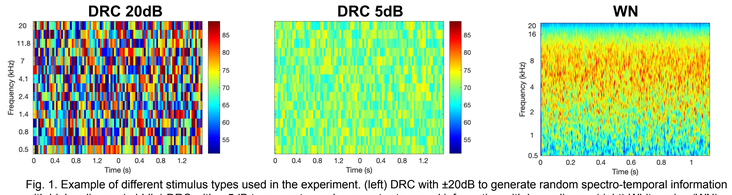

Fig. 1. Example of different stimulus types used in the experiment. (left) DRC with ±20dB to generate random spectro-temporal information with high saliency. (middle) DRC with ± 5dB to generate random spectro-temporal information with low saliency. (right) White noise (WN) to generate more abstract random spectro-temporal information.

- DRC: Each chord duration at 20 ms., 12 chords per segment, 15 log-spaced frequency range between 0.5 kHz and 20 kHz. Segment length about 200 ms., sequence length about 1.26 sec.
- WN: Random Gaussian noise. Segment length about 160 ms., sequence length about 1.12 sec.

- ***Paradigm:*** Random presentation of different sequence conditions.

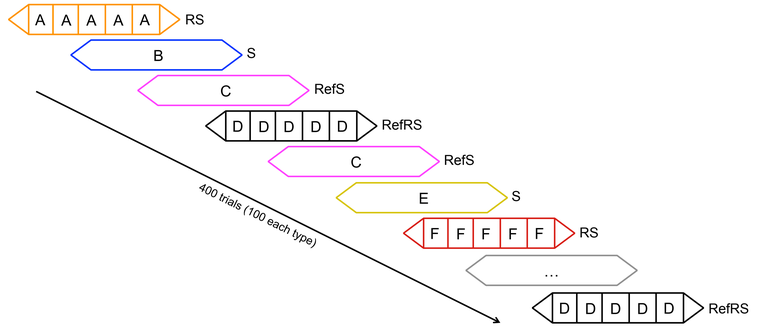

Fig. 2. Example schematic of stimuli presentation during a recording session. All stimuli have ramped pre- and post- random segments. Sequences with the same colour codes and the same letter refer to Reference sequences (RefS and RefRS) while sequences different colour codes refer to S and RS generated afresh for each presentation.

- ***Recording:*** 64-Channel ECoG array (61 + 3 reference channels) placed over the AC area, the recording was done under anaesthesia (female Wistar rats, 8 - 20 weeks, *N* = 6).

3. Results

LFP responses in AC

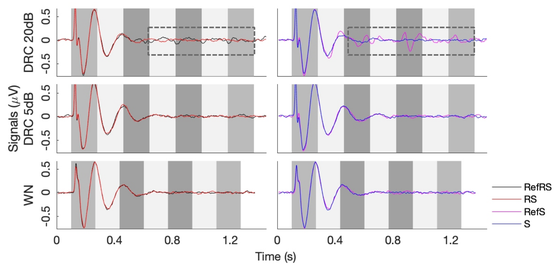

Fig. 3. LFP responses for each condition and stimulus type. First and last gray shaded areas refer to pre- and post ramped random segments. Light and darker gray shaded areas indicate each of five segments within sequences.

Differences in LFP responses between RefRS and RS / RefS and S for DRC 20dB are observed during the sequence presentation.

No such difference was observed in other types of stimuli.

Comparison on time-frequency analysis between conditions

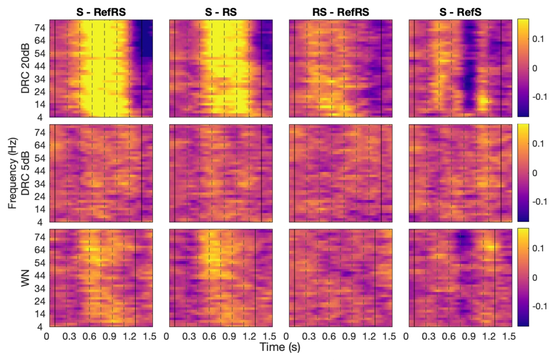

Fig. 5. Time-frequency signal analysis on averaged signals of top 10 response channels. Each column represents differences on averaged analysis results between conditions. Black solid lines indicate sound onset and offset, and gray dashed lines indicate each segment timepoints.

Differences in power for RefRS, RefS, and RS when compared with S for DRC 20dB are observed during the sequence presentation.

Less difference was observed in other types of stimuli.

Topographic distribution of responses

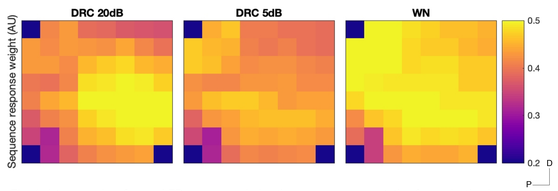

Fig. 4. A topography of mean LFP responses during the sequence presentation for each stimulus type.

Most of channels showed sequence evoked responses. More channels in secondary auditory areas were evoked for DRC 20dB, compared to other two stimulus types.

Signal changes on trial basis

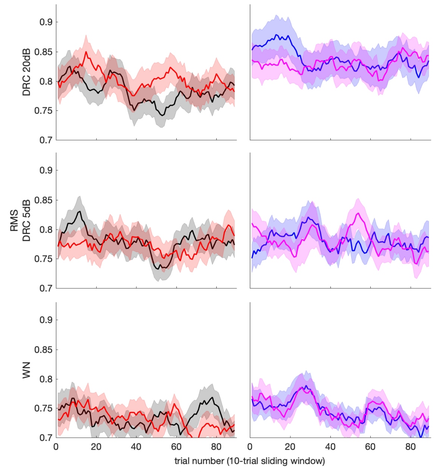

Fig. 6. Root-mean-square (RMS) of signals per each trial, with 10-trial sliding window. Shaded areas indicate standard error across rats.

Clear differences in RMS of LFP signals during the sequence presentation are observed between RefRS and RS for DRC 20dB.

No such difference was observed in other types of stimuli.

4. Discussion

- Evidence of attenuated neural activities for re-occurring patterns (RefRS, RefS, and also for RS) when compared to random patterns (S) was observed in the AC, only for DRC 20dB.
- Gradual change in neural activities along the number of presentations for RefRS was observed.
- Neural recordings using the animal model facilitate understandings of neural mechanisms for the memory processes that are comparable across species.
- Further studies: multi-unit activity recordings, other areas involved in the process.

5. References

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