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Abnormal EEG Power Spectrum in individuals with high autistic personality traits: an eLORETA study

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Abstract

Aim: Autistic traits lie on a continuously distributed spectrum ranging from non-clinical to clinical conditions. Indeed, autistic traits have been observed in general population at sub-threshold levels. Here, the main aim was to investigate differences in resting state (RS) electroencephalographic (EEG) power spectrum in individuals with high vs. low autistic traits.

Methods: Fifty undergraduates completed the Autism-Spectrum Quotient (AQ) and the Empathy Quotient (EQ). For each participant five minutes of RS-EEG were recorded and analysed by means of the exact Low-Resolution Electric Tomography software (eLORETA).

Results: A Two-Step Cluster Analysis revealed two groups: high autistic traits (AT+) and low autistic traits (AT−) group. Compared to AT−, AT+ individuals showed an increase of delta power in parietal/occipital and cortico-limbic areas. No alterations were observed in other frequency bands. Furthermore, both AQ and EQ total scores were positively correlated with delta EEG power after controlling for sex, age, and subclinical psychopathological traits.

Conclusions: Results show that AT+ individuals exhibit an increase in slow RS EEG power in regions involved in self-referential processes, suggesting a reduction in these internally directed mental activities and adding new evidence on the existence of a continuum in the autistic spectrum which spreads from clinical to non-clinical significance.

Keywords: Autism Spectrum Disorders; Autism Spectrum Quotient; Autistic traits; EEG Power Spectra; eLORETA; Empathy quotient; Personality; Psychopathology.

1. Introduction

Autism Spectrum Disorders (ASDs) are a set of heterogeneous highly heritable neurodevelopmental conditions characterized by repetitive behaviours and limited interests alongside a persistent impairment in social cognition (American Psychiatric Association 2013), including empathy domain (Baron-Cohen, 1995). Although from a clinical point of view it is necessary to meet certain criteria to receive a diagnosis of ASDs (American Psychiatric Association 2013), some evidences suggest that autistic traits could also be observed at sub-threshold levels in general population (Constantino and Todd 2003, 2005; Posserud et al. 2006). These traits are considered highly stable (Robinson et al. 2011), especially in males (Whitehouse et al. 2011). Furthermore, it has been proposed (Abu-Akel et al. 2019; Wakabayashi et al. 2006), that in the general population, autistic traits are independent of the big five personality dimensions and may represent a sixth factor of personality (i.e., individual differences in autism-related domains such as communication, social skills, and attention to details). These evidences suggest that autism could be considered a condition extending along a continuum, which spreads from clinical significance to non-clinical individual difference (Constantino and Todd 2003; Robinson et al. 2016). In fact, as reported (Skuse et al. 2009; Spiker et al. 2002), autistic traits show a graded nature in which ASDs represent the extreme condition and in which non-clinical individuals and clinically affected individuals are related to the same genetic susceptibilities (Lundstrom et al. 2012).

From a neurobiological point of view, several studies have shown functional (Iidaka et al. 2019; Pierce et al. 2001) and structural abnormalities in subjects with ASDs (Sparks et al. 2002), including alterations in social cognition-related brain areas (e.g., fusiform face area and amygdala) (Pinkham et al. 2008). Moreover, functional Magnetic Resonance Imaging (fMRI) studies suggest that, compared to controls, patients with ASDs show an absent or a diminished activation in task-related regions (e.g., fusiform face area) in favour of an enhanced activity in task-unrelated areas (e.g., primary visual cortex) during perceptual and sensorimotor tasks (e.g. visually guided saccade task, face/shape perception tasks; Pierce et al. 2001; Takarae et al. 2007). Furthermore, task-free

condition studies in individuals with ASDs reported functional alterations in Resting-State (RS) related networks, particularly the Default Mode Network (DMN) (Cherkassky et al. 2006; Yerys et al. 2015). Lastly, quantitative electroencephalographic (qEEG) studies (i.e., numerical computations of EEG parameters) showed several neurophysiological alterations in individuals with ASDs during RS, such as higher power both in slow (mainly delta and theta) (Chan et al. 2007; Pop-Jordanova et al. 2010) and high frequency bands (i.e., beta and gamma; Murias et al. 2007; Orekhova et al. 2007).

