



Psychometric properties of the PANSS autism severity score (PAUSS) in young peoples at clinical high risk for psychosis: does it really measure autistic features?

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Abstract

The PANSS Autism Severity Score (PAUSS) is a commonly used measure for autistic features in early psychosis, including in adolescents at Clinical High Risk (CHR). However, no research examining its psychometric properties in this at-risk population has been published to date. Therefore, we explored reliability, validity, and longitudinal course of PAUSS scores in a sample of young CHR individuals treated in an early intervention service in Italy during 2 years of follow-up. Participants completed the Autism-spectrum Quotient (AQ) and the Positive And Negative Syndrome Scale (PANSS) at baseline and annually during the follow-up. Cronbach's α statistics were used for internal consistency, while Cohen's k statistics and Spearman's correlation coefficients (ρ) were used for convergent validity with AQ scores and longitudinal stability. In the 214 recruited CHR participants, Cronbach's value was 0.849, but the PANSS G5 item showed unacceptable inter-item and item-total correlations. Furthermore, Cohen's k value in relation to AQ scores was unacceptable (0.022), as were ρ (<0.750) and k (<0.600) values for longitudinal stability. The results of this research suggest that the PAUSS may not be a valid tool for assessing autistic characteristics in CHR individuals. In fact, it may detect attenuated psychotic symptoms and their transient psychopathological severity, rather than being a reliable indicator of autistic features. Alternatively, its poor discriminatory ability could also reflect contamination of autism measurement by concurrent psychopathology. Therefore, it should never replace careful clinical judgment and the use of appropriate instruments for the diagnosis of ASD.

Keywords Autism · Clinical High Risk · Early psychosis · Psychopathology · Psychometrics

Introduction

Psychosis and *Autism Spectrum Disorders* (ASD) often co-occur. In this regard, recent meta-analytic studies have shown a pooled comorbidity prevalence rate of 9.4% [1] and reported that ASD influences the onset of psychosis with a probability approximately 4 times greater than in healthy control subjects [2].

In recent years, there has been growing interest in exploring ASD in prodromal phase of psychosis, particularly in shared clinical characteristics such as stereotyped behaviors, deficits in social interaction, and unusual thought content [3]. In this regard, meta-analytic findings showed that approximately 12% of young people at *Clinical High Risk for Psychosis* (CHR-P) also met diagnostic criteria for ASD [4], and that prodromes of psychosis were detected in

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over 40% of individuals with ASD [5], who also manifested impaired global functioning, severe language difficulties, and relevant cognitive deficits [6, 7].

Following recent developments in the psychometric assessment of ASD features in early stages of psychosis (including CHR-P mental states), a new and rapid psychopathological score has been derived from 8 specific items of the Positive And Negative Syndrome Scale (PANSS) [8]: i.e., the “PANSS Autism Severity Score” (PAUSS) [9]. These items were selected to hypothetically cover the three main ASD clinical dimensions according to the DSM-IV-TR criteria (i.e., repetitive patterns of interest/behavior and deficit in communication and social interaction [10] (see Supplementary Materials [Table S1] for details about the PAUSS configuration). The PAUSS was developed to evolve as a rapid and easy-to-use screening tool for the detection of ASD in psychosis [9], ultimately complementing gold-standard diagnostic instruments such as the Autism Diagnostic Observation Schedule (ADOS). Indeed, it showed good criterion validity and internal consistency in both ASD and schizophrenia spectrum disorders [11–13], as well as good convergent validity with the ADOS score [14]. Since these good psychometric properties have been substantially confirmed in several international samples of young individuals with first episode psychosis (FEP) [15–17], in recent years, the PAUSS has also been calculated in CHR-P populations to explore the presence of ASD features, with promising but inconclusive results [18]. In this respect, the severity of ASD attributes (measured with the PAUSS) in CHR-P patients resulted to be significantly lower than in patients with schizophrenia but higher than in subjects with mood disorders [19]. Furthermore, a significant positive association was also found between ASD symptoms and formal thought disorders [20]. Finally, CHR-P subjects with more severe ASD features showed worse baseline global functioning and higher PAUSS total scores that persisted over an 18-month follow-up period [21]. However, from a clinical perspective, a crucial underlying question remains open regarding conceptual bias in assessing ASD features during the clinical high-risk state. Specifically, a broader concern is that symptom overlap between attenuated psychotic phenomena and ASD may inherently limit the validity of any autism screening tool in CHR-P populations.

