Resting State EEG and Sensory Responsivity in ASD and Schizophrenia

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Background

- Atypical sensory experiences and responses are frequently reported and displayed by individuals with autism spectrum disorder (ASD).
- Across different sensory modalities, individuals may experience hyper- or hyposensitivity to certain stimuli and react with sensory-avoidant or sensory-seeking behaviors.
- Atypical sensory experiences and responses are frequently reported by individuals with schizophrenia spectrum disorders (SZ), as well as by many typical adults, suggesting that these sensory features vary continuously throughout the population.
- Increased understanding of the mechanisms underlying the heterogeneity of sensory profiles in individuals with and without ASD will inform understanding of sensory responsivity more broadly and may guide clinical management of sensory issues that interfere with daily living.
- This study sought to examine (1) variation in EEG power spectra associated with differences in individuals' sensory responsivity and (2) how these associations differ between individuals with ASD, SZ, and typically developing adults (TD).

Methods

Group	N (N males)	Mean Age	Min. Age	Max. Age
ASD	32 (23)	25	17	41
SZ	16 (15)	24.75	19	43
TD	20 (10)	24.78	18.7	35.7

EEG Data Acquisition, Pre-processing, and Analysis:

- EEG recorded at 500 Hz with 128-channel Hydrocel Geodesic Sensor net, as participants alternated between watching abstract screensaver videos and sitting with their eyes closed.
- Data were filtered from 0.1-100 Hz, re-referenced to average reference, and divided into 2-second segments. Segments containing artifacts were rejected, and subjects with less than 30 seconds of artifact-free EEG data were excluded.
- Power spectra were generated for prespecified scalp regions (see Figure 1; two-toned circles indicate that electrodes were analyzed as part of multiple regions), for the delta (1-4 Hz), theta (4-6 Hz), alpha (6-13 Hz), beta (13-30 Hz), and gamma (30-80 Hz) frequency bands using EEGLAB and FieldTrip.

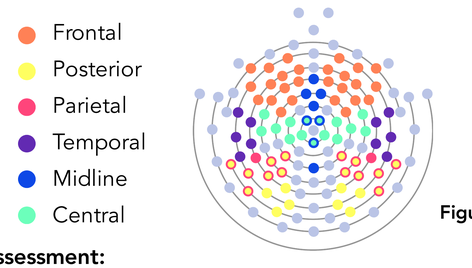

Figure 1

Behavioral Assessment:

- To quantify sensory sensitivity and responsivity, participants were administered the Glasgow Sensory Questionnaire (GSQ), a 42-question self-report instrument that quantifies visual, auditory, gustatory, olfactory, tactile, vestibular, and proprioceptive hypo- and hypersensitivity.

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Results

Sensory Sensitivity and Responsivity Across Diagnostic Groups:

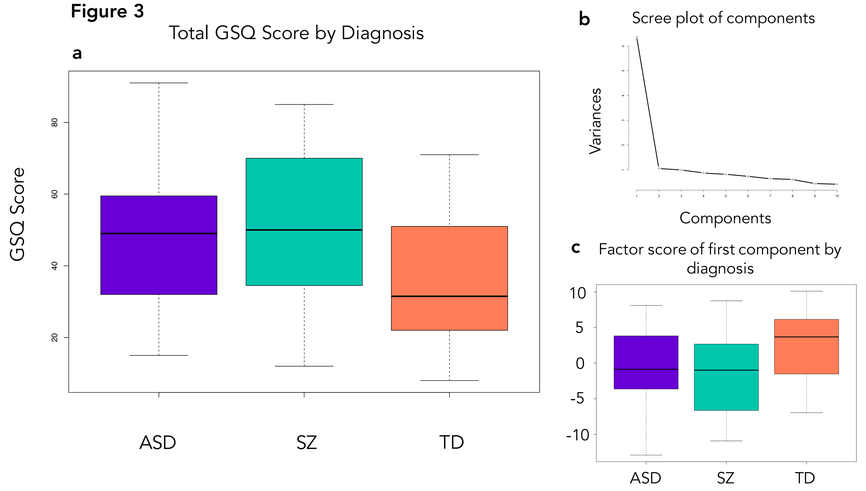
- Summary statistics are presented for the hypo-, hyper-, and total sensitivity scores for each sensory modality by diagnostic group (Figure 2). One-way ANOVAs were conducted, comparing the mean scores on each subscale between ASD, SZ, and TD groups.