Although a large body of literature have explored the neural correlates of ASDs in the clinical samples (Iidaka et al. 2019; Pierce et al. 2001; Sparks et al. 2002), few studies have focused on non-clinical subjects with high autistic personality traits (von dem Hagen et al. 2011). Investigating the association between neurophysiological alterations and autistic traits in non-clinical samples is considered an important research topic in order to understand the neural correlates of ASDs within a dimensional perspective (Barttfeld et al. 2013).

Von dem Hagen et al. (2011) reported in subjects with high autistic traits structural and functional alterations in the posterior superior temporal sulcus (a brain region involved in processing social stimuli), which is known to be also altered in individuals with ASDs (Shih et al. 2011). Alterations in cortical motor areas (e.g., supplementary motor area, motor and pre-motor cortex) have also been observed in a qEEG study performed during action observation task in individuals with high autistic traits (Puzzo et al. 2010).

Although RS EEG is a suitable technique to explore ASD-related abnormalities at different ages and all over the spectrum (Wang et al. 2013), up to now, qEEG correlates during RS in non-clinical individuals with high personality autistic traits have been rarely investigated (Barttfeld et al. 2013; Carter Leno et al. 2018; Moore and Franz 2017). Barttfeld et al. (2013) documented a significant negative association between EEG functional connectivity (mainly in delta and theta bands) and increased levels of autistic traits. Carter Leno et al. (2018) reported a positive correlation between behavioural rigidity autistic trait and absolute alpha power in the parietal scalp region.

Lastly, Moore et al. (2017), in a within EEG study design, showed that autistic traits were positively associated with the difference between eyes-closed RS and eyes-open RS in the distribution of alpha and beta power in the parietal areas (i.e., high levels of autistic traits predicted a greater tendency for both alpha and beta power to be lower during eyes-open RS compared to eyes-closed RS).

The RS qEEG differences between individuals with high and low autistic personality traits have been still rarely investigated. Furthermore, it is possible that the relation between autistic traits and qEEG data found by previous studies is partially mediated by other potential variables (e.g., sex and general psychopathology). Therefore, the main aim of the present study was to extend previous studies, investigating differences in RS EEG power spectrum in individuals with high vs. low autistic personality traits, using the exact Low Resolution Electric Tomography software (eLORETA) a validated tool for localizing electrical brain activity (Pascual-Marqui et al. 2011). Furthermore, another aim was to investigate the association between qEEG data and autistic traits controlling for sex, age and psychopathology.

2. Materials and methods

2.1 Participants

Participants were 50 students (thirty-six women) enrolled through advertisements posted in the university. Enrolment procedures lasted from November 2017 to April 2018. The following inclusion criterion was considered: age between 18 and 30 years. Exclusion criteria were: left-handedness; head trauma; diagnosis or a history of major psychiatric disorders; history of neurological diseases and the previous central nervous system active drugs intake in the last two weeks before the assessment. A checklist with dichotomous items was used to assess inclusion/exclusion criteria and socio-demographic data. All participants received information concerning the aims and the procedures of the study, all of them subscribed the informed consent which was approved by the local ethics committee according to the Helsinki Declaration standards.

153

154 *2.2 Questionnaires*

155 All participants completed the Autism-Spectrum Quotient (AQ; Baron-Cohen et al. 2001b), the
156 Empathy Quotient (EQ; Baron-Cohen and Wheelwright 2004) and the Brief Symptom Checklist
157 (BSI; Derogatis and Melisaratos 1983).

158

159 *2.2.1 The Autism-Spectrum Quotient (AQ).* The AQ (Baron-Cohen et al. 2001b) is a widely used
160 self-report to assess autistic traits in adult population. It is composed of 50 items divided into 5
161 subscales of 10 items (rated on a 4-point scale from "Definitely agree" to "Definitely disagree"), in
162 which each subscale concerns a psychological domain implicated in ASDs (e.g., detail-oriented
163 attention). The AQ also provides a global score, with higher values reflecting higher levels of
164 autistic traits. From a psychometric point of view, the AQ has shown both good internal consistency
165 and test-retest reliability (Baron-Cohen et al. 2001b). Furthermore, the AQ scores predict
166 performance in tasks involving ASDs impaired cognitive function, both in clinical and in general
167 population (Baron-Cohen et al. 2001a; Grinter et al. 2009). In the current study the Italian version
168 of AQ (Ruta et al. 2012) has been used and AQ total score has been considered. In the present study
169 the Cronbach's α was 0.84 for the AQ total score.

