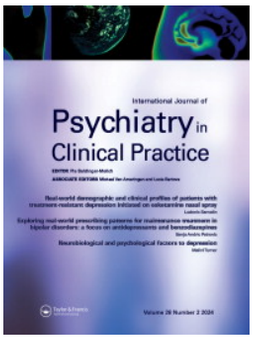

International Journal of Psychiatry in Clinical Practice

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ijpc20

Sex differences in the prevalence and clinical correlates of autistic features in patients with chronic schizophrenia: a large scale cross-sectional study

Qihui Guo, Rongrong Zhu, Zheng Ma, Ying He, Dongmei Wang & Xiangyang Zhang

To cite this article: Qihui Guo, Rongrong Zhu, Zheng Ma, Ying He, Dongmei Wang & Xiangyang Zhang (05 Mar 2025): Sex differences in the prevalence and clinical correlates of autistic features in patients with chronic schizophrenia: a large scale cross-sectional study, International Journal of Psychiatry in Clinical Practice, DOI: 10.1080/13651501.2025.2472672

To link to this article: https://doi.org/10.1080/13651501.2025.2472672

Published online: 05 Mar 2025.

INTERNATIONAL JOURNAL OF PSYCHIATRY IN CLINICAL PRACTICE
https://doi.org/10.1080/13651501.2025.2472672

Sex differences in the prevalence and clinical correlates of autistic features in patients with chronic schizophrenia: a large scale cross-sectional study

Qihui Guo[a,b], Rongrong Zhu[a,b], Zheng Ma[a,b], Ying He[a,b], Dongmei Wang[a,b] and Xiangyang Zhang[a,b]

[a]Institute of Psychology, Chinese Academy of Sciences, Beijing, China; [b]Department of Psychology, University of Chinese Academy of Sciences, Beijing, China

ABSTRACT

Objective: Sex differences have been suggested in both schizophrenia (SCZ) and autism spectrum disorder (ASD). This study aims to assess the prevalence and clinical correlates of autistic features in male and female patients with chronic SCZ.

Methods: A total of 1690 chronic SCZ patients (M/F: 1122/568) were recruited from ten psychiatric hospitals in China. The Positive and Negative Syndrome Scale Autism Severity Score and the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) were utilised to assess the presence of autistic features and measure cognitive function, respectively.

Results: Female SCZ patients had a higher prevalence of autistic features than male SCZ patients. In male patients, those with autistic features exhibited higher illness duration and RBANS scores, but lower years of education. Whereas in female patients, those with autistic features had higher RBANS scores, but lower years of education. Binary logistic regression analysis revealed that years of education, illness duration, visuospatial/constructional abilities, and language were correlated with autistic features in male patients. In female patients, years of education, language, and delayed memory were correlated with the presence of autistic features.

Conclusions: Our findings suggest that sex differences exist in the prevalence and clinical correlates of autistic features in chronic SCZ patients.

KEY POINTS

- Sex differences exist in the prevalence and clinical correlates of autistic features in patients with chronic SCZ.
- Years of education, illness duration, visuospatial/constructional abilities, and language were correlated with autistic features in male chronic SCZ patients.
- Years of education, language, and delayed memory were correlated with autistic features in female chronic SCZ patients.

ARTICLE HISTORY
Received 10 July 2024
Revised 2 December 2024
Accepted 21 February 2025

KEYWORDS
Sex differences; schizophrenia; autistic features

Introduction

Schizophrenia (SCZ) is one of the most severe psychiatric disorders (Jauhar et al., 2022), with a global lifetime prevalence of about 1% (Saha et al., 2005). SCZ is marked by impaired perception, thinking, emotions, behaviour, cognitive function and mental activities (Saha et al., 2005) and imposes significant healthcare burdens on patients (Cloutier et al., 2016). SCZ patients have a higher lifetime risk of suicide, and the mean life expectancy of SCZ patients was about 15 years shorter than healthy people (Hjorthøj et al., 2017).

Autism spectrum disorder (ASD) is a neurodevelopmental condition marked by abnormality in social interaction, communication, and sensory perception and repetitive, stereotyped behaviour (American Psychiatric Association, 2013). In fact, prior to the 1970s, the term 'autism' and 'schizophrenia' were often used synonymously (Chisholm et al., 2015). As research and understanding in the field continued to grow, a clearer distinction between the two conditions emerged. ASD is now considered a developmental disorder separate from SCZ. ASD and SCZ are distinct diagnoses, but share some common features (Jutla et al., 2022). They both fall under the umbrella of neurodevelopmental disorders (Goldstein et al., 2002). Individuals with ASD may exhibit psychotic symptoms, whereas those diagnosed with early-onset SCZ may exhibit features commonly associated with ASD (Chisholm et al., 2015). Previous studies have demonstrated that ASD develops SCZ later in life (de Lacy & King, 2013; Larson et al., 2017), and that childhood-onset SCZ has a higher likelihood of co-occurring with ASD (Rapoport et al., 2009). According to a review, the prevalence of ASD in patients diagnosed with SCZ ranges from 3.4% to 52% (Zheng et al., 2018).

There are many clinical, aetiological, and pathophysiological similarities between SCZ and ASD (Barlati et al., 2019; Chisholm et al., 2015; de Lacy & King, 2013; Wilson et al., 2014). For example, affective retardation in SCZ patients is similar to emotional reciprocity in ASD patients. The parallels alogia (poverty of speech) in SCZ patients is similar to the delayed or absent speech development in ASD patients. Social communication deficits and catatonic features are observed in both SCZ and ASD (Chisholm et al., 2015). Social cognition deficits, particularly social information processing deficits, are prevalent in individuals with both SCZ and ASD (Eack et al., 2013; Sugranyes et al., 2011). SCZ patients with autistic features perform poorer in social cognition (Deste et al.,

CONTACT Dongmei Wang wangdm@psych.ac.cn; Xiangyang Zhang zhangxy@psych.ac.cn Institute of Psychology, Chinese Academy of Sciences, 16 Lincui Road, Chaoyang District, Beijing 100101, China

2020; Vita et al. 2020). Also, genetic evidences support an association between the two diagnoses, as children of parents with SCZ face a higher risk of developing ASD (Sullivan et al., 2012). Additionally, there are some similarities in neuroimaging findings, such as smaller grey matter volume in limbic-striato-thalamic circuitry of both SCZ and ASD patients (Cheung et al., 2010). Notably, Nakata et al. (2020) found that treatment-resistant SCZ patient were close to ASD patients, suggesting SCZ patients with autistic features may not respond well to treatment. Thus, SCZ patients with autistic features appear to exhibit some specific features that warrant study as a separate subgroup.

There are also many differences between SCZ and ASD (Tarasi et al., 2022). Psychometric analysis has revealed that autistic features predominantly overlap with negative symptoms of SCZ, but display differences when compared to positive symptoms (Nenadić et al., 2021; Zhou et al., 2019). According to Trevisan et al. (2020), SCZ and ASD can be more effectively differentiated by their positive symptoms than by their negative symptoms. Additionally, previous reviews indicate that SCZ and ASD exhibit notable distinctions in areas such as neurocognition, social cognition, decision-making processes, and neural oscillations (Ozbek et al., 2023; Tarasi et al., 2022). Autistic features have also been found to exert significant impacts on non-ASD populations. For instance, Liu et al. (2023) demonstrated a correlation between autistic features and empathy. In SCZ patients, Deste et al. (2020) discovered that autistic features were associated with social cognitive performance, with higher autistic features being linked to poorer social cognitive performance.

