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Autistic traits distribution in different psychiatric conditions: A cluster analysis on the basis of the Adult Autism Subthreshold Spectrum (AdAS Spectrum) questionnaire

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ABSTRACT

Increasing interest is being paid on full-threshold and sub-threshold autism spectrum conditions among adults. Sub-threshold autistic traits (AT) seem to be distributed in a continuum from the clinical to the general population, being particularly higher among subjects with other psychiatric disorders. The aim of the present study was to evaluate the distribution of AT in a sample of subjects with different psychiatric conditions by means of a cluster analysis on the basis of the score reported to the AdAS Spectrum instrument. A total of 738 subjects recruited by seven Italian Universities were divided in 5 groups depending on the clinical diagnosis: Autism spectrum disorder (ASD), subthreshold ASD symptoms (partial ASD), Bipolar disorder (BD), Feeding and eating disorders (FED), and controls (CTLs). All subjects were assessed with the AdAS Spectrum. The cluster analysis identified 3 clusters: the *high, medium* and *low autism* clusters. The *Restricted interests and rumination* domain reported the highest influence in forming the clusters. The *high, medium* and *low autism* clusters were respectively more represented in the ASD, partial ASD and CTL groups. The clusters were represented intermediately in the FED and BD groups, confirming the presence of intermediate levels of AT in these clinical populations.

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by persistent deficits in social communication and interactions, in association with narrow interests and repetitive behaviors, which may show very different grades of symptom severity (APA, 2013, 2022). Despite the etiology of ASD remains unclear, the high heritability of the condition is well-known in the literature, with a strong genetic influence as well as a recognized role of intrauterine environment (Carpita et al., 2018; Tick et al., 2016). The description and the diagnostic criteria of ASD reported in DSM-5-TR (APA, 2022), refer to those full-threshold manifestations that should be considered only the extreme end of a broader spectrum of cognitive and behavioral features - commonly reported as autistic traits (AT) - that are distributed along a continuum in both clinical and general population (Constantino and Charman, 2016; Dell'Osso et al., 2016). Originally detected among first-degree relatives of ASD probands (Carpita et al., 2020a), AT have recently been the focus of a growing interests in the general population and in patients with other psychiatric disorders (Berthoz et al., 2013; Carpita et al., 2020b; De la Marche et al., 2012; Sucksmith et al., 2011),

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justified by the evidence that such features, even when subthreshold, may be associated with lower quality of life and higher vulnerability towards the development of other psychiatric disorders and suicidal ideation and behaviors (Takara and Kondo, 2014; Dell'Osso et al., 2018a, 2018b, 2019a, 2019b; 2019c; Kato et al., 2013). Several questionnaires have been developed for measuring AT among adults without intellectual or language impairment (Baron-Cohen et al., 2001; Dell'Osso et al., 2017; Eriksson et al., 2013). The most recent instrument is the Adult Autism Subthreshold Spectrum (AdAS Spectrum), already used in several studies for assessing the whole spectrum of autism spectrum conditions, demonstrating to be a useful instrument in clinical and non-clinical settings (Carpita et al., 2019; Dell'Osso et al., 2017, 2019b, 2019c, Carpita et al., 2020a, Dell'Osso et al., 2021a). High comorbidity rates are frequently found between ASD and several kinds of psychiatric disorders, apparently different from each other, such as Feeding and Eating Disorders (FEDs) (Inoue et al., 2021) or Mood Disorders (Carpita et al., 2020c). In particular, bipolar disorder (BD) is also reported to share with ASD also genetic underpinnings, while both the conditions have been associated in the literature with immune disorders and FED (Bartalena et al., 1990; Carpita et al., 2020b; Ramacciotti et al., 2005). Like in other disorders, the presence of AT may lead to a worse clinical outcome of the mood disorder (Dell'Osso et al., 2019c) and to a higher prevalence of suicidal thoughts, reported also in non-clinical samples (Dell'Osso et al., 2009, 2019b, 2021a). The clinical significance of AT in patients with BD supports the usefulness of a dimensional approach to the autism spectrum (Dell'Osso et al., 2019c; Frank et al., 1998).

More recently, in the framework of the increasing attention towards sex difference in psychopathology, several studies highlighted a possible between autism spectrum conditions and FED (Baron-Cohen et al., 2013; Carpita et al., 2020c; Huke et al., 2013). This association was suggested by not only the frequently reported evidence of ASD-like traits among FED patients and of abnormal eating behaviors among patients with ASD (Baron-Cohen et al., 2013; Carpita et al., 2020c; Dell'Osso et al., 2016a; Huke et al., 2013), but also by the presence of a familiar aggregation and of an opposite gender ratio between the two disorders (Carpita et al., 2020c) that led some authors to hypothesized that AN may be considered as a sex-specific phenotype of ASD; hypothesis supported by recent epidemiological, neurobiological and psychopathological studies (Carpita et al., 2020c; Inoue et al., 2021). Even though most of the research in this field was focused on AN, both ASD and AT seem to be detectable also in other kinds of FED, further stressing the presence of a continuum of the autism spectrum symptoms in this population (Carpita et al., 2020c, 2021; Dell'Osso et al., 2018b).