170

171 *2.2.2 The Empathy Quotient (EQ).* The EQ (Baron-Cohen and Wheelwright 2004) is a forced-
172 choice self-report questionnaire developed for people with normal intelligence used both in clinical
173 and in general adult population. EQ is composed by 20 filler items and 40 items that assess
174 affective, behavioural and cognitive empathic features (Baron-Cohen and Wheelwright 2004). The
175 EQ also provides a global score designed to assess the overall levels of empathy with higher values
176 reflecting higher levels of empathy. The EQ is often used in combination with the AQ due to their
177 inverse correlation and this aspect could be considered an important sign of EQ validity (Baron-
178 Cohen and Wheelwright 2004). Indeed, due to the centrality of this deficit in detecting others'

179 mental states, autism has also been conceptualized as an empathy disorder (Yirmiya et al. 1992;
180 Baron-Cohen and Wheelwright 2004; Gillberg 1992). Satisfactory psychometric properties have
181 been reported in the original validation study (Baron-Cohen and Wheelwright 2004) and in the
182 Italian version (Preti et al. 2011) which was used in the present study. Good internal consistency for
183 the EQ total score (Cronbach's α= 0.89) was also observed in the current sample.
184
185 *2.2.3 The Brief Symptom Inventory (BSI).* The BSI is a widely used 53-item self-report which
186 assesses psychopathology both in clinical and in general population, measuring several
187 symptomatologic dimensions: somatization (SOM), obsessive-compulsive symptoms (OC),
188 interpersonal sensitivity (IS), depression (DEP), anxiety (ANX), hostility (HOS), phobic anxiety
189 (PHOB), paranoid ideation (PAR) and psychoticism (PSYC). The BSI provides some distress
190 indices such as the Global Severity Index (GSI) which assesses the general level of
191 psychopathology. In the present study, the Italian version of the BSI (De Leo et al. 1993) has been
192 used and the Cronbach's α for the GSI was 0.94.
193
194 *2.3 EEG recordings and analysis*
195 EEG recordings were performed in RS condition. In order to get RS condition, each subject
196 was invited to sit in a comfortable armchair in a semi-darkened room in an EEG laboratory.
197 Recordings were acquired for 5 minutes consecutively and subjects were asked to keep their eyes
198 closed during the whole recording session. RS recordings were obtained for all subjects. All EEG
199 recordings were visually evaluated and no significant alterations of background rhythm frequency
200 (including evidence of drowsiness or sleep during the recordings) have been detected.
201 Micromed System Plus digital EEGraph (Micromed© S.p.A., Mogliano Veneto, TV, Italy)
202 was used to obtain all EEG recordings. EEG signals were obtained by 31 standard scalp leads
203 located conforming to the 10–20 system at the following recording sites: Fp1, AF3, F3, FC1, C3,
204 CP1, P3, PO3, O1, F7, FC5, T7/T3, CP5, T5, Fz, Cz, Pz, Fp2, AF4, F4, FC2, C4, CP2, P4, PO4,

O2, F8, FC6, T8/T4, CP6, T6. Furthermore, in the current study, Electrooculography (EOG) and Electrocardiography (ECG) signals have been considered. Details about EEG recordings could been found elsewhere (Imperatori et al. 2013; Imperatori et al. 2016; Imperatori et al. 2019c). Briefly, the reference electrodes were placed on right mastoid during the recording session and then were re-referenced offline to the algebraic average of the left and right mastoids. Impedances were kept below 5 kΩ before starting EEG recording and checked again at the end of EEG session for each participants. In particular, impedances of the right and left mastoid reference electrodes were checked to be identical. Sampling frequency was 256 Hz; A/D conversion was made at 16 bit; preamplifiers amplitude range was ±3,200 μV and low-frequency pre-filters were set at 0.15 Hz.

According to previous studies (Adenzato et al. 2019a; Imperatori et al. 2019a; Imperatori et al. 2019b) artifact rejection procedure was performed visually and through the independent component analysis (ICA). Specifically, EEG intervals containing artifacts were first rejected by inspection. The remaining EEG was then subjected to ICA, and non-cerebral artifacts such as eye movements, cardiac pulses and muscular activations were corrected by removal of non-neural independent components.

