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]

- Auditory stimuli elicit a robust **evoked gamma band response** (eGBR), phase-locked to stimulus onset, 0-150 ms following it.[3-7]
- **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 may be linked to the time course of the P3 ERP component.[4, 8]

AGE	GENDER		TOTAL
	M	F	
7 - 9	20	27	47
10 - 12	19	28	47
13 - 15	11	22	33
16 - 18	13	24	37
Adults (19 -25)	10	17	27
Total	73	118	***191***

Table 1. Participants by Gender in each Age Category

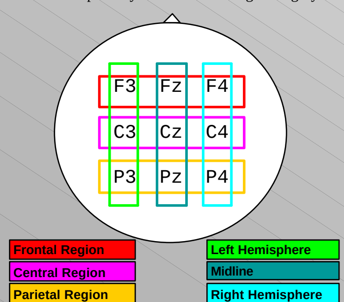

Figure 1. Electrode sites involved in regional analyses

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 eGBR 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.

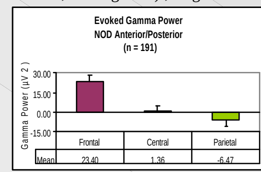

Figure 2. NOD Ant/Pos Effect

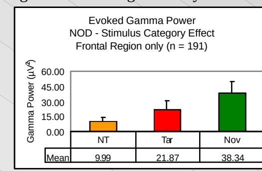

Figure 3. NOD Frontal Category Effect

- Children's (7-18 yrs) data showed no developmental effects. However a large Category x Anterior/posterior x Laterality interaction was found which was not apparent in our adult sample (F (8, 164) = 2.62, p = 0.025, see Figure 4).

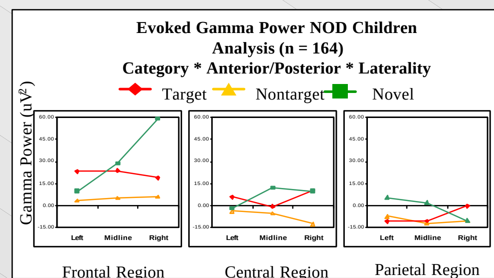

Figure 4. NOD Category by Ant/Pos by Laterality Interaction for ages 7 to18.

Dual-NOD

-The addition of a secondary task to the NOD served only to eliminate the frontal GBR, and any other significant main effects in children and adults.

Induced Gamma Band Response (iGBR)

Single Task NOD

- iGBR was lower at the frontal than parietal region for both target and non-targets, and the reverse for novel stimuli (F (4,191) = 4.42, p = 0.006; see Figure 5)
- At the parietal region, the stimulus differences were greatest at the sites on the right (F (4,191) = 4.20, p = 0.007; see Figure 6)

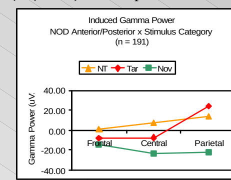

Figure 5. Induced NOD Ant/Pos x Category Interaction

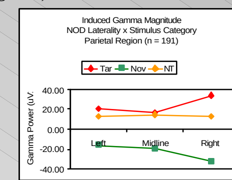

Figure 6. Induced NOD Laterality x Category Interaction for Parietal sites only

- Again, no developmental effects.

Dual-NOD

- In general, the distracter task did not change the relative effects of stimulus category on regional iGBRs (F (4, 191) = 2.88, p = 0.043), but it lowered the iGBR power. This can be seen by comparing Figures 5 and 7.

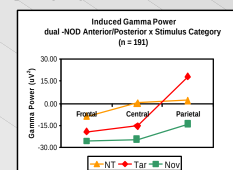

Figure 7. Induced dual-NOD Ant/Pos x Category Interaction

Conclusions:

1. Novel stimuli produce a dominant frontal eGBR and target stimuli produce a dominant parietal iGBR, consistent with the frontal attention system's predilection for novelty processing and the parietal attention system's evaluation processes.
2. 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]
3. 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]

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