Sex differences have been reported in various aspects of SCZ, including prevalence, onset age, clinical symptoms, and social functioning. For example, studies have indicated that male SCZ patients have a higher prevalence and younger onset age of SCZ compared to female SCZ patients (Loranger, 1984; McGrath et al., 2008). Moreover, male SCZ patients tend to have fewer affective symptoms than female SCZ patients (Ochoa et al., 2012). It has been observed that male SCZ patients tend to exhibit more pronounced social isolation, unemployment, and withdrawal compared to female SCZ patients (Vila-Rodriguez et al., 2011; Zhang et al., 2012). Additionally, studies have indicated sex differences in the structure of brain regions and DNA methylation in patients with SCZ (Adanty et al., 2022; Kovalev et al., 2003). Similarly, sex differences exist in multiple aspects of ASD patients (Hull et al., 2017). For example, the prevalence of ASD has been consistently reported to be higher in males than females (Fombonne, 2009; Goldblum et al., 2024). Female ASD patients exhibit poorer reciprocal behaviour than male ASD (Backer van Ommeren et al., 2017). In younger higher functioning ASD patients, males exhibit more repetitive and stereotyped behaviours (Knutsen et al., 2019). A recent review suggested there were sex differences in social behaviours and social communication in young ASD patients (de la Roche & Kelley, 2024).

In conclusion, sex differences have been suggested in both SCZ and ASD patients. This study aimed to explore sex differences in the prevalence and clinical correlates of autistic features in patients with chronic SCZ, as this may contribute to a better understanding of autistic features in SCZ patients.

Methods

Study design and study population

This study was a large scale cross-sectional multi-centre study. A total of 1690 chronic SCZ patients from ten psychiatric hospitals in China were recruited. The study was approved by the Institutional Review Board of the Institute of Psychology, Chinese Academy of Sciences (H18031).

The inclusion criteria were as follows: (1) aged between 16 to 75 years; (2) diagnosis of SCZ by two experienced psychiatrists using the Structured Clinical Interview for DSM-IV (SCID); (3) illness duration of at least 1 year; (4) stable dose of antipsychotics for at least six months. The exclusion criteria were: (1) history of substance or alcohol abuse, except for nicotine; (2) pregnant or lactating; and (3) organic brain diseases or severe physical illnesses.

Data collection and assessment

A questionnaire was designed in this study to collect the demographic information (age, sex, marital status, BMI) and clinical information (onset age, illness duration, family history of SCZ, antipsychotic dosages, suicidal attempts) from all participants. All participants were required to state a male or female gender according to their biological features. The Insomnia Severity Index (ISI) was used to assess the severity of insomnia (Bastien et al., 2001). The higher the ISI scores, the more severe insomnia.

The Positive and Negative Syndrome Scale (PANSS) was used to assess the psychiatric symptoms and the severity of clinical symptoms in SCZ patients (Kay et al., 1987). Mohr's five-factor model (negative, positive, cognitive, mood, hostility) was utilised as the subscales of PANSS (Jiang et al., 2013). The higher PANSS scores indicate more severe the psychotic symptoms.

The PANSS Autism Severity Score (PAUSS) was used to assess the presence of autistic features in SCZ patients (Kästner et al., 2015). The items of PAUSS were extracted from PANSS. PAUSS contains three subscales: social activities (N1, N3, N4), communication (N5, N6), and stereotypic behaviour (N7, G5, G15). The higher the PAUSS score, the more pronounced the autistic features, and a PAUSS score above 30 is defined as the presence of autistic features (Kästner et al., 2015).

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) was used to assess the cognitive function, including immediate memory, visuospatial/constructional ability, language, attention, and delayed memory (Randolph et al., 1998). RBANS assessment was conducted by several psychiatrists through structured interviews, all psychiatrists had received standardised training. The higher RBANS scores indicate better cognitive functioning.

Statistical analysis

Normality was examined using Skewness and Kurtosis test, with 'skewness < 2 and kurtosis < 7' indicating that the data distribution was normal (Kim, 2013). In order to compare the differences in demographic and clinical variables between patients with autistic and without autistic features, Student's t-tests, Mann-Whitney nonparametric and x^2 test were utilised for categorical variables, continuous, non-normally distributed continuous, respectively. The calculated Cohen's d values represented effect sizes. Bonferroni corrections were utilised to correct multiple tests.

Binary logistic regression analyses were performed separately for male and female patients to determine independent associations between autistic features and other variables. Regression analyses were performed using backward methods. The area under the receiver operating characteristic (AUC-ROC) was calculated to determine the ability of the significant variables in regression model to discriminate autistic features in male or female SCZ patient.

All statistical analyses were performed using SPSS version 25.0 and R version 4.3.1. p Values <.05 (two-tailed) were considered statistically significant.

Results

Sex differences in the prevalence of autistic features in SCZ patients

Of the 1690 SCZ patients, 66.39% ($n = 1122$) patients were male and 33.61% ($n = 568$) patients were female. There were significant sex differences in the following characteristics: age, marital status, body mass index (BMI), illness duration, family history (all $p < .05$). Please see Table 1 for details.

Autistic features were present in 18.54% ($n = 208$) of the male patients and 25.70% ($n = 146$) of the female patients. The sex difference in prevalence of autistic features was statistically significant ($\chi^2 = 11.694$, $p = .001$).

Sex differences in clinical characteristics of SCZ patients with and without autistic features

Table 2 indicates that among male SCZ patients, individuals with autistic features had lower years of education and BMI, along with longer illness duration (all $p < .05$), compared to those without autistic features. Additionally, individuals with autistic features showed higher PANSS total score, PANSS negative factor score, PANSS cognitive factor score, PANSS hostility factor score, PANSS mood factor score, and lower RBANS total score and all of its subscale scores (all $p < .01$, all Bonferroni corrected $p < .05$).

Table 2 shows that among female SCZ patients, individuals with autistic features had lower years of education ($p < .001$), compared to those without autistic features. Additionally, individuals with autistic features showed higher PANSS total and all of its subscale scores, as well as lower RBANS total and all its subscale scores (all $p < .001$, Bonferroni corrected $p < .01$).

Sex differences in clinical correlates of autistic features in SCZ patients

In male SCZ patients, a binary logistic regression was performed with several variables including years of education, BMI, illness duration and all subscale scores of RBANS as independent variables, and the presence of autistic feature as a dependent variable. The results showed that years of education ($B = -0.069$, $p = .037$, odds ratio [OR] = 0.934, 95% confidence interval [CI] = 0.875–0.995), RBANS visuospatial/constructional subscale ($B = -0.025$, $p < .001$, OR = 0.976, 95%CI = 0.964–0.987), and RBANS language subscale ($B = -0.056$, $p < .001$, OR = 0.946, 95%CI = 0.933–0.958) were negatively correlated with the presence of autistic features, while illness duration ($B = 0.015$, $p = .024$, OR = 1.015, 95%CI = 1.002–1.029) was positively correlated with autistic features (Table 3). The predictive performance of the regression model and individual variables were assessed using ROC curves. The AUC for years of education was 0.624, for illness duration was 0.547, for RBANS visuospatial/constructional subscale was 0.680, for RBANS language subscale was 0.719 (Figure 1(a)). Combined these variables, the AUC for regression model was 0.654.

