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Introduction

In a previous study of local field potentials (LFPs) from two neurosurgical patients (Griffiths et al. 2010) we demonstrated induced responses during pitch presentation from auditory cortex in Heschl's Gyrus in the gamma range (80- 120 Hz). The responses occurred when the repetition rate of regular interval noise (RIN) was above the lower limit of pitch. Those responses arose from both medial and lateral HG, whilst previous studies based on the BOLD response in normal subjects demonstrate maxima in lateral HG (although responses are also present in medial HG: see Griffiths et al. 2010 for discussion). In this study we map similar induced gamma responses from depth electrodes in HG across 6 subjects to seek differences in responses in different regions of HG.

Methods

Subjects were six neurosurgical patients undergoing chronic invasive monitoring for medically refractory epilepsy. All research protocols were approved by the NIH and The University of Iowa IRB, and subjects who consented to the research could rescind consent at any time without detriment to their medical evaluation.

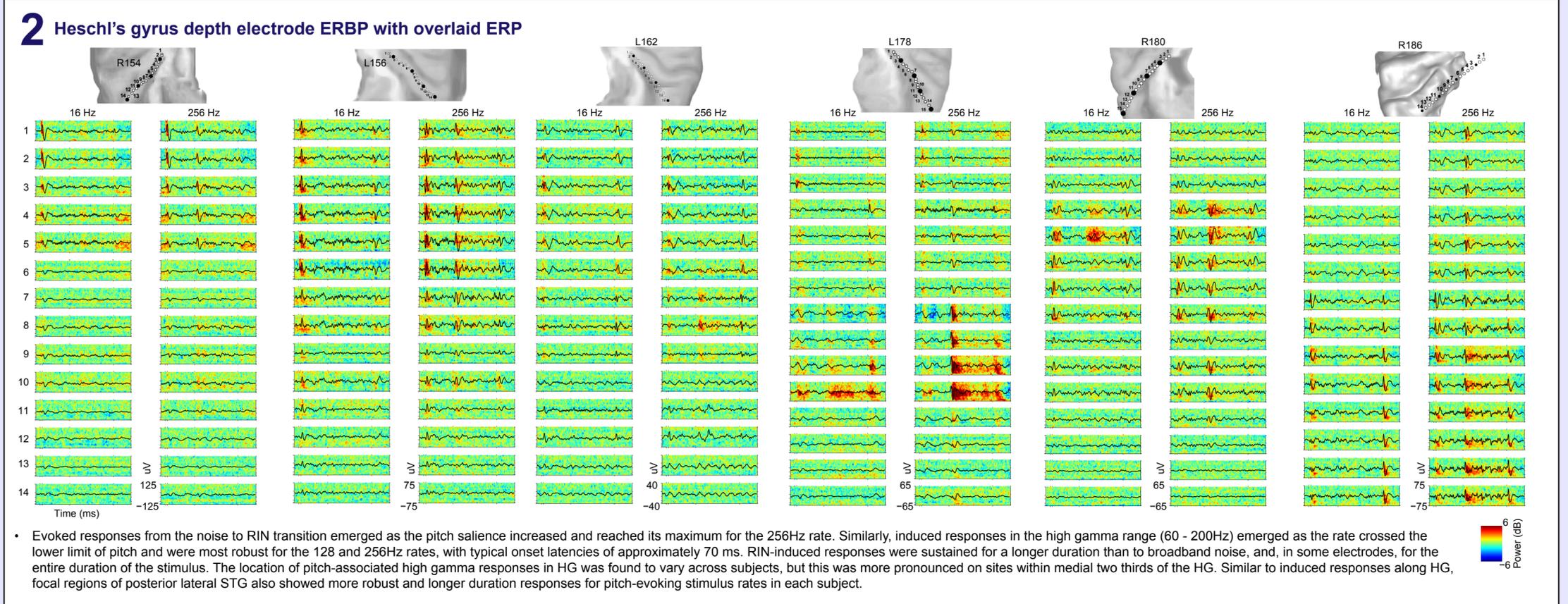
Stimuli were sound complexes consisting of 1 s bursts of broadband noise followed by 1.5 s regular interval noise. See 1 below. RIN stimuli were generated from a random noise using a delay-and-add algorithm with 16 iterations, highpassed at 1 kHz, with a broadband noise below 1 kHz to mask cochlear distortion products. RIN segments were presented at rates (8, 16, 32, 64, 128, 256 Hz) below and above the lower limit of perceived pitch of about 30 Hz (Krumbholz et al., 2000).

