Charting Developmental EEG Gamma Changes in the Auditory Modality

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Introduction

Purpose: To examine evoked and induced gamma band responses to rare target, frequent nontarget, and rare novel auditory stimuli, from ages 7 years to adulthood in single and dual task conditions.

Background: EEG gamma (30 to 100 Hz) may be fundamental to perceptual processes referred to as binding (the integration of thoughts and perceptions). ¹ ² ³

- Auditory stimuli elicit a robust evoked gamma band response (eGBR), phase-locked to stimulus onset, 0-150 ms following it. ³ ⁴ ⁵
- Induced gamma band response (iGBR) is less consistent. When found, it appears later (250 -750 ms post stimulus) and is not phase-locked to the stimulus. Some have also argued that it is apparent in our adult sample (³ ⁴ ⁵).

Method

Participants: See Table 1.

Tasks:

(1) Auditory Novelty Oddball (NOD)
- Targets: 15% of trials, 1500 Hz pure tone
- Nontargets: 70%, 600 Hz pure tone
- Novels: 15%, non-repeating sliding tones

- Preferred hand response to target stimuli
- Binaural presentation through ear inserts

(2) NOD with distracter task (dual-NOD)

Distracter task: Numbers 1 through 9 presented visually every 1000 ms. Response made with non-preferred hand for three odd consecutive numbers.

Data Collection:

- 29 scalp + bipolar EOG sites.
- 500 Hz EEG sampling.
- Bandpass 0.23 - 100 Hz.
- Impedances kept below 5 kOhms.

Data for 9 primary sites were extracted and regions of interest were defined as in Figure 1.

Processing Gamma:

- Data were filtered to within the gamma range (30 to 100 Hz, notch filter of 60 Hz).
- All incorrect trials were discarded.
- Gamma magnitude at 35.2-43.0 Hz was calculated at each sample point starting at 300ms prior to stimulus onset to 750ms after.
- Calculated using FFT (128 ms moving epochs with Hanning window at each data point).

Statistical Analysis:

- Independent variables included age category, stimulus category, the anterior/posterior dimension (frontal, central, & parietal regions), laterality (left and right hemispheres, & midline region), and experimental task (NOD, dual-NOD).
- Gamma power was scored for evoked (0-150 ms) or induced (250-750 ms) compared to a prestimulus baseline (-300 to -100 ms).

Results

Evoked Gamma Band Response (eGBR)

Single Task NOD
- Greater GBR at frontal region (F(2,191) = 18.08, p < 0.001; see Figure 2).
- Within frontal region, novel stimuli produced largest power (F(2,191) = 3.15, p = 0.049; see Figure 3); targets and nontargets were not significantly different.

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Conclusions:

- Novel stimuli produce a dominant frontal eGBR and target stimuli produce a dominant parietal iGBR, consistent with the frontal attention system’s prediction for novelty processing and the parietal attention system’s evaluation processes.
- Novelty increases the eGBR in the right frontal region but decreases the iGBR in the right parietal region; target stimuli increase the iGBR in the right parietal region. The right hemisphere is more sensitive to attentional and stimulus features than the left, due perhaps to the right having greater areas of associative cortex and (the right frontal especially) a better ability to deal with informational complexity. ⁹
- As young as age 7, the eGBR and iGBR has matured and remains consistent throughout the investigated lifespan. This is consistent with the conclusion of Yordanova and colleagues. ⁷

References