Figure 2

	ASD	SZ	TD	F(2,67)	*p*
Visual Hypersensitivity	3.09	4.13	2.45	2.283	0.110
Visual Hyposensitivity	3.25	3.63	2.55	1.488	0.234
Visual Total	6.34	7.75	5.00	2.414	0.097
Auditory Hypersensitivity	6.22	5.25	5.10	1.399	0.254
Auditory Hyposensitivity	5.06	5.50	4.20	1.843	0.166
Auditory Total	11.28	10.75	9.30	1.573	0.215
Gustatory Hypersensitivity	3.56	3.19	2.40	2.094	0.131
Gustatory Hyposensitivity	2.28	2.69	1.90	0.776	0.465
Gustatory Total	5.84	5.88	4.30	1.552	0.220
Olfactory Hypersensitivity	3.13	3.31	2.65	0.447	0.641
Olfactory Hyposensitivity	1.91	3.31	2.60	3.636	**0.032**
Olfactory Total	5.03	6.63	5.25	1.267	0.289
Tactile Hypersensitivity	3.25	2.56	3.25	0.627	0.537
Tactile Hyposensitivity	4.16	4.44	3.05	3.601	**0.033**
Tactile Total	7.41	7.00	6.30	0.700	0.500
Vestibular Hypersensitivity	2.81	3.75	2.30	2.319	0.106
Vestibular Hyposensitivity	2.41	3.13	1.20	3.712	**0.030**
Vestibular Total	5.22	6.88	3.50	4.318	**0.017**
Proprioceptive Hypersensitivity	1.84	2.94	1.25	4.290	**0.018**
Proprioceptive Hyposensitivity	3.59	3.38	2.20	3.452	**0.038**
Proprioceptive Total	5.44	6.31	3.45	5.171	**0.008**
Overall Hypersensitivity	23.91	25.13	19.40	1.668	0.197
Overall Hyposensitivity	22.66	26.06	17.70	3.481	**0.037**
Total GSQ Score	46.56	51.19	37.10	2.724	0.073

- Principal components analysis confirmed that variance in the GSQ loaded on a single component (Figure 3b and 3c), supporting use of total GSQ score as a proxy for sensory responsivity when examining correlations between brain and sensory profile.

Figure 3



Results

- Linear regression models examining the relationship between total score on the GSQ and power in each region and frequency band did not suggest any significant independent effects of sensory responsivity on power. Relationships were modeled as follows, including both main and interaction effects:
  Power of frequency band in given region ~ Diagnosis * Total GSQ Score
- Oscillatory power in theta and delta bands at temporal electrodes revealed an interaction effect of sensory responsivity and diagnosis on power.
- Left temporal theta power showed main effects of ASD diagnosis (β = 33.5, p = 0.006) and SZ diagnosis (β = 40.2, p = 0.004), such that left temporal theta power was greater in individuals with ASD than in TD controls, and greater in individuals with SZ than in either of the other groups. This effect was modulated by an interaction effect of GSQ score such that among individuals with diagnoses of ASD or SZ, lower GSQ scores were associated with greater temporal theta power (ASD: β = -0.59, p = 0.026; SZ: β = -0.58, p = 0.039; Figure 4a and 4b).
- Left temporal delta power showed a main effect of ASD diagnosis on power such that individuals with ASD exhibited greater left temporal delta power compared to TD controls (β = 69.7, p = 0.021), with an interaction effect of GSQ score suggesting that left temporal delta power was greater in individuals with ASD and low GSQ scores than in individuals with ASD and high GSQ scores (β = -1.51, p = 0.024; Figure 4c).

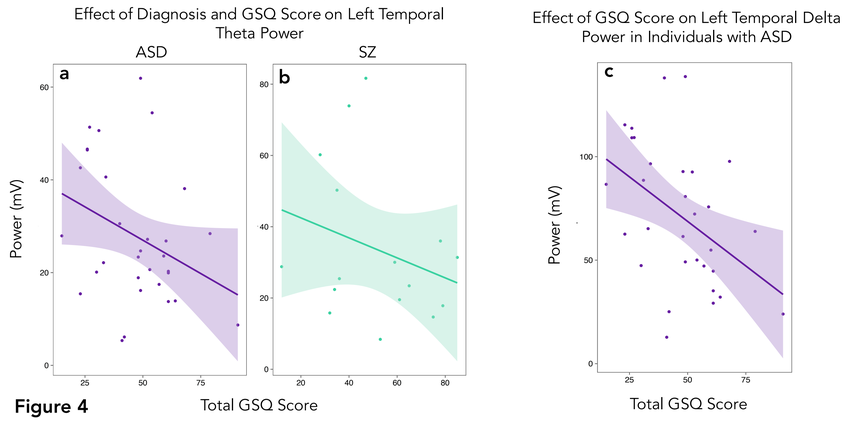


Figure 4

Conclusions

- Analysis of resting state EEG data suggests that variation in the power of low frequency oscillations within the brains of individuals with ASD and SZ may be associated with sensory responsivity.
- Future research should examine sensory responsivity in a more granular way; while the GSQ differentiates heightened or dampened sensitivities among sensory modalities, a next step will be to differentiate between perceptual and behavioral/affective components of sensory responsivity.
- Relationships between resting EEG and dimensional variation in sensory responsivity require replication in larger samples.
- Some areas that have been implicated in past studies of sensory responsivity are deeper brain structures, and as such may not be effectively measured by EEG, which measures oscillatory activity primarily from cortex.
- EEG may not be an optimal modality for examining the relationship between resting state brain activity and sensory responsivity, as many sensory features of the EEG may cause stress or discomfort to individuals with hypersensitivites.