However, to date, no specific studies have been published examining the psychometric properties of the PAUSS in CHR-P populations. Since preliminary psychometric investigations are essential to obtain statistically robust research findings, the *aim* of this research was to explore psychometric characteristics of the PAUSS in a sample of CHR-P adolescents and young adults treated in an “early intervention in psychosis” (EIP) service. In this regard, we first analyzed the internal consistency and convergent/discriminant validity

of the PAUSS as compared with more specific and widely used questionnaires for measuring ASD features. Second, we examined its factor structure and longitudinal course of its scores over a 2-year follow-up. As this was an exploratory study on the psychometric properties of the PAUSS, no a-priori hypotheses were formulated. Since the PAUSS has been conceptualized and widely used as a potential tool to identify ASD characteristics in young individuals with psychosis or at CHR-P, we performed a specific examination of its psychometric features in comparison with another instrument that specifically measures ASD attributes even in the absence of psychosis, in order to obtain better evidence of its detection potential.

Methods

Setting

Adolescents and young adults at CHR-P were recruited through the “Parma At-Risk Mental States” (PARMS) program from January 2016 to December 2022. The PARMS program is a diffused EIP infrastructure implemented in all adolescent mental health services of the Parma Department of Mental Health, in Northern Italy [22].

Inclusion criteria were: seeking specialist help for mental health needs, age 16–25 years, and to meet CHR-P criteria as described in the “Comprehensive Assessment of At-Risk Mental States” (CAARMS: i.e., “Brief Intermittent Psychotic Symptoms” [BIPS], “Vulnerability Group” [VG] and “Attenuated Psychotic Symptoms” [APS]) [23] (see Supplementary Materials Table S2 for details on CAARMS categories). *Exclusion criteria* were past overt psychotic episodes, past antipsychotic exposure, medical disease with psychiatric features, and known intellectual disability (IQ < 70). Past antipsychotic treatment was here considered a proxy for the presence of a past psychotic episode, consistently with the original definition of the CAARMS psychosis threshold [24].

This research complied with the 1964 Helsinki Declaration (and its later amendments) and obtained local ethical approvals (AVEN Ethics Committee protocol no. 559/2020/OSS*/AUSLPR). All CHR-P participants (including guardians in the case of minors) gave their written informed consent prior the participation in this study.

Instruments

For the specific purposes of this research, psychopathological evaluation included the CAARMS, the PANSS, and the Autism-spectrum Quotient (AQ) [25].

The *CAARMS* is a structured interview to specifically assess psychopathology in CHR-P individuals. In this research, trained PARMS staff members administered the authorized Italian version of the *CAARMS* [26], which showed excellent interrater reliability in our CHR-P samples [27].

The *PANSS* is a structured interview widely used to assess psychopathology in psychosis, including in CHR-P subjects [19, 28, 29]. In this study, qualified PARMS staff researchers used the Italian version of the *PANSS* [30], which showed good psychometric properties in our individuals at CHR-P [31]. In the original validation research on patients with psychosis, participants scoring above 30 on the PAUSS were categorized as having severe autistic-like features [9]. However, to date, no specific PAUSS cut-off value has been identified in CHR-P populations to define those individuals with an autistic phenotype.

The *AQ* is a popular self-report questionnaire to assess autism-spectrum traits in adolescents and adults. Its 50 items are scored using a 4-point Likert scale ranging from 1 (“definitely agree”) to 4 (“definitely disagree”). An *AQ* total score > 31 indicates a highly probable diagnosis of ASD, while subjects with ASD-traits usually scored above 25 [32]. In this research, we used the Italian version of the *AQ* [33], which showed good psychometric properties in young patients with early psychosis [34, 35]. At baseline, this questionnaire was completed after the administration of all diagnostic and psychopathological interviews. It is not a diagnostic tool but serves as a screening measure to help individuals understand their ASD characteristics and seek appropriate support [25].

