Predicting Sensory Gating Measures From Sensory Registration Measures in Children with and without Sensory Processing Disorders

William J. Gavin, Patricia L. Davies, Wen-Pin Chang
Department of Occupational Therapy, Colorado State University

Purpose

Explore the contribution of following variables to account for individual differences in sensory gating.

- Maturation as measured by Age
- Organization of the brain's response to auditory stimuli differing in intensity and frequency
- Diagnosis of a sensory processing disorder

Introduction

Studies of sensory gating in children with and without disabilities have shown large within group variances. Freedman, et al. (1987) studied 108 typical children aged 1-19 years. They reported that the P50 T/C ratio in typical children ranged from 0 to 1. Myles-Worsley et al. (1996) examined the developmental and genetic influences on the P50 sensory gating in 127 participants ages 10-39 years. Contrary to Freedman et al. (1987), their results indicated that there was not a difference in the P50 ratio between children and adults. Kemner, et al. (2002) examined 12 children with autism and 11 children without autism aged 7-13 years. The mean P50 T/C ratio for typical children was .47 (*SD* = .50) and for children with autism was .28 (*SD* = .36). Marshall, et al. (2004) included a group of 10 outgoing children, a group of 12 socially withdrawn children, and an "unselected" group of 10 children, all within the ages of 7-13 years old. The mean P50 T/C ratio across whole sample was .90 (*SD* = .53).

Measures of brain response to simple auditory stimuli might provide insight to the sources of variability in children. For example, Lincoln et al. (1995) investigated N1 and P2 amplitude and latency differences based on changes in stimulus intensity and frequency (Hz), assessing the regulation of sensory input in children 8 to 14 years old with and without autism. According to Lincoln et al. (1995), children with autism do not show an increase in N1 amplitude in response to increased auditory stimuli intensity compared to normal children.

Characterizing the sources of the individual differences in sensory gating in young children may lead to better early detection and treatment of children with sensory processing disorders.

References

Freedman, R., Adler, L.E., & Waldo, M. (1987). Gating of the auditory evoked potential in children and adults. *Psychophysiology*, 24, 223-227.
Kemner, C., Oranje, B, Verbaten, M.N., & van Engeland, H. (2002). Normal P50 gating in children with autism. *Journal of Clinical Psychiatry, 63*, 214-217.
Lincoln, A. J., Courchesne, E., Harms, L., & Allen, M. (1995). Sensory modulation of auditory stimuli in children with autism and receptive developmental language disorder: Event-related brain potential evidence. Journal of Autism and Developmental Disorders, 25, 521-539.
Marshall, P. J., Bar-Haim, Y., & Fox, N. A. (2004). The development of P50 suppression in the auditory event-related potential. *International Journal of Psychophysiology, 51*, 135-141.
Myles-Worsley, M., Coon, H., Byerley, W., Waldo, M., Young, D., & Freedman, R. (1996). Developmental and genetic influences on the P50 sensory gating phenotype. *Biological Psychiatry*, 39, 289-295.

Method

Participants

- 18 Adults aged 21 to 55 years (9 females & males)
- 53 children aged 5 to 12 years
  - 25 typical children (12 females & 13 males)
  - 28 children with sensory processing disorders (6 females and 22 males)

Procedures

- Participants were seated in a semi-reclined position with eyes opened quietly listening to auditory clicks while watching a silent movie or to tones while staring at a fixed object
- Auditory threshold testing
- Sensory Gating ERP paradigm
  - Click intensity = ~ 85 dB SPL
  - Click duration = 3 ms
  - Paired-clicks paradigm with SOA = 500 ms
  - Time between presentation of pairs = 10 s
  - 120 pairs of clicks were presented while watching a silent movie
- 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 = 52 dB SPL
    - 3 kHz at intensity = 73 dB SPL
  - Each tone duration = 50 ms with 10 ms ramp
  - Time between presentation of stimuli = 2 s
  - Presented in random order with 3 breaks while staring at a fixed object on computer screen

Electrophysiological Measurements

- 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 10-200 Hz band pass for scoring P50
- Offline filter .23-30 Hz band pass for scoring N1&P2
- EOG artifact rejection (+/- 100 µV)
- Cz site was used for statistical analyses

Results

Findings for Sensory Gating – P50

- Significant differences between the amplitude of Conditioning click (click 1) and that of Test click (click 2) were found for all 3 groups - see Figure 1.
- P50 T/C ratios were lowest for Adults and highest for children with SPD – see blue text in Figure 1.
- Significant differences between the mean T/C ratios of Typical children and children with SPD. The mean T/C ratios of both child groups were significantly different from the Adults – see green text in Figure 1.