In light of the relevance of ATs also in non-ASD clinical samples, some authors raised the hypothesis that different kinds of psychiatric conditions may be developed as a consequence of a neurodevelopmental alteration similar to the one linked to ASD (Dell'Osso et al., 2016b, 2019d; White et al., 2012). On the basis of this hypothesis, the wide spectrum of ASD presentations should be considered as the tip of an iceberg that features several clinical and non-clinical phenotypes (Dell'Osso et al., 2017, 2019e).

In this framework, the aim of the present study was to evaluate the distribution of AT in a sample of subjects with different disorders (full-blow and partial ASD, BD, FED) and healthy controls (CTL), by means of a cluster analysis on the basis of the score reported to the AdAS Spectrum.

2. Materials and methods

2.1. Study sample

The present study included a sample of 738 subjects recruited by seven Italian University Departments of Psychiatry (Brescia, Catania, Firenze, Napoli, Pavia, Pisa, Siena), coordinated by the University of Pisa. The sample features five diagnostic groupsm distinguished according to DSM-5 diagnostic criteria (APA, 2013): the first group of 66 subjects was recruited among adult outpatients with a full-blown ASD diagnosis without intellectual or language impairment, who were following a treatment program for ASD (ASD); the second group included 76 university students that satisfied only one of the DSM-5 symptomatologic criteria for ASD (partial ASD); the third group was composed by 141 patients with Feeding and eating disorders (FED); the fourth group included 177 patients with Bipola Disorder (BD); the final group included 278 subjects without current or lifetime mental disorders (CTL). The study was conducted in accordance with the Declaration of Helsinki. The Ethics Committee of the Azienda Ospedaliero-Universitaria of Pisa approved allrecruitment and assessment procedures. Eligible subjects provided written informed consent, after receiving a complete description of the study and having the opportunity to ask questions. Subjects were not paid for their participation.

2.2. Psychometric instruments

All subjects were assessed with the Structured Clinical Interview for DSM-5 disorders (SCID-5) (First et al., 2015) and the Adult Autism Subthreshold Spectrum (AdAS Spectrum). Assessment procedures were conducted by trained psychiatrists.

2.2.1. AdAS spectrum

The AdAS Spectrum is a self-report questionnaire aiming to evaluate the wide range of autism spectrum manifestations in adults without language or intellectual impairment. The instrument is composed of 160 dichotomous items (yes/no), grouped in seven domains: Childhood/adolescence (I); Verbal communication (II); Non-verbal communication (III); Empathy (IV); Inflexibility and Adherence to Routine (V); Restricted interests and rumination (VI); Hyperand hyporeactivity to sensory input (VII). The AdAS Spectrum was developed by Dell'Osso et al. (2017), and in the validation study showed high internal-consistency, excellent test-retest reliability (Kunder-Richiardson coeffi-cient = 0.964, ICC = 0.976) and convergent validity with other dimensional measures of autism spectrum. The validity and reliability of the questionnaire was also confirmed by further studies (Dell'Osso et al., 2017, 2020a; Donati et al., 2019).

2.3. Statistical analyses

Student' *t*-test and Chi-square tests were used for comparing socio-demographic variables among groups. A K-Means cluster analysis based on the 9 standardized AdAS Spectrum domains was performed in order to evaluate the specific distribution of subthreshold autism spectrum symptoms in the sample. We used squared Euclidean Distance for the divergence measure between cases. The method of iterative updating of clustered centroids was chosen for classifying cases, with the new clusters' centers being calculated after all cases are assigned to a given cluster. To ensure maximum efficiency the final cluster centers estimated from a random sample were utilized as initial centers to classify the entire file. An ANOVA analysis was performed to confirm the significance of differences in AdAS spectrum scores among the identified clusters. In order to assess the stability of a given solution, we compared results on data sorted in different ways. After comparing the results obtained for different K values, we identified as the most satisfactory solution the one that involves 3 clusters ($K = 3$). This analysis determined a small within-cluster variability compared to the difference between clusters, and the cluster sizes were greater than 10% of the total sample size. Subsequently, a discriminant analysis was performed in order to confirm the validity of the group differentiation according to the cluster znalysis and to evaluate which AdAS domains show a higher discriminating value. Finally, the characterization of the diagnostic groups on the basis of the three identified clusters was described through the use of stacked histograms and Chi-Square tests for comparisons. All statistical analyses were performed using the Statistical Package for

Table 1
Comparison of socio-demographic variables among groups.