In female SCZ patients, a binary logistic regression was performed with several variables including years of education, and all subscale scores of RBANS as independent variables, and autistic feature as a dependent variable. The results showed that years

Table 1. Characteristics of patients with chronic schizophrenia grouped by sex.

	Male ($n = 1122$)	Female ($n = 568$)	$t/Z/x^2$	p Value	Cohen's d
Age	45.68 ± 13.28	44.38 ± 12.65	1.97	**.049**	0.100
Years of education	9.33 ± 2.94	9.10 ± 3.44	1.39	.166	0.075
Marital status			158.90	**<.001**	
Single	797	235			
Married	168	208			
Divorced	149	107			
Widowed	8	18			
BMI	24.23 ± 4.67	24.92 ± 4.93	−2.55	**.011**	−0.145
Onset age	25.07 ± 7.95	25.32 ± 8.43	−0.59	.559	−0.031
Illness duration	20.62 ± 12.33	19.06 ± 11.99	2.82	**.005**	0.049
Family history			7.15	**.008**	
Yes	168	115			
No	954	453			
Antipsychotic dosages	409.03 ± 511.53	384.26 ± 500.06	0.95	.340	0.049
Suicidal attempts			3.08	.079	
Yes	120	78			
No	1002	490			
ISI	3.00 ± 3.95	3.43 ± 4.23	−1.61	.108	−0.105
PANSS	76.71 ± 18.94	83.95 ± 20.31	−7.08	**<.001**	−0.373
Negative factor	21.53 ± 7.64	22.23 ± 7.80	−1.75	.080	−0.091
Positive factor	11.99 ± 5.46	13.91 ± 5.60	−6.72	**<.001**	−0.349
Cognitive factor	25.05 ± 7.29	27.32 ± 8.10	−5.64	**<.001**	−0.300
Hostility factor	7.59 ± 3.37	8.68 ± 3.46	−6.17	**<.001**	−0.320
Mood factor	10.58 ± 3.85	11.81 ± 4.10	−5.97	**<.001**	−0.313
PAUSS	23.22 ± 7.35	24.79 ± 7.50	−4.10	**<0.001**	−0.212
Difficulty in social	9.67 ± 3.66	10.00 ± 3.59	−1.74	.082	−0.089
Difficulty in communication	7.03 ± 2.63	7.27 ± 2.68	−1.73	.085	−0.089
Stereotypic behaviour	6.52 ± 2.68	7.53 ± 2.93	−6.90	**<.001**	−0.366
RBANS	360.13 ± 63.76	347.69 ± 60.79	3.70	**<.001**	0.198
Immediate memory	58.67 ± 21.81	57.65 ± 16.01	0.94	.350	0.051
Visuospatial/constructional	77.67 ± 17.22	72.17 ± 15.76	6.57	**<.001**	0.328
Language	80.17 ± 13.29	75.12 ± 16.62	6.30	**<.001**	0.349
Attention	78.20 ± 16.20	78.19 ± 17.92	0.02	.985	0.001
Delayed memory	64.57 ± 18.36	64.05 ± 18.42	0.55	.586	0.028
PANSS minus PAUSS	53.49 ± 13.66	59.16 ± 14.82	−7.63	**<.001**	−0.405

Note: BMI: body mass index; ISI: Insomnia Severity Index; PANSS: Positive and Negative Syndrome Scale; PAUSS: PANSS Autism Severity Score; RBANS: Repeatable Battery for the Assessment of Neuropsychological Status. Bold font indicates statistical significance.

Table 2. Characteristics of chronic schizophrenia patients with and without autistic features grouped by sex.

	Male					Female				
	Non-autistic ($n = 914$)	Autistic ($n = 208$)	$t/Z/x^2$	p Value	Cohen's d	Non-autistic ($n = 422$)	Autistic ($n = 146$)	$t/Z/x^2$	p Value	Cohen's d
Age	45.35 ± 13.29	47.17 ± 13.15	−1.80	.073	−0.137	44.26 ± 12.78	44.74 ± 12.3	−0.41	.689	−0.038
Years of education	9.56 ± 2.95	8.32 ± 2.68	5.94	**<.001**	0.430	9.69 ± 3.32	7.38 ± 3.19	7.45	**<.001**	0.701
Marital status			1.80	.614				3.31	.508	
Single	645/914	152/208				172/422	63/146			
Married	136/914	32/208				152/422	56/146			
Divorced	127/914	22/208				86/422	21/146			
Widowed	6/914	2/208				12/422	6/146			
BMI	24.37 ± 4.77	23.61 ± 4.14	2.27	**.023**	0.163	24.92 ± 4.91	24.93 ± 5.0	−0.08	.938	−0.002
Onset age	25.13 ± 7.86	24.78 ± 8.34	0.55	.583	0.044	25.59 ± 8.01	24.54 ± 9.54	1.19	.237	0.124
Illness duration	20.22 ± 12.27	22.38 ± 12.49	−2.27	**.024**	−0.176	18.67 ± 12.24	20.2 ± 11.19	−1.39	.166	−0.128
Family history			2.71	.100				0.06	.800	
Yes	145/914	23/208				87/422	28/146			
No	769/914	185/208				355/422	118/146			
Antipsychotic dosages	395.45 ± 497.18	468.69 ± 567.76	−1.79	.073	−0.143	402.03 ± 557.94	332.89 ± 265.34	1.64	.100	0.138
Suicidal attempts			0.00	1.000				0.51	.477	
Yes	98/914	22/208				61/422	17/146			
No	816/914	186/208				361/422	129/146			
ISI	2.94 ± 3.94	3.28 ± 3.98	−1.03	.301	−0.086	3.28 ± 4.06	3.85 ± 4.68	−1.50	.133	−0.135
PANSS	71.84 ± 16.36	98.1 ± 14.1	−23.49	**<.001**	−1.644	77.01 ± 17.23	104.03 ± 14.33	−18.60	**<.001**	−1.634
Negative factor	19.22 ± 6.21	31.66 ± 4.4	−33.81	**<.001**	−2.100	19.37 ± 6.45	30.49 ± 4.97	−21.50	**<.001**	−1.821
Positive factor	11.86 ± 5.44	12.53 ± 5.53	−1.59	.115	−0.123	13.45 ± 5.57	15.23 ± 5.48	−3.36	**<.001**	−0.320
Cognitive factor	23.03 ± 6.01	33.93 ± 5.58	−25.06	**<.001**	−1.838	24.57 ± 6.65	35.29 ± 6.47	−17.13	**<.001**	−1.623
Hostility factor	7.36 ± 3.24	8.59 ± 3.75	−4.35	**<.001**	−0.366	8.21 ± 3.25	10.03 ± 3.69	−5.30	**<.001**	−0.542
Mood factor	10.39 ± 3.72	11.38 ± 4.31	−3.07	**.002**	−0.258	11.41 ± 3.96	12.97 ± 4.29	−3.87	**<.001**	−0.386
PAUSS	20.7 ± 5.32	34.33 ± 3.95	8.38	**<.001**	−0.667	21.56 ± 5.36	34.14 ± 4.25	−17.90	**<.001**	−2.467
Difficulty in social	8.56 ± 2.93	14.59 ± 2.24	−32.89	**<.001**	−2.140	8.69 ± 2.96	13.77 ± 2.43	−14.80	**<.001**	−1.792
Difficulty in communication	6.26 ± 2.17	10.39 ± 1.64	−30.65	**<.001**	−1.981	6.28 ± 2.19	10.12 ± 1.76	−15.00	**<.001**	−1.838
Stereotypic behaviour	5.88 ± 2.24	9.35 ± 2.61	−17.77	**<.001**	−1.499	6.59 ± 2.41	10.26 ± 2.54	−12.90	**<.001**	−1.502
RBANS	367.77 ± 61.07	326.56 ± 64.64	9.54	**<.001**	0.667	359.18 ± 58.07	314.45 ± 56.26	7.83	**<.001**	0.776
Immediate memory	59.74 ± 22.96	53.98 ± 14.97	4.72	**<.001**	0.266	59.52 ± 16.31	52.25 ± 13.82	5.12	**<.001**	0.463
Visuospatial/ constructional	79.62 ± 17.41	69.11 ± 13.34	8.14	**<.001**	0.628	74.15 ± 16.2	66.43 ± 12.81	5.09	**<.001**	0.501
Language	82.33 ± 11.76	70.7 ± 15.36	9.89	**<.001**	0.930	77.68 ± 15.82	67.69 ± 16.7	6.40	**<.001**	0.623
Attention	79.59 ± 15.53	72.11 ± 17.64	6.12	**<.001**	0.469	81.05 ± 16.63	69.92 ± 18.97	6.73	**<.001**	0.645
Delayed memory	66.33 ± 18.39	56.81 ± 16.08	6.85	**<.001**	0.529	66.43 ± 18.33	57.16 ± 16.93	5.62	**<.001**	0.516
PANSS minus PAUSS	51.15 ± 12.84	63.77 ± 12.36	−12.10	**<.001**	−0.990	55.45 ± 13.64	69.88 ± 12.78	−10.2	**<.001**	−1.075

