Electrophysiological markers of atypical auditory temporal processing associated with symptom severity in autism spectrum disorder

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BACKGROUND

- Sensory processing abnormalities are amongst the most commonly reported symptoms associated with Autism Spectrum Disorder (ASD).
- Auditory processing is a particular area in which both clinical report and experimental evidence indicate atypicalities in ASD.
- Our previous studies have revealed impaired auditory temporal processing in children with ASD with regard to their ability to:
  - Resolve the temporal order of two sequential auditory stimuli presented at brief intervals, using a temporal order judgment task.[4]
  - Detect brief silent gaps in auditory stimuli, using a classic gap detection paradigm.
- Abnormalities in processing of timing information have been posited to underlie core ASD symptoms, and difficulties with auditory temporal processing could relate to language processing deficits.
- The neural basis of auditory temporal processing deficits in ASD remains unknown.

Objective

- To explore the brain basis of auditory temporal processing deficits in ASD using electrophysiology and to examine relations among neural markers of auditory temporal processing and clinical features of ASD.

METHOD

Participants

- 15 children with ASD and 17 children with TD (10-13 years old)
- ASD diagnoses confirmed with ADOS and ADI-R administration, and clinical judgment of a licensed psychologist using DSM-IV-TR criteria
- Typical hearing abilities, confirmed with behavioral audiometry
- No psychotropic medications

	Age	Sex	Handedness	WASI Full Scale IQ
ASD	11.86 (1.4)	14 M; 1 F	12 R; 3 L	118.27 (13.8)
TD	12.23 (1.2)	17 M; 0 F	14 R; 1 L	112.56 (12.6)

* No group differences in age, sex, handedness, or IQ

Clinical Assessments

- ADOS and ADI-R: Reciprocal Social Interaction, Communication, Repetitive Behavior Domain Scores
- Clinical Evaluation of Language Fundamentals – 4th Edition (CELF-4)
- Comprehensive Test of Phonological Processing (CTOPP)

References: [1]Kellerman, Fan & Gorman, 2005, CNS Spectr.; [2]Foss-Feig, Stone, & Wallace, 2013, IRRDD; [3]Rosen, 1992, *Philos Trans R Soc Lond B Biol Sci*; [4]Kwakye, Foss-Feig, Cascio, Stone, & Wallace, 2011, Front Int Neurosci

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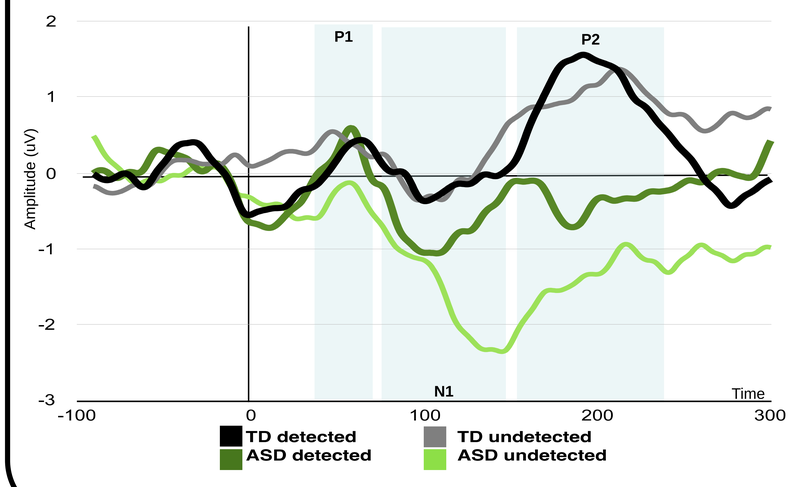
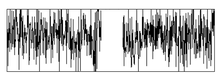
RESULTS



Experimental Stimuli

- 1000ms white noise bursts, either continuous or with silent gaps (1-30ms gap duration)
- All silent gaps onset 400ms after initial stimulus onset
- Near-threshold (i.e., 3ms) gaps were the focus of analyses



Experimental Task Procedures

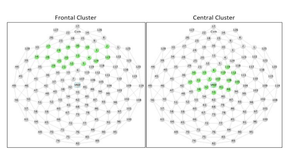
- On each trial, participants were presented with a single stimulus, either continuous or containing a silent gap.
- Participants were asked to make forced choice decisions, using a button press response, as to whether a gap was present (i.e., yes or no).
- Inter-trial interval of 800-1500ms; 3000ms response window for each trial.