		Full ASD mean±SD	Partial ASD mean±SD	FED mean±SD	BD mean±SD	CTL mean±SD	F	P
Age		24.97 ± 4.95	21.34 ± 1.96	32.94 ± 13.06	46.27 ± 11.81	32.87 ± 11.85	75.57.00	<0.001*
		n(%)	n(%)	n(%)	n(%)	n(%)	Chi-square	P
Sex	M	36(54.5)	38(50.7)	10(7.1)	104(58.8)	114(41.2)	97.25.00	<0.001#
	F	30(45.5)	37(49.3)	130(92.9)	73(41.2)	163(58.8)		

Post-hoc: F: FED>all other groups; CTL> full ASD, BD.
* Post-hoc: BD>CTL,FED>Full ASD, Partial ASD.

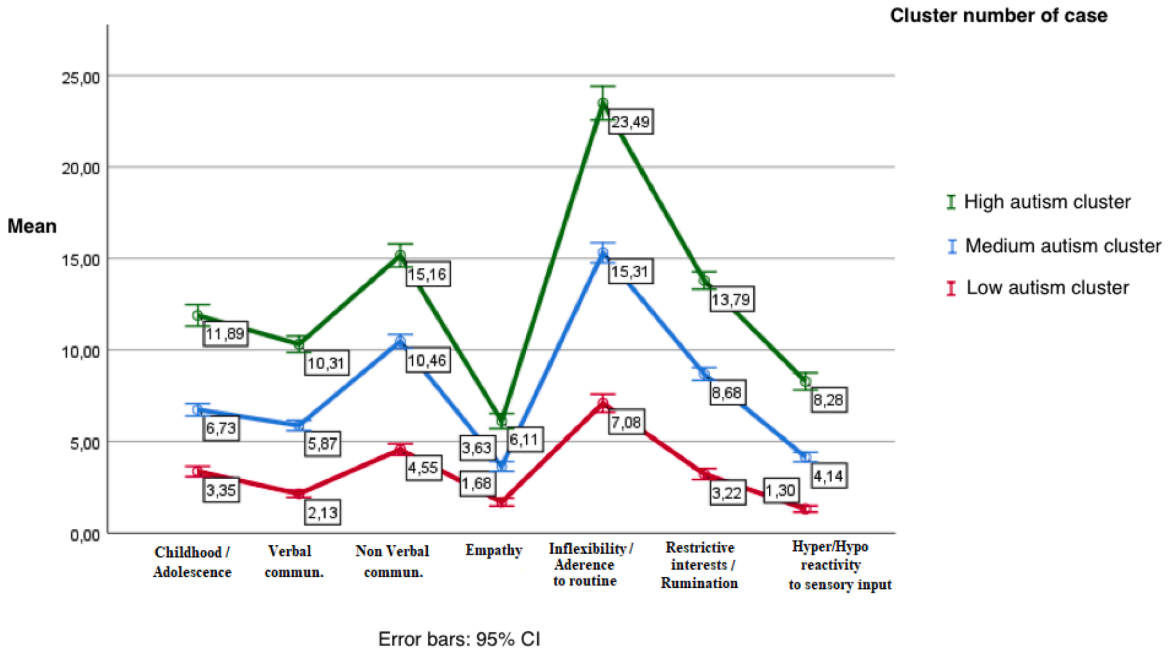

Fig. 1. AdAS Spectrum domain scores in the three clusters.