Note: BMI: body mass index; ISI: Insomnia Severity Index; PANSS: Positive and Negative Syndrome Scale; PAUSS: PANSS Autism Severity Score; RBANS: Repeatable Battery for the Assessment of Neuropsychological Status. Bold font indicates statistical significance.

Table 3. Binary logistic regression model to predict the presence of autistic features.

	Male				Female			
	B	Wald x^2	p	OR (95% CI)	B	Wald x^2	p	OR (95% CI)
Years of education	−0.069	−4.347	**.037**	0.934(0.875,0.995)	−0.156	−19.844	**<.001**	0.856(0.798,0.915)
Illness duration	0.015	5.072	**.024**	1.015(1.002,1.029)				
RBANS								
Visuospatial/ constructional	−0.025	−15.817	**<.001**	0.976(0.964,0.987)				
Language	−0.056	−70.939	**<.001**	0.946(0.933,0.958)	−0.021	−8.532	**.003**	0.979(0.965,0.993)
Attention					−0.013	−3.057	.080	0.987(0.973,1.001)
Delayed memory					−0.014	−4.055	**.044**	0.986(0.973,1.000)

Note: RBANS: Repeatable Battery for the Assessment of Neuropsychological Status. Bold font indicates statistical significance.

of education ($B = -0.156$, $p < .001$, OR = 0.856, 95%CI = 0.798–0.915), RBANS language subscale ($B = -0.021$, $p = .003$, OR = 0.979, 95%CI = 0.965–0.993), RBANS delayed memory subscale ($B = -0.014$, $p = .044$, OR = 0.986, 95%CI = 0.973–1.000) were negatively associated with the presence of autistic features (Table 3). The AUC for years of education was 0.692, for RBANS language subscale was 0.677, for RBANS delayed memory subscale was 0.680 (Figure 1(b)). Combined these variables, the AUC for regression model was 0.766.

Discussion

Sex differences in prevalence of autistic features in SCZ patients

Our study revealed that the prevalence of autistic features was higher in female SCZ patients than male SCZ patients (25.70% vs 18.54%). A systematic review by Zeidan et al. (2022) demonstrated a significant sex difference in the prevalence of ASD (Zeidan et al.,

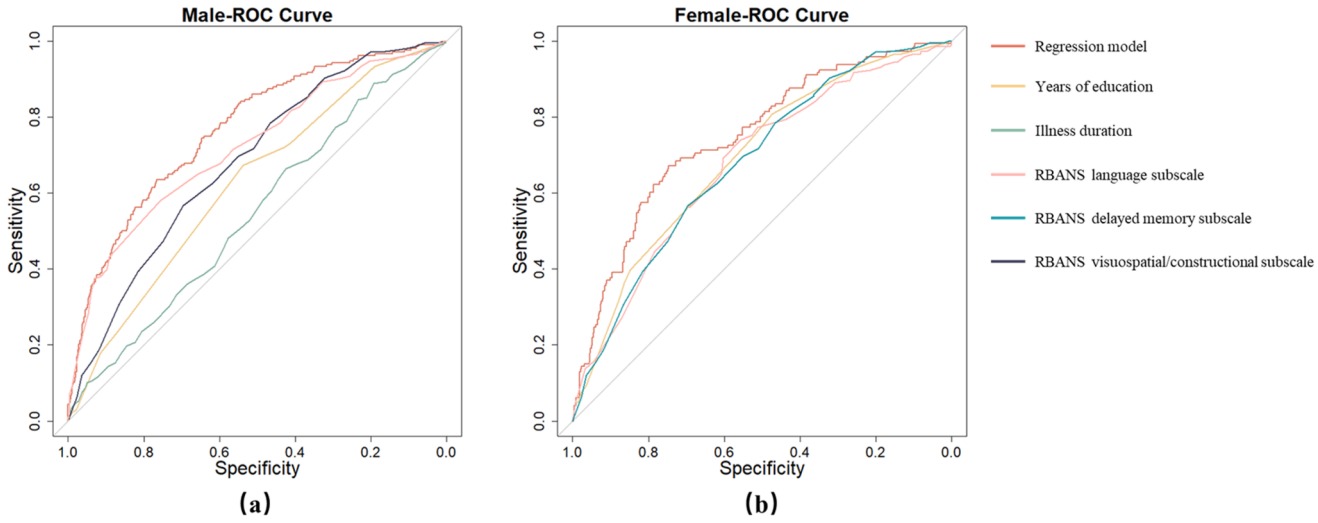

Figure 1. (a) ROC curve in male patients with chronic schizophrenia; and (b) ROC curve in female patients with chronic schizophrenia. *Note:* AUC in male-ROC curves (regression model = 0.766; years of education = 0.624; illness duration = 0.547; RBANS visuospatial/constructional subscale = 0.680; RBANS language subscale = 0.719). AUC in female-ROC curves (regression model = 0.747; years of education = 0.692; RBANS language subscale = 0.677; RBANS delayed memory subscale = 0.680).