Recordings were made simultaneously from Heschl's gyrus (HG) and perisylvian cortex using multicontact depth and subdural grid electrodes, respectively. Locations of recording sites were confirmed by coregistration of pre- and post-implantation structural imaging and aided by intraoperative photographs.

Analysis of recorded responses was done by measuring event-related band power (ERBP) in the high gamma frequency range, normalized relative to a baseline interval (300-100 ms prior to the transition to RIN). Evoked responses (ERPs) were filtered 1-20 Hz.

Conclusions

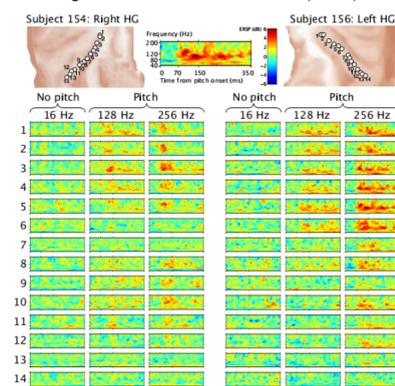
- In general subjects show an increasing function of induced gamma power as a function of stimulus rate across HG electrodes with a "take-off" above the lower limit of pitch at approximately 30Hz (see figure 3).
- The data confirm the presence of high gamma activity in both medial and lateral parts of HG. Modelling work (Kumar et al. 2011) suggests that the activity is not part of a poorly localized region for pitch analysis but distinct components of a pitch system in core and belt homologues respectively.



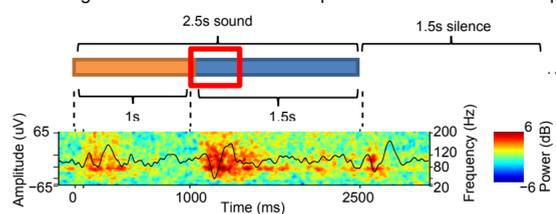
1 Background/Methods

- An earlier report of the experiment with two subjects (Griffiths et al., 2010) found a sustained response in induced high gamma to the RIN stimulus beginning about 70 ms after the transition from the noise stimulus. This response was selective to RIN stimuli above the lower limit of pitch.

Figure 2 results Griffiths et al. (2010)