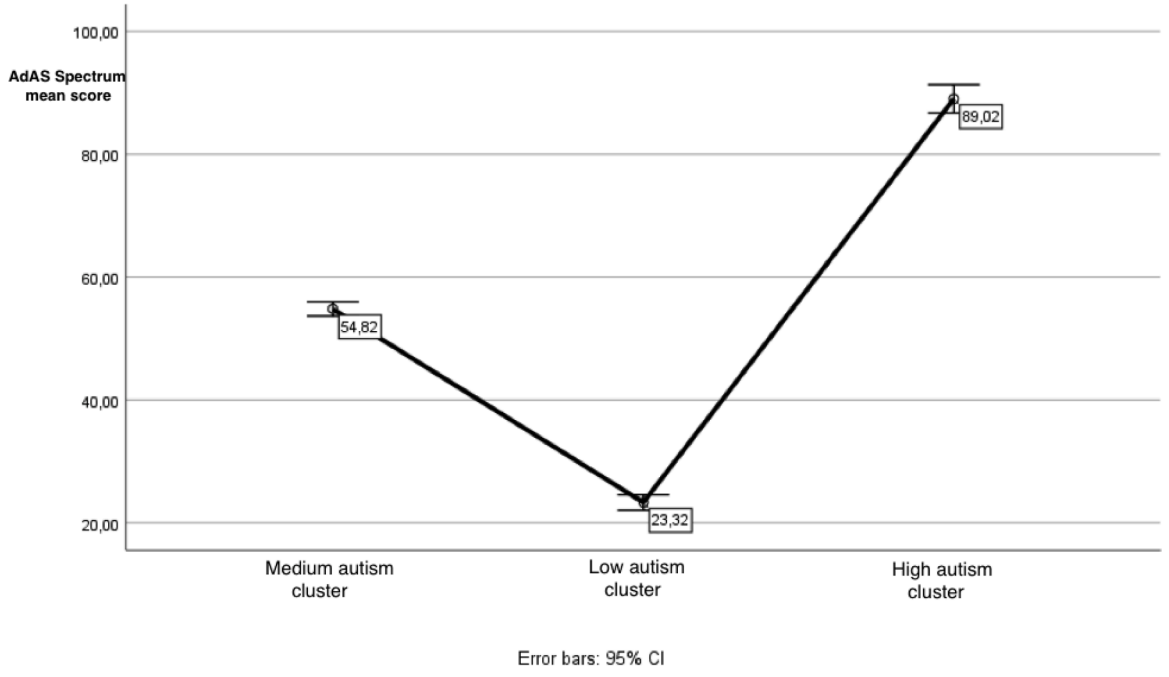

Fig. 2. AdAS Spectrum total score in the three clusters.

Table 2
Comparison of AdAS Spectrum scores among the three identified clusters.

AdAS Spectrum scores	Low autism mean ±SD	Medium autism mean±SD	High autism mean ±SD	F	p
Childhood/ Adolescence	3.35 ± 2.49	6.73 ± 2.91	11.89 ± 3.61	430.80	<0.001 *
Verbal communication	2.13 ± 1.73	5.87 ± 2.41	10.31 ± 2.78	688.78	<0.001 *
Non-verbal communication	4.55 ± 2.73	10.46 ± 3.27	9.01 ± 5.18	594.47	<0.001 *
Empathy	1.68 ± 1.88	3.63 ± 2.31	6.11 ± 2.53	207.07	<0.001 *
Inflexibility and adherence to routine	7.08 ± 4.35	15.31 ± 4.71	24.49 ± 5.68	615.23	<0.001 *
Restricted interest and rumination	3.22 ± 2.66	8.68 ± 3.02	13.79 ± 2.90	723.65	<0.001 *
Hyper– and hyporeactivity to sensory input	1.30 ± 1.46	4.14 ± 2.26	8.28 ± 2.93	530.73	<0.001 *
Total Score	23.32 ± 11.03	54.81 ± 10.05	89.02 ± 14.84	1722.01	<0.001 *

* Post-hoc: High autism > Medium autism > Low autism.

Table 3
K-Means Cluster Analysis features. Dispersion analysis.

AdAS Spectrum Z scores	Cluster mean square (SE)	F	p
Childhood/Adolescence	201.222 (0.467)	430.805	<0.001
Verbal communication	240.943 (0.355)	677.777	<0.001
Non-verbal communication	226.326 (0.381)	594.474	<0.001
Empathy	131.663 (0.636)	207.069	<0.001
Inflexibility and adherence to routine	231.938 (0.377)	615.229	<0.001
Restricted interest and rumination	248.266 (0.343)	723.647	<0.001
Hyper– and hyporeactivity to sensory input	212.246 (0.400)	530.727	<0.001

Social Science, version 26.0 (SPSS Inc.).

3. Results

The sample was composed by 433 (58.9%) females and 302 (41.1%) males. In the total sample, 3 subjects (1 from the CTL group, 1 from the partial ASD group, 1 from the FED group) chose to not indicate a sex. Significant differences in sex composition were found among groups. The mean age of the sample was 34.18±14.39, with significant differences among groups (see Table 1). We used as initial clusters the final centers estimated by a preliminary application of a k-means cluster analysis on a random sample of 400 subjects, in order to reduce the distance calculations and to select a good set of initial clusters. The second K-means Cluster Analysis applied to the entire data file met criterion 0 of convergence at the eighteenth iteration. We defined the 3 cluster of subjects determined by the second K-means Cluster Analysis: the *high autism* cluster ($n = 149$, 20.2%), the *medium autism* cluster ($n = 289$, 39.2%) and the *low autism* cluster ($n = 300$, 40.7%) respectively. The lines charts of Figs. 1 and 2 show respectively the mean values of the AdAS domain and total scores in the three clusters. All the differences in the scores were significant according to the ANOVA analysis (see Table 2). The distances between the final cluster centers were: 2.859 between the *high autism* and the *medium autism* clusters; 5.371 between the *high autism* and the *low autism* clusters; 2.545 between the *medium autism* and the *low autism* clusters. The average distance of cases from their classification cluster center was 1.64±0.51. In the dispersion analysis, the *Restricted interests and rumination* domain presented the greatest influence in forming the clusters ($F = 723.65$), while the Empathy domain had the lowest influence ($F = 207.07$) (see Table 3).