Our assessment battery was administered at presentation and annually during the follow-up period. Finally, a *sociodemographic/clinical chart* collecting data on a broad range of demographic, social, and clinical parameters was completed at entry for each CHR-P participant.

Procedures and statistical analysis

Data were analyzed using JASP, version 0.98.0 (2026) for Windows [36]. All statistical analyses considered critical *p*-values set at 0.05. When applicable, in Spearman correlation analyses the Bonferroni correction was also applied to minimize multiple comparisons [37].

The *internal consistency* of the PAUSS was analyzed using Cronbach’s statistics in the total sample [38]. Alpha values > 0.700 were usually considered for acceptable internal consistency [39]. We also explored PAUSS inter-item correlations and correlations of each item with the total score. Specifically, *r* values < 0.400 were indicative for item deletion [40]. Finally, we examined α scores if each item was eliminated. An increase in the α value after item

deletion indicated that item removal improved the overall reliability of the PAUSS [41].

The *convergent/discriminant validity* of the PAUSS was initially examined calculating Spearman’s (ρ) inter-correlation coefficients between PAUSS and *AQ* total scores in the total sample at entry. We then used Cohen’s *k* statistics to compare the agreement between PAUSS and *AQ* classification. As indicated in the original validation study, a PAUSS cut-off score > 30 was indicative of the presence of relevant ASD features [9]. However, this value was calculated within a clinical population of patients with overt psychosis and may not be appropriate for adolescents and young adults at CHR-P, who often show lower *PANSS* scores than subjects with FEP [42], although less evidently for negative and disorganized symptoms [43]. Therefore, following the methodology proposed by Komatsu and colleagues [21], whose research is still the only one published in the literature to propose a method of dichotomizing CHR-P subjects with or without relatively high ASD features, we used a cut-off score based on the baseline median PAUSS score within the whole sample (18.5). Specifically, a PAUSS cut-off score > 18.5 categorized the CHR-P subgroup as having relatively high ASD features. Conversely, an *AQ* cut-off score > 25 was suggestive of the presence of autism-spectrum traits [32]. *K* values > 0.600 indicated substantial agreements between the two instruments [44].

Regarding *longitudinal course/stability* of PAUSS scores, we first performed the Wilcoxon signed-rank test for repeated measure over the follow-up period (i.e., at 1- and 2-year time points) in the entire sample. Longitudinal stability of PAUSS scores was indicative of the presence of enduring ASD features. Longitudinal changes in PAUSS scores were also examined by calculating Spearman’s correlation coefficients (ρ) between scores obtained at baseline and at follow-ups. According to more conservative psychometric requirements for clinical variables, ρ values > 0.750 were interpreted as acceptable and indicative of moderately strong and stable correlations over time [45]. Finally, the proportion of concordance observed among CHR-P participants with PAUSS score > 18.5 at follow-up assessments was calculated using Cohen’s *k* statistics. *K* values > 0.600 indicated substantial agreements.

The statistical ability of different *PAUSS cut-off* scores to predict CHR-P individuals with *AQ* score > 25 (i.e., indicative of the presence of autism-spectrum traits) was explored via Receiver Operator Characteristic (ROC) curve in the entire baseline sample. An area under the ROC curve (AUC) value > 0.700 was considered acceptable [46]. Furthermore, the Youden index (*j*) was calculated to examine optimal cut-off values from ROC curves, giving equivalent weight to sensitivity and specificity [47]. In fact, this index is the farthest point on the ROC curve from the diagonal

Table 1 Item-total statistics for each PAUSS item and total score in the CHR-P total sample at baseline ($n=214$)