2022). In China, the sex ratio (M:F) of ASD was reported as 4.3 (Zhou et al., 2020). It is also worth noting that the prevalence of SCZ is usually higher in males than females (McGrath et al., 2008). However, in this study, the prevalence of autistic features was higher in female patients than male patients with SCZ.

One possible explanation for the higher prevalence of autistic features in female SCZ patients is that their clinical symptoms were more severe in this study. We observed that PANSS scores and its subscale scores (except for the negative factor) were higher in female patients compared to male patients with SCZ. Additionally, female SCZ patients had lower RBANS scores than male SCZ patients, implying that female SCZ patients have more severe cognitive impairment. When assessing the subscales of the PAUSS, significant differences between female and male SCZ patients were found only in the stereotypic behaviour subscale, with female SCZ patients exhibiting more severe stereotypic behaviour than male SCZ patients. Stereotypic behaviour is one of the core autistic features. However, stereotypic behaviour has been reported to be milder in female ASD patients than male ASD patients (Horwitz et al., 2023). Based on these evidences, female SCZ patients had more severe clinical symptoms than male SCZ patients, specifically in stereotypic behaviour, and female SCZ patients have higher prevalence of autistic features than male SCZ patients.

Common correlates associated with autistic features in both male and female SCZ patients

A previous study reported a strong association between years of education and the risk of developing SCZ (Luo et al., 2020). In the present study, years of education was found to be associated with autistic features in both male and female patients with SCZ. It was observed that SCZ patients with autistic features had fewer years of education than those without autistic features. Individuals with autistic features tend to struggle with education, and students with ASD face numerous challenges, especially in social and academic skills (Anderson et al., 2017; Gelbar et al., 2014).

Also, we found that language was associated with autistic features in both males and females with SCZ. Additionally, we found that SCZ patients with autistic features had lower language skills than those without autistic features. Language and communication impairments are a core feature of ASD patients (Georgiou & Spanoudis, 2021; Riches et al., 2011). Delayed communication, impaired language initiation, or poor language skills compared to peers are the primary reasons why parents seek professional ASD evaluation and diagnosis for their children (Kozlowski et al., 2011). In addition, language impairment is also common in SCZ patients (Hartopo & Kalalo, 2022). Therefore, the severity of language impairment may serve as a potential marker in distinguishing the presence of autistic features in SCZ patients.

Sex differences in correlates associated with autistic features in SCZ patients

In this study, illness duration and RBANS visuospatial/constructional subscale was associated with autistic features in male SCZ patients while not in female SCZ patients. In male SCZ patients, those with autistic features had longer illness duration and weaker visuospatial/constructional abilities compared to those without autistic features. Studies indicated that male psychiatric patients with longer illness duration have higher levels of social and global disability (Hanlon et al., 2017). Therefore, male SCZ patients with longer illness duration may exhibit more autistic features, whereas this effect is not significant in female SCZ patients.

Visuospatial ability is an important cognitive function that facilitates our interaction with the environment (Cardillo et al., 2020; Jansen et al., 2010). Abnormal processing of visuospatial material has been reported in both patients with ASD (Cardillo et al., 2022; Caron et al., 2006) and patients with SCZ (Daniell et al., 2021; Ribolsi et al., 2015). Furthermore, previous studies found that there are sex differences in visuospatial ability, with males typically performing better than females (Herlitz & Rehnman, 2008; Voyer et al., 1995). There are also sex differences in visuospatial ability in ASD patients (Beacher et al., 2012). Based on these findings, we speculate that visuospatial impairment has significant impact on the presence of autistic features in male SCZ patients while not in female SCZ patients.

The RBANS delayed memory subscale was associated with autistic features in female SCZ patients while not in male SCZ patients. Impairment in delayed memory is a common feature of

ASD patients. Previous studies indicated that episodic memory retrieval abilities of children with ASD would deteriorate over time (Almeida et al., 2019; Southwick et al., 2011). Similarly, SCZ patients also had poor performance on delayed memory tasks (Garcia et al., 2012; Robles et al., 2008). In ASD patients, females exhibited better memory performance than males (Demetriou et al., 2021). Interestingly, this study revealed that SCZ patients did not exhibit a sex-based memory difference. A previous study found that oestrogen hormone plays an important role in learning and memory, suggesting that high oestrogen can improve the impairments in learning and memory (Iqbal et al., 2024). Our study identified a significant association between delayed memory and the presence of autistic features, but only in female SCZ patients. This intriguing observation may be linked to the influence of oestrogen; however, further studies are needed to clarify this complex phenomenon.

Limitations

This study has several limitations that are worth considering. Firstly, the cross-sectional design conducted in this study limits our ability to infer causality. In order to prospectively understand sex differences in SCZ patients with autistic features, a longitudinal study is needed in the future. Second, it is worth noting that the present study included only hospitalised patients with chronic SCZ, who typically exhibit more severe symptoms and cognitive deficits. Thus, there may be a selection bias which could account for our results. Thirdly, there were sex differences in the PANSS scores in patients with SCZ. Since the PAUSS is extracted from the PANSS, there may be a potential bias in detecting sex differences in the prevalence and clinical correlates of autistic features in patients with SCZ. Forth, it should be noted that autistic features did not equate to a diagnosis of autism, so SCZ patients with autistic features cannot represent SCZ patients comorbid with ASD.

Conclusions

In conclusion, this study provides valuable insights into understanding autistic features in chronic SCZ patients. The findings suggest that autistic features are more prevalent in female SCZ patients and that there are significant sex differences in the clinical correlates associated with autistic features. Therefore, it is necessary to consider sex differences in the study and clinical treatment of autistic features in SCZ patients. Future studies are warranted to deeply explore the sex differences of autistic features in SCZ patients, which will provide a prospective view to deepen our understanding of autistic features in SCZ patients.

Acknowledgements

We are thankful to all patients who participated in the study.

Ethics statement

The authors declare that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the CAS International Cooperation Research Program [153111KYSB20190004] and the CAS Key Lab of Mental Health.

Data availability statement

The data that support the findings of this study are publicly available. The corresponding author can be contacted upon reasonable request.

References

Adanty, C., Qian, J., Al-Chalabi, N., Fatemi, A. B., Gerretsen, P., Graff, A., & De Luca, V. (2022). Sex differences in schizophrenia: A longitudinal methylome analysis. *Journal of Neural Transmission*, *129*(1), 105–114. https://doi.org/10.1007/s00702-021-02439-4

Almeida, T. S., Lamb, M. E., & Weisblatt, E. J. (2019). Effects of delay on episodic memory retrieval by children with autism spectrum disorder. *Applied Cognitive Psychology*, *33*(5), 814–827. https://doi.org/10.1002/acp.3524

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Anderson, A. H., Stephenson, J., & Carter, M. (2017). A systematic literature review of the experiences and supports of students with autism spectrum disorder in post-secondary education. *Research in Autism Spectrum Disorders*, *39*, 33–53. https://doi.org/10.1016/j.rasd.2017.04.002

Backer van Ommeren, T., Koot, H. M., Scheeren, A. M., & Begeer, S. (2017). Sex differences in the reciprocal behaviour of children with autism. *Autism: The International Journal of Research and Practice*, *21*(6), 795–803. https://doi.org/10.1177/1362361316669622

