

Auditory Evoked Potentials Discriminate between Adults, and Children with and without Sensory Processing Disorders

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Purpose

- To investigate whether the organization of the auditory evoked potentials (AEPs) obtained from presentation of stimuli differing in intensity and frequency can assist in classifying adults, and children with and without sensory processing disorder (SPD) while controlling for the maturation effect (i.e., age) and the number of the trials in the AEP.

Introduction

- The AEPs have been increasingly studied in developmental research in children and young adults.^{1,2}
- The AEPs have exhibited age-related physiological changes, which may reflect the development of complex neural network processes, such as higher stimulus-specificity, automatic information processing, and maturation of adaptive and attention-related processes.³
- Among the AEP components, age-related decreases in the amplitude and latency of the N1 and P2 have been shown across 5 to 20 years.²
- Amplitude changes in the N1/P2 have been shown in response to different stimulus intensities.⁴ Studies have also shown that children with autism do not exhibit increased amplitudes of the N1/P2 in response to increased stimulus intensity compared to typically developing children.^{4,5}
- An age-related increase in amplitude of the N2 has been found from ages 4 to 10 and thereafter an age-related decrease to reach adult level by age 17.²
- Age-related changes of the P3 have been found. Children produced large P3s to the target stimuli with a posterior maximum and start to show the standard adult pattern by age 13.⁵
- There is a paucity of studies examining the organization or inter-relationship of these AEP components. Characterizing the inter-relationship of these AEP components in children with and without SPD may lead to a better understanding of dynamic changes in brain function that contribute to sensory processing dysfunction.

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Method

Participants

- 18 Adults (9 males) aged 20-55 years ($M = 33.28$, $SD = 11.25$)
- 25 typically developing children (13 males) aged 5-10 years ($M = 8.33$, $SD = 1.88$)
- 28 children with SPD (22 males) aged 5-12 years ($M = 7.70$, $SD = 1.80$)

Procedures

- Participants were seated quietly in a relaxed position with eyes opened and listening to auditory stimulus while staring at a fixed object
- Sensory Registration ERP paradigm
 - 100 presentations of each of 4 auditory stimuli
 - 1 kHz at intensity = 50 dB SPL
 - 1 kHz at intensity = 70 dB SPL
 - 3 kHz at intensity = 53 dB SPL
 - 3 kHz at intensity = 73 dB SPL
- Each stimulus duration = 50 ms with 10 ms ramps
- Time between presentation of stimuli = 2 s
- Presented in random order with 100 stimuli per block with a break between blocks

Electrophysiological Recordings

- BioSemi EEG ActiveTwo system
- 32 scalp sites, 2 bipolar eye monitors
- Recorded at A/D Rate = 1024 Hz
- Bandwidth = 268 Hz, Gain: 1000
- Offline filter .23 – 30 Hz band pass
- EOG artifact rejection (+/- 100 μ V)
- Fz, Cz and Pz sites were used for statistical analyses

AEP Component Analyses

- N1: 70 – 140 ms (Adult); 80 – 170 ms (Child)
- P2: 130 – 240 ms (Adult); 130 – 270 ms (Child)
- N2: 200 – 350 ms (Adult); 200 – 375 ms (Child)
- P3: 250 – 400 ms (Adult); 250 – 450 ms (Child)

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Results

Comparison Between Groups via ANCOVA

Peak-to-Peak Amplitude from N1 to P2

- Group(3) x Intensity(2) x Frequency(2) x Site(3) design with number of trials/ERP as the covariate revealed:

- Group $F_{(2,60)} = 6.03$, $p = .004$
- Group x Site $F_{(4,120)} = 7.43$, $p < .0001$
- Site x Intensity $F_{(2,120)} = 4.09$, $p = .019$

Peak-to-Peak Amplitude from N2 to P3

- Group(3) x Intensity(2) x Frequency(2) x Site(3) design with number of trials/ERP as the covariate revealed:

- Group $F_{(2,62)} = 8.17$, $p = .049$
- Group x Site $F_{(4,124)} = 3.20$, $p = .028$
- Site x Intensity $F_{(2,124)} = 3.61$, $p = .036$
- Group x Intensity $F_{(2,62)} = 3.93$, $p = .025$

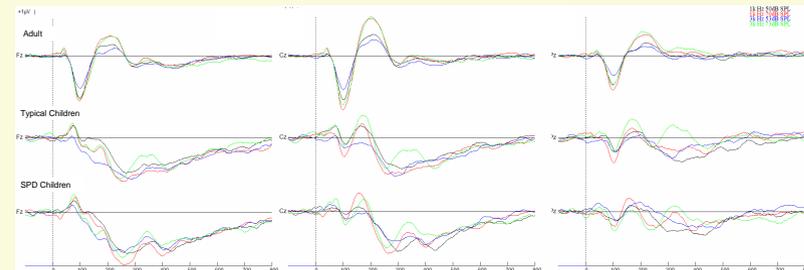


Figure 1 – Grand averaged AEPs for each level of the intensity and frequency at 3 electrode sites for each group

Classification Between Groups

Discriminant Function Analysis - Full Model

- The results revealed two significant functions

- Function 1: $\eta^2 = .052$, $p < .0001$
- Function 2: $\eta^2 = .391$, $p < .0001$
- Correct Classification: Over All = 95.2%
Adult = 100%; Typical = 90%; SPD = 96%

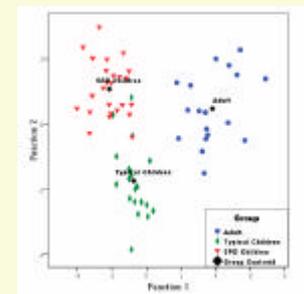


Figure 2 – The territorial map of the full model analysis

Discriminant Function Analysis - Stepwise

- The results revealed two significant functions

- Function 1: $\eta^2 = .102$, $p < .0001$
- Function 2: $\eta^2 = .622$, $p < .0001$
- Correct Classification: Over All = 85.3%
Adult = 100%; Typical = 78.3%; SPD = 81.5%

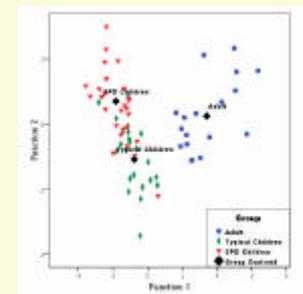


Figure 3 – The territorial map of the stepwise analysis

Full Model Analysis Revealed

- Function 1 separated adults from children with principal variable being:
 - The amplitude difference of the N1-P2 for 3k Hz stimulus at Pz ($\beta = .620$)
- Function 2 separated typical children from SPD children with the principal variables being:
 - The amplitude difference of the N2-P3 for 1k Hz stimulus at Fz ($\beta = .794$)
 - The latency difference of the N1-P2 ($\beta = .608$) for 3k Hz stimulus at Fz
 - The latency difference of the N2-P3 ($\beta = .770$) for 3k Hz stimulus at Fz

Stepwise Analysis Revealed

- Function 1 separated adults from children with principal variable being:
 - The amplitude difference of the N1-P2 for 3k Hz stimulus at Pz ($\beta = .418$)
- Function 2 separated typical children from SPD children with the principal variable being:
 - The latency difference of the N2-P3 ($\beta = .747$) for 3k Hz stimulus at Fz

In Both Analyses: The maturation variable (Age) and the number of trials/AEP were mediator variables.

Conclusions

- The organization of the AEPs successfully discriminated between adults, typical children and SPD children with 95.2% accuracy.
- The AEPs may serve as a clinical tool to identify children with sensory processing disorders.

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