PAUSS items ($\alpha=0.849$)	Item-total (r) correlation	Cronbach's α if item deleted
N1 Blunted affect	0.588	0.830 (95% CI = 0.793-0.853)
N3 Poor rapport	0.773	0.804 (95% CI = 0.776-0.832)
N4 Social withdrawal	0.784	0.812 (95% CI = 0.777-0.839)
N5 Abstract thinking	0.682	0.818 (95% CI = 0.777-0.845)
N6 Flow of conversation	0.561	0.835 (95% CI = 0.792-0.851)
N7 Stereotyped thinking	0.716	0.815 (95% CI = 0.773-0.841)
G5 Mannerisms	0.152	0.864 (95% CI = 0.829-0.886)
G15 Preoccupation	0.384	0.856 (95% CI = 0.821-0.875)

Cronbach's α and Pearson correlation (r) coefficients are reported. Cronbach's α value >0.700 =acceptable internal consistency; r values <0.400 (in bold) are indicative for item deletion

PAUSSPANSS Autism Severity Score, PANSSPositive And Negative Syndrome Scale, CHR-PClinical High-Risk for Psychosis, 95% CI95% Confidence Interval

line of random probability, which maximizes the difference between true positive rate (sensitivity) and false positive rate (1-specificity) (i.e., $j = \max [\text{sensitivity} + \text{specificity}] - 1$).

Lastly, we conducted an Exploratory Factor Analysis (EFA) to analyze the factor configuration of the PAUSS, specifically to compare the emerging factors with the 3-factor model hypothesized in the original development of the scale [9]. EFA was conducted because it is widely used technique for identifying hidden patterns in a set of variables and for testing what structure, if any, can be found in the data, rather than imposing a predefined structure [48]. To assess good factorability, both a statistically significant Bartlett's test of sphericity value ($p < .05$) and a Kaiser-Meyer-Olkin (KMO) value greater than 0.600 were used [49]. Specifically, we used the Principal Axis Factoring (PAF) extraction method to determine how factors were derived from the polychoric correlation matrix, an approach more appropriate for analyzing ordinal data or quantitative variables measured in intervals. We retained all factors with eigenvalues greater than 1.0. No parallel analysis or other retention criterion were applied. Promax rotation was performed to clarify the relationship between the factors [50]. Only item loading values greater than 0.450 were considered relevant within each factor [51]. We used the Variance Inflation Factor (VIF) and residual correlation matrices to examine model multi-collinearity and local dependence of PAUSS items, respectively. A VIF value of > 5 suggested problematic multicollinearity and large residual correlations (i.e., > 0.20) indicated local dependence [51].

Table 2 Baseline correlations between PAUSS and AQ scores in the CHR-P total sample ($n=214$)

Variable	AQ total score (p)	p
PAUSS total score	0.168 (95% CI = -0.004-0.331)	0.057
N1 Blunted affect	0.262 (95% CI = 0.193-0.426)	0.040
N3 Poor rapport	0.075 (95% CI = -0.099-0.244)	0.399
N4 Social withdrawal	0.096 (95% CI = -0.081-0.261)	0.409
N5 Abstract thinking	0.120 (95% CI = -0.053-0.287)	0.174
N6 Flow of conversation	0.082 (95% CI = -0.092-0.251)	0.356
N7 Stereotyped thinking	0.038 (95% CI = -0.135-0.209)	0.669
G5 Mannerisms	-0.011 (95% CI = -0.183-0.162)	0.904
G15 Preoccupation	0.165 (95% CI = -0.008-0.382)	0.496

Spearman's rank correlation coefficients (ρ) and *Bonferroni's corrected p values are reported. Statistically significant p values are shown in bold. Specifically, p values were corrected for the total number of comparisons ($n=8$)

PAUSSPANSS Autism Severity Score, AQAutism spectrum Quotient, CHR-PClinical High Risk for Psychosis, T0baseline assessment time; 95% CI=95% Confidence Interval

Results

Over the course of the study, 214 CHR-P adolescents and young adults (110 [51.4%] males; mean age = 19.25 ± 3.76 years) were recruited (see also Supplementary Materials [Table S3] for details on clinical and sociodemographic characteristics of the total sample at baseline).