At least 180 seconds of artifact-free EEG recording (not necessarily consecutive) were selected and analysed for each participant using the eLORETA software, a well validated instrument to localize brain electrical activity, characterized by satisfactory localization agreement with other neuro-imaging techniques (De Ridder et al. 2011; Horacek et al. 2007; Huang et al. 2018; Kirino 2017; Muller et al. 2005; Pizzagalli et al. 2004; Zumsteg et al. 2005), also when low number of electrodes were used (i.e., < 30).

Power spectral analysis was performed on EEG artifact-free 2-sec epochs, using Fast Fourier Transform algorithm and boxcar windowing. The following frequency bands were considered: delta (0.5–4 Hz), theta (4.5–7.5 Hz), alpha (8–13 Hz), beta (13.5–30 Hz), and gamma (30.5–60 Hz) frequency bands were investigated. EEG frequency analysis was performed using monopolar EEG traces: each electrode referred to joint mastoids (i.e., A1 + A2). Topographic sources of EEG

activities were determined using the eLORETA, which estimates 3-dimensional current distribution throughout the brain volume by assuming that connected neurons are activated both simultaneously and synchronously (Kreiter and Singer 1992; Murphy et al. 1992). The computational task is to select the smoothest 3-dimensional current distribution (Grave de Peralta-Menendez and Gonzalez-Andino 1998; Grave de Peralta Menendez et al. 2000), providing a true 3-dimensional tomography, in which the localization of brain signals is conserved with a low amount of dispersion (Pascual-Marqui et al. 2011). The eLORETA solution space was limited to the cortical gray matter, including 6239 voxels of 5 cubic mm spatial resolution.

2.4 Statistical analysis

A Two Step Cluster Analysis procedure was performed to detect groups of subjects with low and high levels of autistic traits based on both AQ and EQ total scores. The Schwarz's Bayesian Criterion (BIC) was used to compare each cluster solution and select the best one. To explore qEEG differences between clusters, Mann-Whitney's U test was used for dimensional variables and Chi-squared ($\chi 2$) test for dichotomous ones.

The power spectrum analysis was performed comparing clusters for each frequency band by means of the statistical nonparametric mapping (SnPM) methodology supplied by the eLORETA software (Nichols and Holmes 2002) . This eLORETA procedure provides empirical t values (both for a significance of $p < 0.01$ and $p < 0.05$) for all comparisons (Friston et al. 1991).

Lastly, partial correlations were performed among any significant qEEG data observed in the between comparisons and both AQ and EQ total scores, controlling for age, sex and psychopathology, which are known to be associated to ASDs (Baio et al. 2018; Hsiao et al. 2013; Lever and Geurts 2016). Cluster and correlational analysis were carried out using the IBM SPSS Statistics 18 software.

3. Results

AQ total score was negatively correlated with EQ total score (r = -0.53; p < 0.001; Figure 1). The Two Step Cluster Analysis procedure indicated a 2-group solution (BIC change = − 10.09; Ratio of distance measures = 2.19). 56.0% of the sample (N = 28) was included in cluster #1, and 44% (N = 22) was included in cluster #2. Compared to participants included in cluster #2, those included in cluster #1 had significantly higher AQ total score and lower EQ total score (Table 1). Therefore, cluster #1 was mainly represented by subjects with higher level of autistic traits (AT+ group) compared to participants included in cluster #2 (AT− group). Groups did not differ in age and sex. However, compared to AT− subjects, AT+ individuals had higher scores in the GSI and in OC, IS, HOST, PAR, and PSYC dimensions.

3.1 Power spectrum analysis

Two-tailed significance thresholds were t= ± 3.852 for p< 0.05 and t= ± 4.386 for p< 0.01. A significant modification in delta frequency band was detected by the eLORETA software. As shown in figure 2, compared to AT− participants, AT+ individuals showed an increase in delta frequency band in occipital, cortico-limbic and parietal areas. These alterations were localized by the eLORETA software in the following brain regions: cuneus [Brodmann Area (BA) 17 and BA 18], precuneus (BA 7 and BA 31), lingual gyrus (BA 17), middle occipital gyrus (BA 19) and posterior cingulate cortex (BA 23 and BA 30). Detailed information about BAs, coordinates, t values and statistical significance was reported in Table 2. No significant differences have been detected by eLORETA software in alpha, beta and gamma frequency bands.