ERP Data Acquisition

- 128-channel EGI nets
- Sampled at 1000 Hz
- Impedances < 40 kOhms
- Filtered 0.1-100Hz with 60Hz notch
- Segmented to gap onset: (100 ms pre-stimulus; 700 ms post-stimulus)
- Artifact detection
- Re-referenced to average reference
- 100ms baseline correction

ERP Extraction

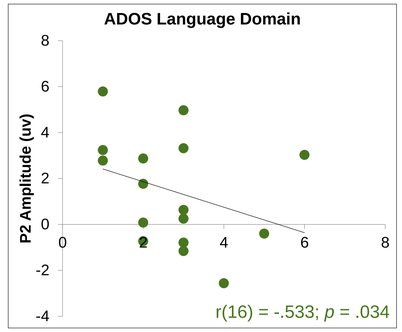
- Components: P1 (40-80ms), N1 (60-130ms), and P2 (120-220ms)
- Mean amplitude and latency to peak amplitude
- Frontal and central scalp
- By Condition: Gap onset, separately for behaviorally **detected** and **undetected** gaps

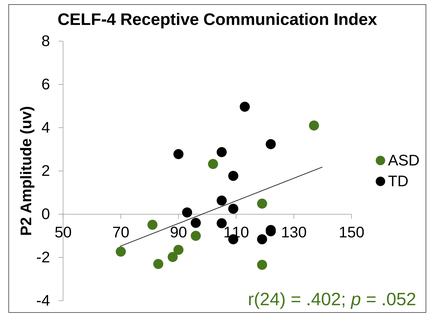


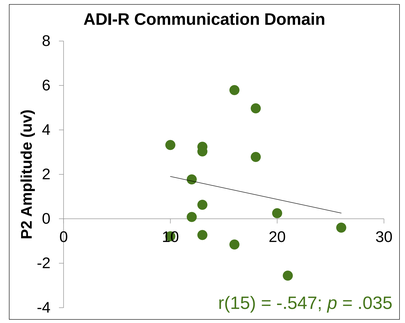
Clusters determined with spatial principal components analysis (sPCA) procedures

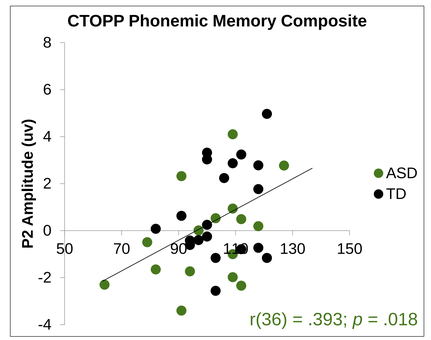
RESULTS

To onset of near-threshold gaps, N1 latency over central electrodes was prolonged for detected vs. undetected gaps in ASD, but did not differ by behavioral detection in TD. Central P2 amplitude was significantly smaller in ASD than TD overall, $F(1,31) = 8.27$, $p = .007$. Additionally, P2 amplitude for undetected versus detected gaps was marginally smaller in ASD, $t(15)=1.79$, $p = .094$, whereas it did not differ by behavioral detection in TD ($p = .94$).









Among children with ASD, P2 amplitude to detected gaps correlated significantly with both parent-reported and clinician-observed ASD symptomatology. Across both ASD and TD groups, stronger P2 amplitude during gap detection was associated with better language functioning.

CONCLUSIONS

- Results suggest delayed orienting of attention (N1) and reduced classification (P2) of near-threshold silent gaps in auditory stimuli in children with ASD, which could explain behavioral deficits in auditory temporal processing and be consistent with clinically observed sensory hyposensitivity.
- P2 amplitude during auditory gap detection was significantly associated with clinical symptoms in ASD and with language functioning across both ASD and TD. Attenuated neural response to near-threshold gaps was associated with ASD language and communication symptoms, whereas more robust response was associated with better receptive language and phonemic memory.
- This research suggests aberrant neural response to low-level sensory information in ASD, which could play an important role in higher-level symptomatology in domains including social communication and language processing.

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