In the entire sample at presentation, although the PAUSS overall demonstrated a good *internal consistency* ($\alpha=0.849$; 95% Confidence Interval [CI] = 0.814-0.870), two items had critical item-total and inter-item associations ($r < .400$): namely, PANSS G15 and PANSS G5 (Table 1; see also Supplementary Materials [Table S4] for details). Indeed, their removal increased PAUSS α scores and should be considered to further improve reliability.

Regarding *convergent/discriminant validity* in the total baseline sample, no statistically significant correlation was observed between the AQ total score and PAUSS scores was observed, except for the PANSS item N1 subscore (Table 2). However, the isolated association between the AQ total score and N1 should be interpreted cautiously in the context of multiple item-level comparisons.

Similarly, Cohen's k value confirmed a very slight agreement between PAUSS and AQ cut-offs scores ($k=0.022$; 95% CI=0.002-0.043) (see also Supplementary Materials [Table S5] for details).

Regarding *longitudinal stability/course* of the PAUSS in the entire sample, the results of Wilcoxon test for repeated measures demonstrated a significant decrease in PAUSS scores over the follow-up period (Table 3). Additionally, unacceptable Spearman correlation coefficients for PAUSS scores were found at both 1 and 2 years ($p < 0.750$). Unacceptable agreements ($k < 0.600$) were also observed among CHR-P individuals with PAUSS score > 18.5 during follow-up assessments (specifically k agreement between T0 and

Table 3 Longitudinal course/stability of PAUSS scores in the CHR-P total group over the 2-year follow-up period

Variable	T0 (n=214)	T1 (n=189)	T2 (n=129)	T0-T1 z (p)	T1-T2 z (p)	T0-T2 z (p)
PAUSS scores	18.5 (13–25)	13 (10–18)	12 (10–19)	–4.213 (0.001)	–3.335 (0.001)	–4.611 (0.001)
Variables	T0 PAUSS score (p)					
T1 PAUSS score	0.744 (95% CI = 0.689–0.822; p=. 001)					
T2 PAUSS score	0.572 (95% CI = 0.423–690; p=. 001)					

Median and interquartile ranges, Wilcoxon test (z) and Spearman's rank correlation (p) values are reported. In Spearman's rank correlations, p values <0.750 are Unacceptable. Statistically significant p values are shown in bold. The paired observations included in the Wilcoxon comparisons and Spearman correlational analyses consider the marginal sample sizes at T1 (n=189) and T2 (129); indeed, the service disengagement involved 85 CHR-P participants (25 in the first year of treatment). There was no missing data

PAUSSPANSS Autism Severity Scores, CHR-P Clinical High Risk for Psychosis, T0 baseline assessment time; T1 1-year assessment time; T2=2-year assessment time; p=statistical significance; 95% CI=95% Confidence Interval

Table 4 Exploratory Factor Analysis (EFA) of the PAUSS in the CHR-P total sample at baseline (n=214)

CHR-P total sample			
Model: $X^2=31.232$, $df=7$, $p=.001$.			
PAUSS items	Factor 1	Factor 2	Item Communalities
N1 Blunted affect	0.674	0.239	0.371
N3 Poor rapport	0.862	0.036	0.764
N4 Social withdrawal	0.883	0.061	0.549
N5 Abstract thinking	0.808	0.270	0.430
N6 Flow of conversation	0.624	0.302	0.398
N7 Stereotyped thinking	0.821	0.246	0.445
G5 Mannerisms	0.239	0.868	0.755
G15 Preoccupation	0.514	0.186	0.346
Percentage of explained variance	49.709	13.630	–

Correlation between the two extracted factors = 0.534

PAUSSPANSS Autism Severity Scores, PANSS Positive And Negative Syndrome Scale, CHR-P Clinical High Risk for Psychosis, df degrees of freedom