3.2 Correlations among both AQ and EQ total scores and EEG power spectra

As reported in Table 3, all significant EEG delta power spectra data observed in the between comparisons (except for BA 18) were positively associated with AQ total scores (r_p> 0.31, p< 0.05) after controlling for age, sex and GSI. All EEG delta power spectra data were also negatively related to EQ total scores (r_p> 0.41, p<0.05) after controlling for age, sex and GSI.

4. Discussion

The main aim of the current study was to investigate differences in RS EEG power spectrum between individuals with high vs. low autistic personality traits. A two Step Cluster Analysis procedure detected two groups of subjects with, respectively, high and low autistic traits.

Our results showed that, the two groups were different both on psychopathological and neurophysiological point of view. Compared to AT−, AT+ individuals reported more psychopathological symptoms, especially in those dimensions investigating schizotypal traits (e.g., paranoid ideation and psychoticism). These is accordance with previous studies suggesting that autistic traits overlap with schizotypal traits (Dinsdale et al. 2013; Ford and Crewther 2014; Ford et al. 2018; Mealey et al. 2014), particularly with negative schizotypal traits (Mealey et al. 2014).

On the neurophysiological point of view, our results showed that, compared to AT−, AT+ individuals exhibit an increase in delta power in parietal, occipital and cortico-limbic areas (i.e., cuneus, precuneus, middle occipital gyrus, posterior cingulate cortex and lingual gyrus). Controlling for sex, age and GSI, increased delta activity in these areas was significantly correlated with both AQ and EQ total scores.

Our results are consistent with previous literature showing alterations in slow frequency bands in subjects with both ASDs (for a review see Wang et al. 2013) and in subjects with high autistic traits (Barttfeld et al. 2013). No differences have been observed in other frequency bands, such as alpha and beta, which have been previously reported to be associated with autistic traits in non-clinical samples (Carter Leno et al. 2018; Moore and Franz 2017).

Our study showed that delta alterations were mainly localized in posterior midline structures including precuneus and PCC which are known to be functionally and structurally altered both in autism (Kennedy et al. 2006; Lynch et al. 2013; Oblak et al. 2011) and in neurotypical adults with autistic traits (Jakab et al. 2013). These brain areas are involved in several critical cognitive functions, such as self-referential processing and mentalization (Andrews-Hanna et al. 2012;

Andrews-Hanna et al. 2010; Ciaramidaro et al. 2007; Tettamanti et al. 2017; Vicari and Adenzato, 2016), which are known to be impaired in ASDs (Bara et al. 2011; Lombardo et al. 2007). Coherently, posterior midline structures' EEG power alterations detected in the current study were localized in the right hemisphere, which is involved in self-related processes as self-recognition (Keenan et al. 2001). Furthermore, several studies reported right-hemisphere alterations (e.g., right hemisphere engagement when not necessary) in individuals with ASDs (Mason et al. 2008; Orekhova et al. 2009). It is also known that PCC and precuneus are crucial hubs of the DMN (Buckner et al. 2008; Greicius et al. 2003), a set of brain areas mostly active during RS. The DMN is a brain network involved in auto-referential processes, including mentalizing and autobiographical memory retrieval (Buckner et al. 2008; Greicius et al. 2003), and several studies reported its alteration in ASDs (Jung et al. 2014; Kennedy et al. 2006; Weng et al. 2010). Coherently, it has been reported that delta frequency band shows a negative correlation with DMN activity (Hlinka et al. 2010). Therefore, in line with previous data, it is possible to speculate that the increase of delta power in midline structures that we have detected in individuals with high autistic personality traits could reflect poor self-referential processes during RS condition similarly to what observed in individuals with ASDs.

We consider this finding as a convergent evidence, at a neurophysiological level, on the existence of a continuum in the autistic spectrum which spreads from clinical significance (the ASDs condition) to non-clinical one (the AT+ condition here investigated). Furthermore, our findings are in line with recent psychiatry research paradigms (Cauvet et al. 2019) recommending dimensional constructs to study behaviors from typical to atypical (RDoC - Research Domain Criteria, NIH).