Barlati, S., Deste, G., Gregorelli, M., & Vita, A. (2019). Autistic traits in a sample of adult patients with schizophrenia: Prevalence and correlates. *Psychological Medicine*, *49*(1), 140–148. https://doi.org/10.1017/S0033291718000600

Bastien, C. H., Vallières, A., & Morin, C. M. (2001). Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Medicine*, *2*(4), 297–307. https://doi.org/10.1016/s1389-9457(00)00065-4

Beacher, F. D. C. C., Radulescu, E., Minati, L., Baron-Cohen, S., Lombardo, M. V., Lai, M.-C., Walker, A., Howard, D., Gray, M. A., Harrison, N. A., & Critchley, H. D. (2012). Sex differences and autism: Brain function during verbal fluency and mental rotation. *PLoS One*, *7*(6), e38355. https://doi.org/10.1371/journal.pone.0038355

Cardillo, R., Lanfranchi, S., & Mammarella, I. C. (2020). A cross-task comparison on visuospatial processing in autism spectrum disorders. *Autism: The International Journal of Research and Practice*, *24*(3), 765–779. https://doi.org/10.1177/1362361319888341

Cardillo, R., Lievore, R., & Mammarella, I. C. (2022). Do children with and without autism spectrum disorder use different visuospatial processing skills to perform the Rey-Osterrieth complex figure test? *Autism Research*, *15*(7), 1311–1323. https://doi.org/10.1002/aur.2717

Caron, M.-J., Mottron, L., Berthiaume, C., & Dawson, M. (2006). Cognitive mechanisms, specificity and neural underpinnings of visuospatial peaks in autism. *Brain: A Journal of Neurology*, *129*(Pt 7), 1789–1802. https://doi.org/10.1093/brain/awl072

Cheung, C., Yu, K., Fung, G., Leung, M., Wong, C., Li, Q., Sham, P., Chua, S., & McAlonan, G. (2010). Autistic disorders and schizophrenia: Related or remote? An anatomical likelihood estima-

tion. *PLoS One*, *5*(8), e12233. https://doi.org/10.1371/journal.pone.0012233

Chisholm, K., Lin, A., Abu-Akel, A., & Wood, S. J. (2015). The association between autism and schizophrenia spectrum disorders: A review of eight alternate models of co-occurrence. *Neuroscience and Biobehavioral Reviews*, *55*, 173–183. https://doi.org/10.1016/j.neubiorev.2015.04.012

Cloutier, M., Aigbogun, M. S., Guerin, A., Nitulescu, R., Ramanakumar, A. V., Kamat, S. A., DeLucia, M., Duffy, R., Legacy, S. N., Henderson, C., Francois, C., & Wu, E. (2016). The economic burden of schizophrenia in the United States in 2013. *The Journal of Clinical Psychiatry*, *77*(6), 764–771. https://doi.org/10.4088/JCP.15m10278

Daniell, K., Kim, J., Iwata, Y., Caravaggio, F., Brown, E., Remington, G., Agid, O., Graff-Guerrero, A., & Gerretsen, P. (2021). Exploring the relationship between impaired illness awareness and visuospatial inattention in patients with schizophrenia. *Journal of Psychiatric Research*, *136*, 468–473. https://doi.org/10.1016/j.jpsychires.2020.10.016

de Lacy, N., & King, B. H. (2013). Revisiting the relationship between autism and schizophrenia: Toward an integrated neurobiology. *Annual Review of Clinical Psychology*, *9*(1), 555–587. https://doi.org/10.1146/annurev-clinpsy-050212-185627

de la Roche, L., & Kelley, E. (2024). A scoping review of sex/gender differences in social communication skills and behaviors of autistic youth—Are sex/gender-specific interventions needed? *Review Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s40489-024-00451-4

Demetriou, E. A., Pepper, K. L., Park, S. H., Pellicano, L., Song, Y. J. C., Naismith, S. L., Hickie, I. B., Thomas, E. E., & Guastella, A. J. (2021). Autism spectrum disorder: An examination of sex differences in neuropsychological and self-report measures of executive and non-executive cognitive function. *Autism: The International Journal of Research and Practice*, *25*(8), 2223–2237. https://doi.org/10.1177/13623613211014991

Deste, G., Vita, A., Penn, D. L., Pinkham, A. E., Nibbio, G., & Harvey, P. D. (2020). Autistic symptoms predict social cognitive performance in patients with schizophrenia. *Schizophrenia Research*, *215*, 113–119. https://doi.org/10.1016/j.schres.2019.11.008

Eack, S. M., Bahorik, A. L., McKnight, S. A. F., Hogarty, S. S., Greenwald, D. P., Newhill, C. E., Phillips, M. L., Keshavan, M. S., & Minshew, N. J. (2013). Commonalities in social and non-social cognitive impairments in adults with autism spectrum disorder and schizophrenia. *Schizophrenia Research*, *148*(1-3), 24–28. https://doi.org/10.1016/j.schres.2013.05.013

Fombonne, E. (2009). Epidemiology of pervasive developmental disorders. *Pediatric Research*, *65*(6), 591–598. https://doi.org/10.1203/PDR.0b013e31819e7203

Garcia, C. P., Sacks, S. A., & de Mamani, A. G. W. (2012). Neurocognition and cognitive biases in schizophrenia. *The Journal of Nervous and Mental Disease*, *200*(8), 724–727. https://doi.org/10.1097/NMD.0b013e3182614264

Gelbar, N. W., Smith, I., & Reichow, B. (2014). Systematic review of articles describing experience and supports of individuals with autism enrolled in college and university programs. *Journal of Autism and Developmental Disorders*, *44*(10), 2593–2601. https://doi.org/10.1007/s10803-014-2135-5

Georgiou, N., & Spanoudis, G. (2021). Developmental language disorder and autism: Commonalities and differences on language. *Brain Sciences*, *11*(5), 589. https://doi.org/10.3390/brainsci11050589

Goldblum, J. E., McFayden, T. C., Bristol, S., Putnam, O. C., Wylie, A., & Harrop, C. (2024). Autism prevalence and the intersectionality of assigned sex at birth, race, and ethnicity on age of diagnosis. *Journal of Autism and Developmental Disorders*, *54*(10), 3777–3791. https://doi.org/10.1007/s10803-023-06104-5

Goldstein, G., Minshew, N. J., Allen, D. N., & Seaton, B. E. (2002). High-functioning autism and schizophrenia: A comparison of an early and late onset neurodevelopmental disorder. *Archives of Clinical Neuropsychology*, *17*(5), 461–475. https://doi.org/10.1016/S0887-6177(01)00129-9

Hanlon, M.-C., Campbell, L. E., Single, N., Coleman, C., Morgan, V. A., Cotton, S. M., Stain, H. J., & Castle, D. J. (2017). Men and women with psychosis and the impact of illness-duration on sex-differences: The second Australian national survey of psychosis. *Psychiatry Research*, *256*, 130–143. https://doi.org/10.1016/j.psychres.2017.06.024

Hartopo, D., & Kalalo, R. T. (2022). Language disorder as a marker for schizophrenia. *Asia-Pacific Psychiatry*, *14*(3), e12485. https://doi.org/10.1111/appy.12485