Statistically significant p values and item loadings are reported in bold. Specifically, item loading values were considered as relevant if >0.45 for each factor. Kaiser-Meyer-Olkin (KMO) value = 0.615. Bartlett's test of sphericity: $p=.001$. A Variance Inflation Factor (VIF) of 4.323 (i.e., < 5) excluded problematic multicollinearity. All residual correlations were <0.20, indicating local independence of PAUSS items. Applied rotation method is promax with Kaiser normalization. Chi-square test (X^2) values are also reported

T1 PAUSS cut-off scores was 0.592 [95% CI = 0.470–0.714] and k agreement between T0 and T2 PAUSS cut-off scores was 0.421 [95% CI = 0.260–0.582]; see also Supplementary Materials [Table S6] for details). However, when interpreting these results, it should be considered that the service disengagement involved 85 CHR-P participants (25 in the first year of treatment). There was no missing data (see Supplementary Materials [Table S7] for comparisons on baseline clinical and sociodemographic characteristics between participants who completed the follow-up period and those who did not).

In this regard, our ROC results showed an unacceptable AUC value < 0.700 for the PAUSS score in predicting participants with AQ score > 25 at entry in the entire CHR-P

sample (AUC=0.602; 95% CI=0.490–0.711) (see also Supplementary Materials [Table S8] for details). In this regard, the optimal cut-off score from the ROC curve maximizing the J index was higher (> 33) than that proposed by Komatsu and coauthors [21], as well as was our median PAUSS score (18.5).

Finally, EFA results suggested the PAUSS factorability and adequacy in our dataset (i.e., KMO index=0.615 and statistically significant Bartlett's test of sphericity [$p=.001$]) (Table 4). Specifically, our analysis showed the presence of two main factors in the entire CHR-P sample explaining 63.3% of the total variance. The first factor (explaining 49.7% of the total variance) included all PAUSS items, except the PANSS G5 item, which was separated into the second factor.

Discussion

ASD features can also be detected in patients with mental disorders other than ASD, fragmenting the prototypical phenotype into dimensional characteristics [52]. In this regard, within the multiple manifestations of psychosis, a distinct subtype with relevant ASD features has recently been proposed [16, 53]. This hypothetical subgroup of psychosis has prevalence rates ranging from 9% to 61% [54] and is associated with an earlier age at onset, more severe psychopathology, worse global functioning and a poor prognosis [55].

Since ASDs have also been described in FEP, with a prevalence ranging from 9% to 18% [56], there has been growing interest in detecting them in prodromal phase of psychosis, including young people at CHR-P, especially using the PAUSS, a promising new index rapidly derived from the PANSS, which is not time consuming and does not require extensive training, unlike standard diagnostic tools for ASD. Notably, even in individuals with CHR-P, baseline PAUSS scores were significantly correlated with the severity of their formal thought disorders [19] and with worse global functioning [29]. Furthermore, an interesting

1-year follow-up study in Japan reported that PAUSS scores improved over time, supporting the idea that ASD features could be considered both transient (state) and enduring (traits) characteristics in CHR-P subjects [21]. However, despite the recent popularity of the PAUSS in early psychosis, its psychometric properties have not been examined in CHR-P samples. Therefore, the examination of these statistical characteristics was the main objective of this research, as well as the evaluation of their stability over a 2-year follow-up period.

Regarding the *reliability* of the PAUSS, the results of this investigation highlight *good internal consistency*, in line with previous studies on patients with FEP and prolonged psychosis [57, 58]. However, two items (i.e., *PANSS G5 and G15*) proved to be particularly critical, showing very weak item-total and inter-item correlations. However, deleting these items resulted in only modest increases in alpha values (from 0.849 to 0.856 and 0.864). These small changes in alpha do not, by themselves, demonstrate that removing the items would significantly improve the internal consistency of the scale. Decisions regarding item elimination should also consider content validity, theoretical coverage, and replicability in independent samples. Therefore, we intended the possible removal of G5 and G15 as a hypothesis for future scale-development research rather than as a direct recommendation based on the current sample.