Findings for Sensory Registration

- Mean N100 amplitude was the largest for adults and smallest for SPD children for all tones except for 3K at 73 dB tone, Typical children had smallest - see Figure 2.
- Mean N100 latency was the shortest for adults and longest for the SPD children for all tones.
- Adults significantly differed in amplitude and latency of N100 from both the Typical and the SPD children. Typical and SPD children did not differ from each other except for latency of 3K at 73dB tone.
- Mean P200 amplitude was the largest for adults and smallest for SPD children for all tones.
- Mean P200 latency was the for longest adults and the shortest for the Typical children.
- Adults significantly differed in both amplitude and latency measures from both child groups. The child groups did not significantly differ from each other.

Developmental Trends

- For the Typical children P50 T/C ratios were significantly correlated with age (r = -.60, p = .001) (see red line in Figure 3).
- Age did not correlate with P50 T/C ratios (r = -.08, p =.34) for the SPD children (blue line in Figure 3).
- For Typical children only, N100 amplitude for the two high intensity tones correlated with Age (r = .46 & .58, p = .023 & .004)
- For Typical children only, P200 amplitude correlated with Age for 3 tones (r >.47, p = .023), not the 1k Hz at 50 dB tone (r = .40, p = .06).

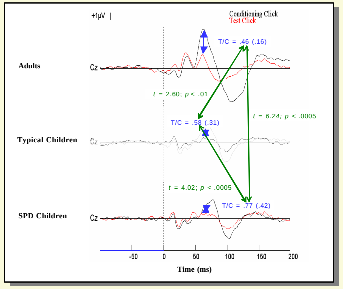

Figure 1 – Grand averaged waveforms for each group showing Sensory Gating responses at P50

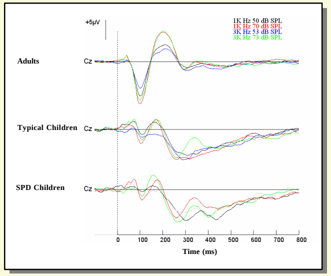

Figure 2 – Grand averaged waveforms for each group showing responses during the Sensory Registration Paradigm

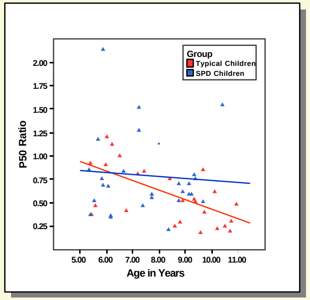

Figure 3 – Age by P50 T/C ratios for each child group

Sensory Registration Predicts Gating

- A regression analysis (3 step model) revealed that the P50 T/C ratios can be predicted from the Age, and the N100 and P200 peak-to-peak amplitude and latency measures of the 4 tones for the Typical children but not for the SPD children.
  - R^2 = .84 (Adj. R^2 = .74) $F_{(9,22)}$ = 7.41, p = .001.
  - Age accounted for 32% of the variance.
  - N1 amplitudes & latencies accounted for 49%
  - P2 amplitudes & latencies accounted for 3%
- Residuals for Typical and SPD children derived from the prediction equation of the above regression analysis revealed that the SPD children are distributed above and below levels of the Typical children (see Figure 4).

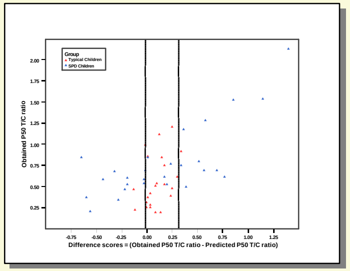

Figure 4 – Separation of SPD children from Typical children

Conclusions

- Children with SPD displayed significantly less P50 sensory gating and more variability than typical children and adults.
- There was a developmental trend in P50 sensory gating in the Typical children but not for children with SPD.
- Organization of auditory responses to intensity and frequency manipulations predict P50 gating in Typical children, but not in children with SPD. Factors other then age and auditory organization must account for the sensory gating variability seen in children with SPD.

Acknowledgements: Funded in part by Wallace Research Foundation to PLD & WJG, from NICHD to PLD, and by Helen F. McHugh Graduate Fellowship to W-PC. Thanks to Dr. Lucy Miller for loaning the project use of her EEG system.

Address correspondence to: William J Gavin, Colorado State University, 219 Occupational Therapy, Fort Collins, CO 80523.
E-mail: bill.gavin@colorado.edu

Presented at the 45th Annual Meeting of the Society for Psychophysiological Research, Lisbon, Portugal. September 21–24, 2005.