Table 4
Discriminant analysis. Summary of canonical discriminant functions.

Eigenvalues Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	5,100[a]	98,8	98,8	,914
2	,063[a]	1,2	100,0	,244

First 2 canonical discriminant functions were used in the analysis.

Wilks' Lambda Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	,154	1368,485	14	,000
2	,941	44,779	6	,000

A Discriminant Analysis performed on the three clusters confirmed the results of the Cluster Analysis. It differentiated the clusters especially with the first discriminant function which absorbs 98.8% of the variance (see Table 4 and Fig. 3). Furthermore, the analysis confirmed the results obtained from the Cluster Analysis in relation to the identification of the weight of each AdAS domain in discriminating the clusters (see the Structure Matrix in Table 5).

Fig. 4 shows the composition of clusters with respect to diagnostic group, while the composition of diagnostic groups with respects of clusters is reported in Fig. 5. Results from the Chi-square analysis reported that the *high autism* cluster was significantly more represented in the full ASD group than in the other ones, while it was more represented in the FED and BD group than in the CTL and partial ASD group. The *medium autism* cluster was significantly more represented in the partial ASD group than in the other ones, while it was intermediately represented in the FED and BD group, who reported a significantly higher proportion of the *medium autism* cluster than the CTL and full ASD group. Finally, the low *autism cluster* was significantly more represented in the CTL group than in other ones, with FED and BD groups reporting intermediate proportions, significantly higher than those reported in full and partial ASD groups (see Table 6).

4. Discussion

According to our results, three groups of significant different severity with respect to AT can be identified through the application of a cluster analysis to the scores obtained in the AdAS Spectrum questionnaire.

The sample used was composed of 735 subjects divided into 5 groups: full ASD, partial ASD, FED, BD and CTL. At the end of the cluster analysis, three distinctive clusters were highlighted: *high autism, medium autism* and *low autism,* based on the mean scores of the AdAS Spectrum domains and on the total score. The validity of the differentiation emerged from the cluster analysis was further confirmed by a discriminant analysis. As expected, the *high autism* cluster was found to be more represented in the full ASD group, the *medium autism* in the partial ASD group and the low autism cluster in the CTLs, confirming the reliability of AdAS Spectrum questionnaire also as a diagnostic and discriminating tool in both qualitative and quantitative evaluation of AT (Dell'Osso et al., 2017, 2020a; Donati et al., 2019). According to both the cluster and the discriminant analysis, the AdAS Spectrum domain showing the highest influence in the differentiation of the clusters was the *Restricted interests and rumination* domain, in line with the crucial role of ruminative thinking in psychopathology and in particular in ASD, as reported by previous literature (Dell'Osso et al., 2019b, 2019f). Rumination is a repetitive and maladaptive kind of thinking, eventually linked to the presence of subthreshold AT, associated with a worse outcome and increased suicidality (Dell'Osso et al., 2019b). Ruminative thinking is believed to exert a crucial role in worsening the adjustment of ASD subjects, particularly after stressful events (Dell'Osso et al., 2017, 2019b, 2020b; Nolen-Hoeksema et al., 2008).

Noticeably, according to our results, the *high autism* cluster was also

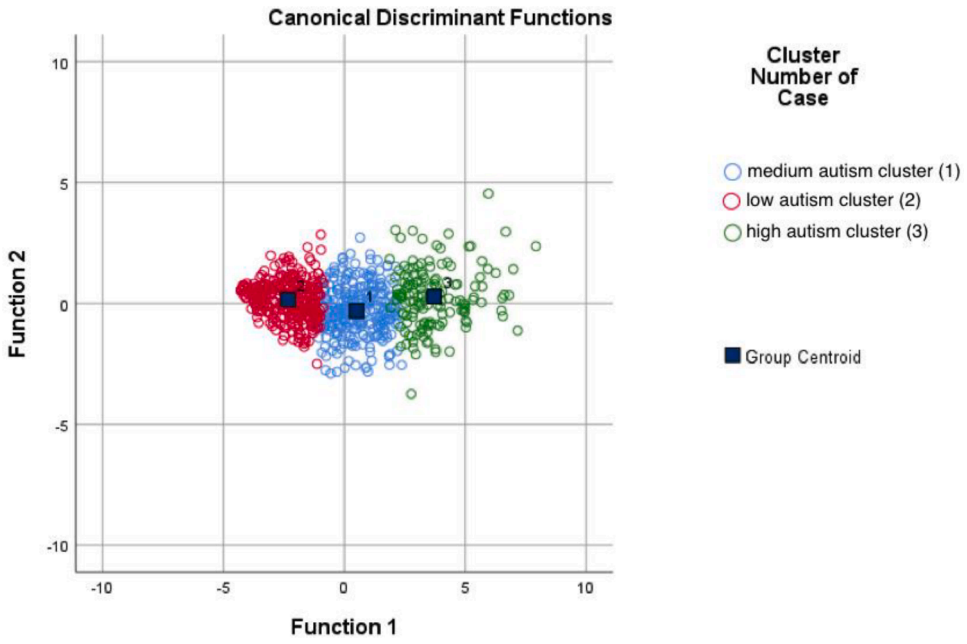

Fig. 3. Discriminant analysis: combined groups graphic.