In the current study there should be considered some limitations in generalizing results. Firstly, the sample was composed for the majority by women and it is known that sex differences could be observed in mentalizing abilities (Adenzato et al. 2017; Adenzato et al., 2019b) and in EEG pattern during RS condition (Miraglia et al. 2015). Secondly, although the eLORETA is

335 considered a validated tool for localizing the sources of electrical activity in cortico-limbic brain
336 areas, we use scalp EEG recordings, which have an intrinsic limit in space resolution, mainly in the
337 identification of deep subcortical sources (e.g., the cerebellum). Furthermore, we did not include a
338 clinical group of patients with ASDs in order to perform a comparison with both AT+ and AT-
339 participants that could have provide further important theoretical information according to the ASD
340 dimensional perspective. Lastly, we considered only self-report measures which could be
341 influenced by psychological aspects like social desirability (Arnold and Feldman 1981). Replication
342 studies with other methods of data collection (e.g. cognitive/emotional tasks), according to a multi-
343 method approach (Lauriola et al. 2011), as well as with the enrolment of clinical samples are
344 welcome and would strengthen the interpretation of the current results.

345 Notwithstanding these limitations, to the best of our knowledge, this is the first study
346 examining the differences of EEG power spectrum between individuals with high vs. low autistic
347 personality traits during RS, using a well validated tool to localize brain electrical activity.

348 In conclusion, the current study has added new evidence that individuals with high autistic
349 traits have similar neurophysiological alterations to those observed in individuals with ASDs
350 supporting the hypothesis of an autism spectrum ranging from non-clinical to clinical conditions
351 (Abu-Akel et al. 2019; Austin 2005; Ruzich et al. 2015). Examining the association between
352 neurophysiological correlates and autistic traits in non-clinical samples is considered an important
353 research topic in order to understand the neural underpinnings of ASDs within a dimensional
354 perspective (Barttfeld et al. 2013). Future researches are still needed in order to identify specific
355 neural patterns distinguishing autistic traits at different stages of the continuum, including ASDs
356 which represents the extreme condition.

357

358 **Declarations of interest:** none

359

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Tables

Table 1. Bivariate analysis of the clusters.

	AT− (*n= 22*)	AT + (*n=28*)	Test Statistics	*p* =
Age – M ± SD	22.50±2.20	22.71±2.59	U= 300	0.87
Males – N (%)	5 (22.73%)	9 (32.14%)	χ^2=0.542	0.46
EQ Total Score – M ± SD	54.55±6.57	37.29±8.79	U= 21	**<0.001**
AQ Total Score – M ± SD	11.09±2.97	18.11±5.96	U= 82.5	**<0.001**
GSI – M ± SD	0.44±0.36	0.89±0.82	U= 202.5	**0.04**
SOM– M ± SD	0.38±0.48	0.74±0.78	U=223.5	0.09
OC– M ± SD	0.61±0.54	1.33±1.04	U=181	**0.01**
IS– M ± SD	0.43±0.60	0.90±0.85	U=188	**0.02**
DEP– M ± SD	0.53±0.59	0.90±0.90	U=223.5	0.10
ANX– M ± SD	0.67±0.51	1.20±1.05	U=260	0.35
HOST– M ± SD	0.29±0.38	0.91±0.97	U=174	**0.01**
PHOB– M ± SD	0.15±0.33	0.46±0.80	U=246.5	0.17
PAR– M ± SD	0.42±0.58	0.86±0.91	U=210	**0.05**
PSYC– M ± SD	0.33±0.42	0.78±0.84	U=200	**0.03**

Abbreviations: AQ (Autistic Quotient); AT+ (high autistic traits group); AT- (low autistic traits group); EQ (Empathy Quotient); GSI (General Severity Index); U (Mann- Whitney Test U), χ^2 (Chi-squared Test); SOM (somatization); OC (obsessive-compulsive); IS (interpersonal sensitivity); DEP (depression); ANX (anxiety); HOST (hostility); PHOB (phobic anxiety); PAR (paranoid ideation); PSYC (psychoticism).

Table 2. eLORETA statistical values for delta frequency band in AT+ group compared to AT− group.

		Delta (0.5-4 Hz)		
BA	**Structure**	**MNI Coordinates (X, Y, Z)**	**Voxel Value t**	***p* <**
7	Precuneus	10, -65, 30	4.54	0.01
17	Lingual Gyrus	20, -95, -5	4.44	0.01
17	Cuneus	10, -95, 0	4.44	0.01
18	Cuneus	10, -75, 20	4.57	0.01
19	Middle Occipital Gyrus	30, -80, 15	4.52	0.01
23	Posterior Cingulate	5, -60, 15	4.59	0.01
30	Posterior Cingulate	5, -65, 15	4.61	0.01
31	Precuneus	10, -65, 20	4.64	0.01

Abbreviations: BA (Brodmann Area); eLORETA (exact Low-Resolution Electric Tomography software); MNI (Montreal Neurological Institute).