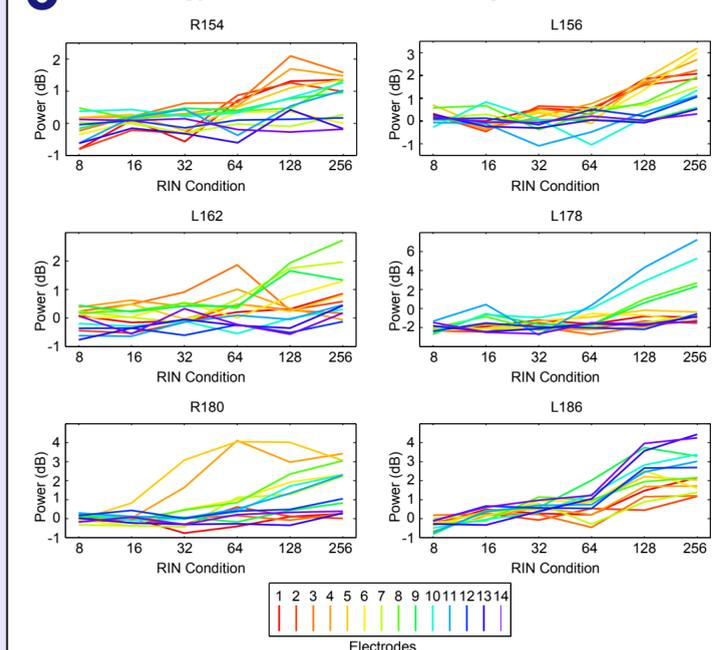


Single trial schematic with example evoked and induced response



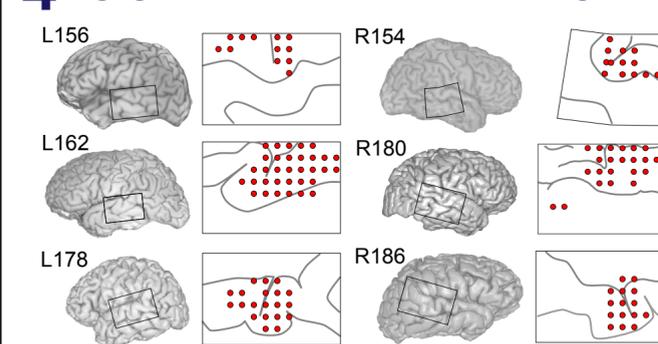
- Schematic of a single 4 sec trial. The red box shows the analysis period shown in the Griffiths et al. (2010) figure from the transition to the RIN stimulus out to 350 ms later.
- An example induced response (ERBP) is shown with evoked response (ERP) overlaid.

3 Heschl's gyrus RIN response tuning



- Heschl's gyrus depth electrode gamma power (80-120 Hz) from 100-300 ms after transition to the RIN stimulus.

4 High gamma ERBP on 96-electrode lateral grid

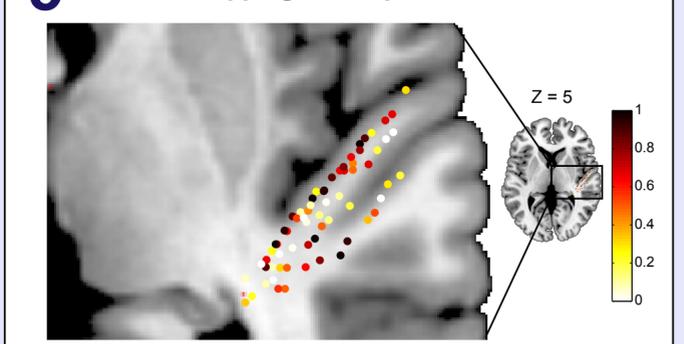


- Brain surface reconstructions for each subject with the 96-electrode grid (5mm spacing) over perisylvian cortex outlined in black.
- Enlargements of the 96-electrode grid are shown for their 256-Hz RIN condition from 100-300 ms after transition to RIN. Electrode sites that exhibited a significant response are filled red. Activity is focal on regions of posterior lateral superior temporal gyrus.

References

Griffiths TD, Kumar S, Sedley W, Nourski KV, Kawasaki H, Oya H, Patterson RD, Brugge JF, Howard MA. Direct recordings of pitch responses from human auditory cortex. *Curr Biol* 20:1128-32, 2010.
 Krumbholz K, Patterson RD, Pressnitzer D. The lower limit of pitch as determined by rate discrimination. *J Acoust Soc Am* 108:1170-80, 2000.
 Kumar S, Sedley W, Nourski KV, Kawasaki H, Oya H, Patterson RD, Howard MA 3rd, Friston KJ, Griffiths TD. Predictive coding and pitch processing in the auditory cortex. *J Cogn Neurosci* 23:3084-94, 2011.

5 Common mapping on template brain



- Heschl's gyrus depth electrode tracks are shown for each subject on an MNI template.
- Normalized high gamma responses demonstrate the distribution of peak activity across HG.
- Note that all electrodes are verified to be in HG gray matter but are projected onto the Z = 5 plane.

Acknowledgements

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