Table 5
Discriminant analysis: structure matrix.

AdAS Spectrum Z scores	Function 1	2
Childhood/Adolescence	.477*	-0.333
Verbal communication	.601*	.088
Non-verbal communication	.560*	-0.209
Empathy	.332*	-0.556
Inflexibility and adherence to routine	.572*	.388
Restricted interest and rumination	.620*	.417
Hyper– and hyporeactivity to sensory input	.530*	.111

significantly more represented in the FED and BD groups than in the partial ASD and CTL groups, while the *medium autism* cluster was significantly more represented in FED and BD than in CTLs and full ASD groups. The increased representation of the *high autism* cluster in the FED group is in consistent with previous findings, which stressed the presence of a psychopathological and neurobiological overlap between FED and ASD (Carpita et al., 2020c, 2021; Dudova et al., 2015; Fisman et al., 1996; Kerbeshian and Burd, 2009; Rothery and Garden, 1988; Westwood and Tchanturia, 2017) such as shared common genetic vulnerability (Gillberg, 1983, 1985; Westwood et al., 2016a) as well as cognitive profiles, like anhedonia, alexithymia, inflexibility, perfectionism, difficulties in cognitive, social and emotional functioning

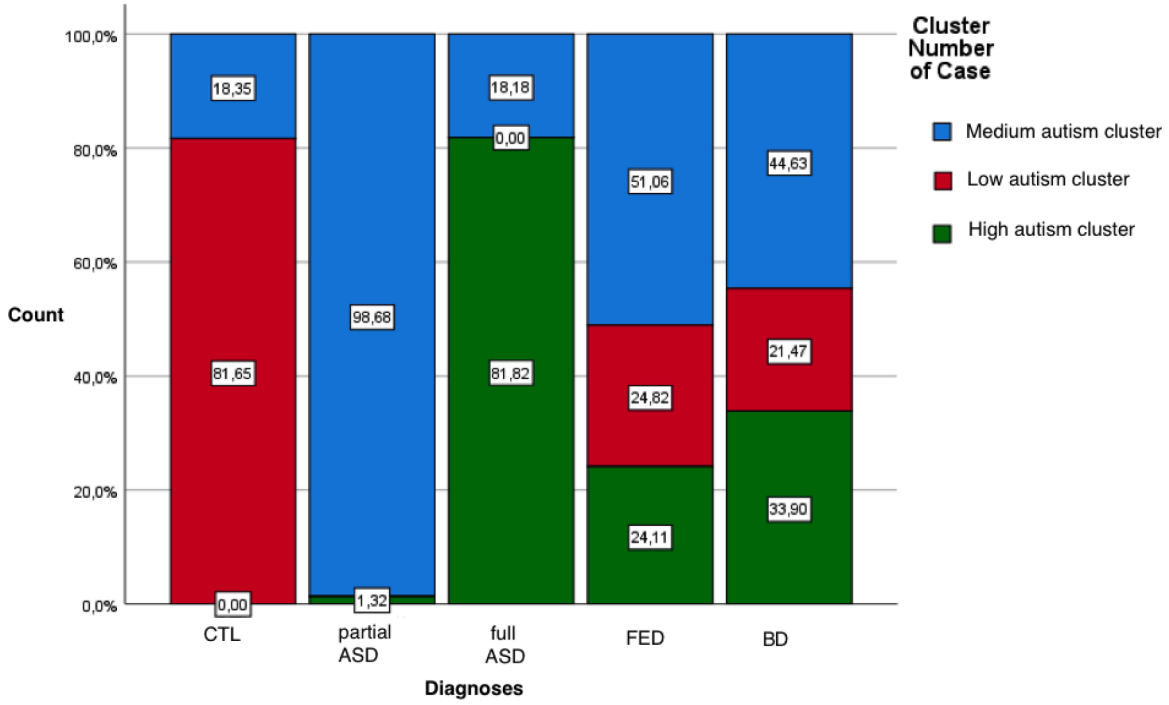

Fig. 4. Diagnostic group composition on the basis of clusters.