Herlitz, A., & Rehnman, J. (2008). Sex differences in episodic memory. *Current Directions in Psychological Science*, *17*(1), 52–56. https://doi.org/10.1111/j.1467-8721.2008.00547.x

Hjorthøj, C., Stürup, A. E., McGrath, J. J., & Nordentoft, M. (2017). Years of potential life lost and life expectancy in schizophrenia: A systematic review and meta-analysis. *The Lancet. Psychiatry*, *4*(4), 295–301. https://doi.org/10.1016/S2215-0366(17)30078-0

Horwitz, E., Vos, M., De Bildt, A., Greaves-Lord, K., Rommelse, N., Schoevers, R., & Hartman, C. (2023). Sex differences in the course of autistic and co-occurring psychopathological symptoms in adolescents with and without autism spectrum disorder. *Autism: The International Journal of Research and Practice*, *27*(6), 1716–1729. https://doi.org/10.1177/13623613221146477

Hull, L., Mandy, W., & Petrides, K. V. (2017). Behavioural and cognitive sex/gender differences in autism spectrum condition and typically developing males and females. *Autism: The International Journal of Research and Practice*, *21*(6), 706–727. https://doi.org/10.1177/1362361316669087

Iqbal, J., Huang, G.-D., Xue, Y.-X., Yang, M., & Jia, X.-J. (2024). Role of estrogen in sex differences in memory, emotion and neuropsychiatric disorders. *Molecular Biology Reports*, *51*(1), 415. https://doi.org/10.1007/s11033-024-09374-z

Jansen, P., Wiedenbauer, G., & Hahn, N. (2010). Manual rotation training improves direction-estimations in a virtual environmental space. *European Journal of Cognitive Psychology*, *22*(1), 6–17. https://doi.org/10.1080/09541440802678487

Jauhar, S., Johnstone, M., & McKenna, P. J. (2022). Schizophrenia. *Lancet*, *399*(10323), 473–486. https://doi.org/10.1016/S0140-6736(21)01730-X

Jiang, J., Sim, K., & Lee, J. (2013). Validated five-factor model of Positive and Negative Syndrome Scale for schizophrenia in Chinese population. *Schizophrenia Research*, *143*(1), 38–43. https://doi.org/10.1016/j.schres.2012.10.019

Jutla, A., Foss-Feig, J., & Veenstra-VanderWeele, J. (2022). Autism spectrum disorder and schizophrenia: An updated conceptual review. *Autism Research*, *15*(3), 384–412. https://doi.org/10.1002/aur.2659

Kästner, A., Begemann, M., Michel, T. M., Everts, S., Stepniak, B., Bach, C., Poustka, L., Becker, J., Banaschewski, T., Dose, M., & Ehrenreich, H. (2015). Autism beyond diagnostic categories: Characterization of autistic phenotypes in schizophrenia. *BMC Psychiatry*, *15*(1), 115. https://doi.org/10.1186/s12888-015-0494-x

Kay, S. R., Fiszbein, A., & Opler, L. A. (1987). The Positive and Negative Syndrome Scale (PANSS) for schizophrenia. *Schizophrenia Bulletin*, *13*(2), 261–276. https://doi.org/10.1093/schbul/13.2.261

Kim, H.-Y. (2013). Statistical notes for clinical researchers: Assessing normal distribution (2) using skewness and kurtosis. *Restorative Dentistry & Endodontics*, *38*(1), 52–54. https://doi.org/10.5395/rde.2013.38.1.52

Knutsen, J., Crossman, M., Perrin, J., Shui, A., & Kuhlthau, K. (2019). Sex differences in restricted repetitive behaviors and interests in children with autism spectrum disorder: An Autism Treatment Network study. *Autism: The International Journal of Research and Practice*, *23*(4), 858–868. https://doi.org/10.1177/1362361318786490

Kovalev, V. A., Kruggel, F., & von Cramon, D. Y. (2003). Gender and age effects in structural brain asymmetry as measured by MRI texture analysis. *NeuroImage*, *19*(3), 895–905. https://doi.org/10.1016/s1053-8119(03)00140-x

Kozlowski, A. M., Matson, J. L., Horovitz, M., Worley, J. A., & Neal, D. (2011). Parents' first concerns of their child's development in toddlers with autism spectrum disorders. *Developmental Neurorehabilitation*, *14*(2), 72–78. https://doi.org/10.3109/17518423.2010.539193

Larson, F. V., Wagner, A. P., Jones, P. B., Tantam, D., Lai, M.-C., Baron-Cohen, S., & Holland, A. J. (2017). Psychosis in autism: Comparison of the features of both conditions in a dually affected cohort. *The British Journal of Psychiatry: The Journal of Mental Science*, *210*(4), 269–275. https://doi.org/10.1192/bjp.bp.116.187682

Liu, S., Tang, F., Dou, H., & Zhang, W. (2023). The relationship between autistic traits and empathy in adolescents: An ERP study. *Neuroscience Letters*, *802*, 137173. https://doi.org/10.1016/j.neulet.2023.137173

Loranger, A. W. (1984). Sex difference in age at onset of schizophrenia. *Archives of General Psychiatry*, *41*(2), 157–161. https://doi.org/10.1001/archpsyc.1984.01790130053007

Luo, Y., Pang, L., Zhao, Y., Guo, C., Zhang, L., & Zheng, X. (2020). Gender difference in the association between education and schizophrenia in Chinese adults. *BMC Psychiatry*, *20*(1), 296. https://doi.org/10.1186/s12888-020-02700-2

McGrath, J., Saha, S., Chant, D., & Welham, J. (2008). Schizophrenia: A concise overview of incidence, prevalence, and mortality. *Epidemiologic Reviews*, *30*(1), 67–76. https://doi.org/10.1093/epirev/mxn001

Nakata, Y., Kanahara, N., Kimura, A., Niitsu, T., Komatsu, H., Oda, Y., Ishikawa, M., Hasegawa, T., Kamata, Y., Yamauchi, A., Inazumi, K., Kimura, H., & Iyo, M. (2020). Autistic traits and cognitive profiles of treatment-resistant schizophrenia. *Schizophrenia Research. Cognition*, *22*, 100186. https://doi.org/10.1016/j.scog.2020.100186

Nenadić, I., Meller, T., Evermann, U., Schmitt, S., Pfarr, J.-K., Abu-Akel, A., & Grezellschak, S. (2021). Subclinical schizotypal vs. autistic traits show overlapping and diametrically opposed facets in a non-clinical population. *Schizophrenia Research*, *231*, 32–41. https://doi.org/10.1016/j.schres.2021.02.018

Ochoa, S., Usall, J., Cobo, J., Labad, X., & Kulkarni, J. (2012). Gender differences in schizophrenia and first-episode psychosis: A comprehensive literature review. *Schizophrenia Research and Treatment*, *2012*, 916198–916199. https://doi.org/10.1155/2012/916198

Ozbek, S. U., Sut, E., & Bora, E. (2023). Comparison of social cognition and neurocognition in schizophrenia and autism spectrum disorder: A systematic review and meta-analysis. *Neuroscience and Biobehavioral Reviews*, *155*, 105441. https://doi.org/10.1016/j.neubiorev.2023.105441