651 **Table 3.** Partial correlations in total sample (n=50) among all significant Brodmann Areas observed
652 in the between comparisons and both AQ and EQ total Score, controlled for GSI, sex and age.

653

		Partial Correlations							
		Delta (0.5-4 Hz)							
Control Variables		**BA 7** *10, -65, 30*	**BA 17** *20, -95, -5*	**BA 17** *15, -95, 0*	**BA 19** *30, -80, 15*	**BA 18** *10, -75, 20*	**BA 23** *5, -60, 15*	**BA 30** *5, -65, 15*	**BA 31** *10, -65, 20*
GSI, sex & age	**AQ TOT**	0.35*	0.32*	0.31*	0.33*	0.24	0.33*	0.32*	0.33*
	EQ TOT	-0.43**	-0.44**	-0.44**	-0.45**	-0.37**	-0.43**	-0.44**	-0.46**

Abbreviations: AQ TOT (Autism Quotient Questionnaire Total Score), BA (Brodmann Area), EQ TOT (Empathy Quotient Total Score), GSI (General Severity Index). Note: two tailed significance *($p<0.05$), **($p<0.01$).

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Figures

Figure 1. Scatterplot of the correlation between AQ and EQ total score.

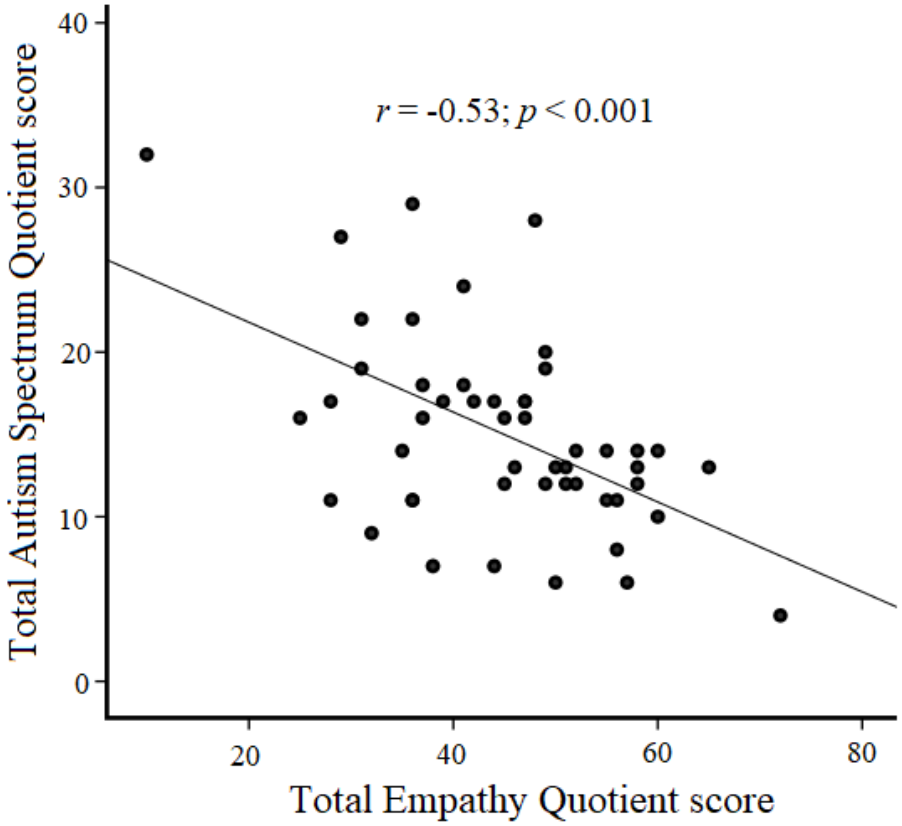

Figure 2. EEG power spectra results from the comparison between groups (AT+ group versus AT− group) in delta, theta, alpha, beta and gamma frequency bands. Compared to AT− participants, AT+ individuals showed a significant increase of delta power in the following Brodmann Areas: 7, 17, 18, 19, 23, 30, 31.