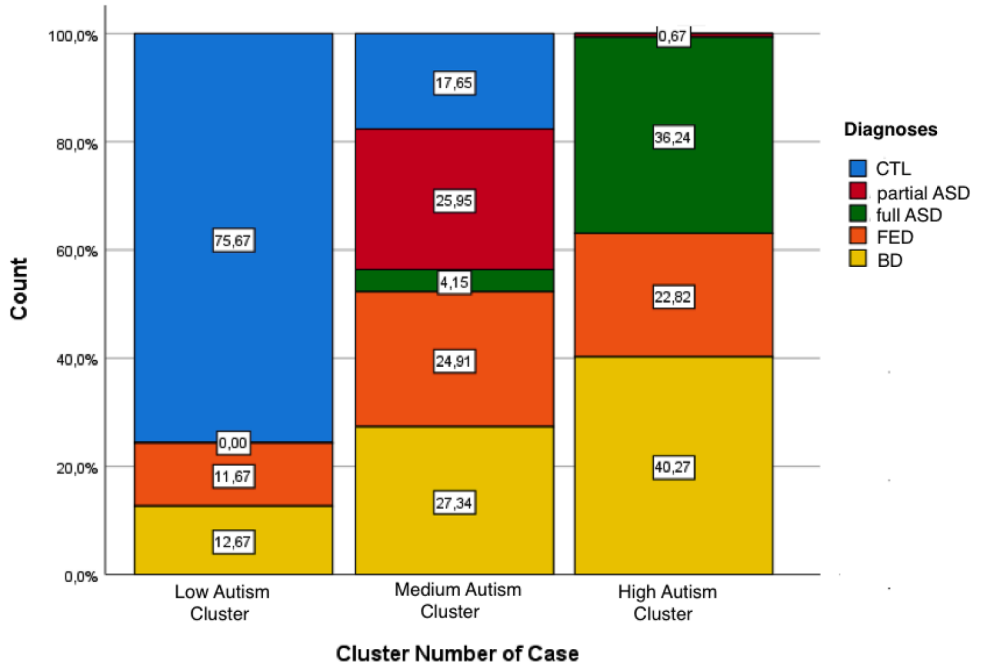

Fig. 5. Clusters' composition on the basis of diagnostic groups.

Table 6
Diagnoses distribution among the clusters.

Clusters		Diagnoses					
		CTL	Partial ASD	Full ASD	FED	BIP	Total
Low autism	Count	227a	0b	0b	35c	38c	300
Cluster	Expected count	113.0	30.9	26.8	57.3	72	300.0
	% within cluster	75.7%	0.0%	0.0%	11.7%	12.7%	100.0%
	% within diagnosis	81.7%	0.0%	0.0%	24.8%	21.5%	40.7%
Medium	Count	51a	75b	12a	72c	79b	289
autism	Expected count	108.9	29.8	25.8	55.2	69.3	289.0
cluster	% within cluster	17.6%	26.0%	4.2%	24.9%	27.3%	100.0%
	% within diagnosis	18.3%	98.7%	18.2%	51.1%	44.6%	39.2%
High autism	Count	0a	1a	54b	34c	60c	149
cluster	Expected count	56.1	15.3	13.3	28.5	35.7	149.0
	% within cluster	0.0%	0.7%	36.2%	22.8%	40.3%	100.0%
	% within diagnosis	0.0%	1.3%	81.8%	24,1%	33.9%	20.2%
Total	Count	278	76	66	141	177	738
	Expected count	278.0	76.0	66.0	141.0	177.0	738.0
	% within cluster	37.7%	10.3%	8.9%	19.1%	24.0%	100.0%
	% within diagnosis	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi square value: 522.057, $p < .001$; Each subscript letter denotes a subset of Diagnoses categories whose column proportions do not differ significantly from each other at the 0.05 level.

(Anderluh et al., 2003; Bulik et al., 2003; Caglar-Nazali et al., 2013; Carton and Smith, 2014; Chevallier et al., 2012; Davies et al., 2016; Gillberg et al., 2010; Klump et al., 2000; Lai and Baron-Cohen, 2015; Oldershaw et al., 2011; Tchanturia et al., 2004, 2012, 2013; Treasure, 2013; Westwood et al., 2016b, 2016c), increased attention to details, poor results in advanced theory of mind (Anckarsäter et al., 2011; Baron-Cohen et al., 2013; Medina-Pradas et al., 2012), and a lack of 'emotional intelligence' (Hambrook et al., 2012; Petrides et al., 2011).

Consistent with our results, several epidemiological studies, including longitudinal investigations, reported a higher prevalence of full-blown ASD or subthreshold AT among subjects with AN (Gillberg et al., 1994; 1995; Huke et al., 2013; Råstam, 1992; Råstam et al., 1989; Carpita et al., 2020c). More recently, increased attention was paid on other kinds of FED, highlighting the presence of AT also among subjects with Bulimia Nervosa (BN) and Binge eating disorder (BED) and Orthorexia nervosa (ON) (Carpita et al., 2020c, 2021; Dell'Osso et al., 2018b). Globally, identifying FED as a population with high/intermediate expression of AT is line with their possible conceptualization as neurodevelopmental disorders (Huke et al., 2013; Jacobi et al., 2003; Jobe and White, 2007; Kalyva, 2008; Karjalainen et al., 2016). In particular, considering the opposite gender ratio between ASD and AN, some authors suggested that AN could be considered as a female phenotype of the autism spectrum, which may remain underdiagnosed among females due to a bias in ASD diagnostic criteria, tailored on the typical manifestations of the disorders among males (Attwood et al., 2006; Dell'Osso et al., 2021b; Koch et al., 2015; Morgan and Huke, 2013; Zucker et al., 2007).