Randolph, C., Tierney, M. C., Mohr, E., & Chase, T. N. (1998). The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS): Preliminary clinical validity. *Journal of Clinical and Experimental Neuropsychology*, *20*(3), 310–319. https://doi.org/10.1076/jcen.20.3.310.823

Rapoport, J., Chavez, A., Greenstein, D., Addington, A., & Gogtay, N. (2009). Autism-spectrum disorders and childhood onset schizophrenia: Clinical and biological contributions to a relationship revisited. *Journal of the American Academy of Child and Adolescent Psychiatry*, *48*(1), 10–18. https://doi.org/10.1097/CHI.0b013e31818b1c63

Ribolsi, M., Di Lorenzo, G., Lisi, G., Niolu, C., & Siracusano, A. (2015). A critical review and meta-analysis of the perceptual pseudoneglect across psychiatric disorders: Is there a continuum? *Cognitive Processing*, *16*(1), 17–25. https://doi.org/10.1007/s10339-014-0640-2

Riches, N. G., Loucas, T., Baird, G., Charman, T., & Simonoff, E. (2011). Non-word repetition in adolescents with specific language impairment and autism plus language impairments: A qualitative analysis. *Journal of Communication Disorders*, *44*(1), 23–36. https://doi.org/10.1016/j.jcomdis.2010.06.003

Robles, O., Blaxton, T., Adami, H., Arango, C., Thaker, G., & Gold, J. (2008). Nonverbal delayed recognition in the relatives of schizophrenia patients with or without schizophrenia spectrum. *Biological Psychiatry*, *63*(5), 498–504. https://doi.org/10.1016/j.biopsych.2007.05.016

Saha, S., Chant, D., Welham, J., & McGrath, J. (2005). A systematic review of the prevalence of schizophrenia. *PLoS Medicine*, *2*(5), e141. https://doi.org/10.1371/journal.pmed.0020141

Southwick, J. S., Bigler, E. D., Froehlich, A., DuBray, M. B., Alexander, A. L., Lange, N., & Lainhart, J. E. (2011). Memory functioning in children and adolescents with autism. *Neuropsychology*, *25*(6), 702–710. https://doi.org/10.1037/a0024935

Sugranyes, G., Kyriakopoulos, M., Corrigall, R., Taylor, E., & Frangou, S. (2011). Autism spectrum disorders and schizophrenia: Meta-analysis of the neural correlates of social cognition. *PLoS One*, *6*(10), e25322. https://doi.org/10.1371/journal.pone.0025322

Sullivan, P. F., Magnusson, C., Reichenberg, A., Boman, M., Dalman, C., Davidson, M., Fruchter, E., Hultman, C. M., Lundberg, M., Långström, N., Weiser, M., Svensson, A. C., & Lichtenstein, P. (2012). Family history of schizophrenia and bipolar disorder as risk factors for autism. *Archives of General Psychiatry*, *69*(11), 1099–1103. https://doi.org/10.1001/archgenpsychiatry.2012.730

Tarasi, L., Trajkovic, J., Diciotti, S., di Pellegrino, G., Ferri, F., Ursino, M., & Romei, V. (2022). Predictive waves in the autism-schizophrenia continuum: A novel biobehavioral model. *Neuroscience and Biobehavioral Reviews*, *132*, 1–22. https://doi.org/10.1016/j.neubiorev.2021.11.006

Trevisan, D. A., Foss-Feig, J. H., Naples, A. J., Srihari, V., Anticevic, A., & McPartland, J. C. (2020). Autism spectrum disorder and schizophrenia are better differentiated by positive symptoms than negative symptoms. *Frontiers in Psychiatry*, *11*, 548. https://doi.org/10.3389/fpsyt.2020.00548

Vita, A., Barlati, S., Deste, G., Rocca, P., Rossi, A., Bertolino, A., Aguglia, E., Amore, M., Bellomo, A., Biondi, M., Carpiniello, B., Collantoni, E., Cuomo, A., D'Ambrosio, E., Dell' Osso, L., di Giannantonio, M., Giordano, G. M., Marchesi, C., Monteleone, P., … Maj, M. for R. on. Italian Network for Research on Psychoses (2020). The influence of autistic symptoms on social and non-social cognition and on real-life functioning in people with schizophrenia: Evidence from the Italian Network for Research on Psychoses multicenter study. *European Psychiatry: The Journal of the Association of European Psychiatrists*, *63*(1), e98. https://doi.org/10.1192/j.eurpsy.2020.99

Vila-Rodriguez, F., Ochoa, S., Autonell, J., Usall, J., & Haro, J. M. (2011). Complex interaction between symptoms, social factors, and gender in social functioning in a community-dwelling sample of schizophrenia. *The Psychiatric Quarterly*, *82*(4), 261–274. https://doi.org/10.1007/s11126-011-9168-0

Voyer, D., Voyer, S., & Bryden, M. P. (1995). Magnitude of sex differences in spatial abilities: A meta-analysis and consideration

of critical variables. *Psychological Bulletin*, *117*(2), 250–270. https://doi.org/10.1037/0033-2909.117.2.250

Wilson, C., Kline, E., Reeves, G. M., Anthony, L., & Schiffman, J. (2014). Blurred edges: Evolving concepts of autism spectrum disorders and schizophrenia. *Adolescent Psychiatry*, *4*(3), 133–146. https://doi.org/10.2174/2210676604031409121613 12

Zeidan, J., Fombonne, E., Scorah, J., Ibrahim, A., Durkin, M. S., Saxena, S., Yusuf, A., Shih, A., & Elsabbagh, M. (2022). Global prevalence of autism: A systematic review update. *Autism Research*, *15*(5), 778–790. https://doi.org/10.1002/aur.2696

Zhang, X. Y., Chen, D. C., Xiu, M. H., De Yang, F., Haile, C. N., Kosten, T. A., & Kosten, T. R. (2012). Gender differences in never-medicated first-episode schizophrenia and medicated chronic schizophrenia patients. *The Journal of Clinical Psychiatry*, *73*(7), 1025–1033. https://doi.org/10.4088/JCP.11m07422

Zheng, Z., Zheng, P., & Zou, X. (2018). Association between schizophrenia and autism spectrum disorder: A systematic review and meta-analysis. *Autism Research*, *11*(8), 1110–1119. https://doi.org/10.1002/aur.1977

Zhou, H., Xu, X., Yan, W., Zou, X., Wu, L., Luo, X., Li, T., Huang, Y., Guan, H., Chen, X., Mao, M., Xia, K., Zhang, L., Li, E., Ge, X., Zhang, L., Li, C., Zhang, X., Zhou, Y., … Wang, Y. (2020). Prevalence of autism spectrum disorder in China: A nationwide multi-center population-based study among children aged 6 to 12 years. *Neuroscience Bulletin*, *36*(9), 961–971. https://doi.org/10.1007/s12264-020-00530-6

Zhou, H., Yang, H., Gong, J., Cheung, E. F. C., Gooding, D. C., Park, S., & Chan, R. C. K. (2019). Revisiting the overlap between autistic and schizotypal traits in the non-clinical population using meta-analysis and network analysis. *Schizophrenia Research*, *212*, 6–14. https://doi.org/10.1016/j.schres.2019.07.050