However, our data showed that the high and medium autism clusters were more represented also among BD patients: this result is also in line with the recent literature that described a frequent comorbidity between the two conditions, together with a significant overlap in neurobiological and genetic underpinnings (Carroll et al., 2009; Hofvander et al., 2009; Muneuse et al., 2008; Selten et al., 2015; Skokauskas and Frodl, 2015; Sullivan et al., 2012; Ragunath et al., 2011), raising the

hypothesis of a possible neurodevelopmental pathway for BD (O'Connell et al., 2018; O'Shea et al., 2016; Sanches et al., 2008). In particular, recent studies highlighted shared genes involved in the regulation of the circadian rhythms, which represent susceptibility for both ASD and BD (Khanzada et al., 2017; Muneuse et al., 2008; Ragunath et al., 2011). Most of the studies highlighted both a significant prevalence – up to 60% - of mood disorders in patients with ASD (Dell'Osso et al., 2019c; Hofvander et al., 2009;) than a high prevalence of ASD and AT in BD patients - from 2 to 30% (Abu-Akel et al., 2017; Axelson et al., 2006; Dell'Osso et al., 2019b, 2021a; Joshi et al., 2013; Matsuo et al., 2015; Pine et al., 2008; Takara and Kondo, 2014). Other authors focused on showing the impact of AT on the clinical manifestation of BD: a high prevalence of AT was found to be associated with an earlier onset of BD, a greater number of episodes with mixed feature and greater functional impairment (Borue et al., 2016; Dell'Osso et al., 2019c; Joshi et al., 2013).

Moreover, many studies are acknowledging the relationship between ASD and AT and suicidal ideation and behaviors (Raja et al., 2011; Kato et al., 2013), highlighting an increased rate of suicidal ideation in high functioning ASD patients and also identifying BD and more in general mood disorders as a significant risk factor (Cassidy et al., 2014). On the other hand, many studies have instead referred to ASD as a risk factor for suicide attempts in BD patients (Takara and Kondo, 2014) reporting increased suicidality scores in both subjects with ASD or subthreshold AT (Dell'Osso et al., 2019b).

Globally, results from this study further confirm not only the validity of the AdAS Spectrum as a quantitative and qualitative tool for detecting autism spectrum conditions, but also the hypothesis of an increased presence of AT among subjects affected by other kinds of mental disorders, in particular FED and BD. The proposed reconceptualization of many mental disorders as neurodevelopmental conditions, foresee a neurodevelopmental alteration as a substrate of which the specific quality and severity of the alteration, the timing, and the interaction with other neurobiological and environmental factors would be involved in shaping different psychopathological trajectories (Chu and Yang, 2022; Dell'Osso et al., 2017). The present work should be considered in light of several limitation. Firstly, the study was led with a cross-sectional design, thus excluding the possibility to make inferences about eventual temporal or causal relationships between the investigated variables. Secondly, our sample was composed by several different groups, with a relatively small sample size. Significant sex and age differences were also reported among groups. While some differences may be in line with the specific demographic distribution of the disorders, such as the higher representation of females in the FED group, this issue could have led to biases in our results. Moreover, the use of a self-reported instrument may be associated with biases over- or under-estimation of symptoms by the subjects. Further studies with longitudinal designs in wider samples are needed to confirm the presence and distribution of AT in different kinds of clinical populations.

CRediT authorship contribution statement

Liliana Dell'Osso: Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing, Supervision. **Barbara Carpita:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **Bendetta Nardi:** Writing – original draft, Investigation. **Francesca Benedetti:** Investigation. **Valerio Dell'Oste:** Investigation. **Gabriele Massimetti:** Formal analysis. **Ivan Mirko Cremone:** Investigation. **Stefano Barlati:** Investigation. **Giovanni Castellini:** Investigation. **Mario Luciano:** Investigation. **Letizia Bossini:** Investigation. **Matteo Rocchetti:** Investigation. **Maria Salvina Signorelli:** Investigation. **Valdo Ricca:** Methodology, Investigation. **Eugenio Aguglia:** Methodology, Investigation. **Andrea Fagiolini:** Methodology, Investigation. **Antonio Vita:** Methodology, Investigation. **Pierluigi Politi:** Methodology, Investigation. **Mario Maj:** Conceptualization, Methodology, Investigation.

Declaration of Competing Interest

None

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