The results of our factor analysis partly went in the same direction, highlighting the separation of G5 item from the other PAUSS items. According to the findings of our EFA, the PAUSS items except G5 appeared to belong to a single coherent dimension that explained approximately 50% of the total variance. Further studies on the PAUSS are needed to replicate our results and better discuss the theoretical concept underlying the PAUSS score. Indeed, being based on the 3 main clinical domains of ASD described in the DSM-IV-TR [10], the PAUSS does not address its conceptual discrepancy with the 2-domain model of the current DSM-5 diagnostic framework [59] and a re-evaluation of this psychopathological construct is recommended.

However, it should also be noted that the KMO value of 0.615 indicated only marginal sampling adequacy. Therefore, while it passed our predefined minimum criterion, it did not provide strong evidence of a robust or stable factorial structure. Furthermore, the second reported factor consisted exclusively of the PANSS G5 item, and a latent factor defined by a single item cannot generally be considered as a stable or clearly interpretable dimension. This result can also be plausibly interpreted as evidence that the item G5 performed differently from the remaining PAUSS items or shared very little variance with them. Therefore, a more conservative and perhaps more accurate interpretation suggests that seven items loaded onto a predominant common factor,

whereas G5 exhibited atypical or isolated item behavior. Consequently, these findings should not be presented as strong evidence supporting a substantial two-factor structure. In contrast, our EFA results did not independently confirm the “unidimensionality” of the revised seven-item version of the PAUSS. This conclusion absolutely warrants further analyses and replication, preferably via confirmatory factor analysis in independent CHR-P samples. Our current factorial solution should therefore be presented as preliminary and sample-dependent. The results of this research also showed a weak *convergent validity* between AQ and PAUSS total scores in our CHR-P sample at presentation and inadequate agreement between their cut-off scores according to the κ statistics. In this regard, our ROC analysis confirmed an unacceptable AUC value for the PAUSS in predicting an AQ score > 25 and suggested a higher optimal PAUSS cut-off score (> 33) to maximize sensitivity and specificity. As a result, lower PAUSS cut-offs were found to be more effective in excluding CHR-P subjects without ASD symptoms than in including those with ASD features. This discrepancy may be partly related to the fact that ASD characteristics often induce impairments in introspective and self-assessment abilities, negatively affecting individual’s performance on self-report instruments [60].

However, our positive Spearman correlation between continuous PAUSS and AQ scores provided evidence of convergent construct validity, although the association was weak in the current sample. Nonetheless, this poor convergence with AQ scores does not, by itself, demonstrate that the PAUSS does not measure any autism-related construct. Indeed, the observed association could be influenced by differences between clinician ratings and self-report assessments, limitations of the AQ in early psychosis, difficulties in self-evaluation, limited score variability, or differences in the specific characteristics captured by the two measures. Moreover, the AQ is not a gold-standard diagnostic tool for ASD but serves as a screening measure to help individuals understand their ASD characteristics and seek appropriate support [25]. Therefore, in the specific context of the testing (i.e., CHR-P mental states), the presented data may more directly demonstrate poor discriminatory ability between ASD features and concurrent attenuated psychotic symptoms, rather than the absence of construct validity per se. Indeed, given the substantial phenomenological overlap between ASD and CHR-P psychopathology, our results more likely suggest that the PAUSS lacks sufficient discriminant validity in this clinical context, reflecting a possible contamination of ASD measurement by comorbid psychopathology.

Finally, Cohen’s kappa coefficients assessed the agreement between two classifications based on the selected PAUSS and AQ thresholds and did not specifically establish

the diagnostic validity or interchangeability between the two instruments. Similarly, the ROC analysis assessed the ability of PAUSS scores to distinguish participants with scores above or below the AQ cut-off of >25 threshold, not the ability of the PAUSS to detect individuals with a clinical diagnosis of ASD. Specifically, the reported AUC of 0.602 indicated limited discrimination relative to AQ-defined status. Furthermore, the proposed PAUSS cut-off of >33 was selected and evaluated using the same sample. Therefore, it should be considered an exploratory and not clinically validated value, which could provide an optimistic estimate of its performance in independent samples.

Regarding the *longitudinal course/stability* of the PAUSS, our results highlighted significant *reductions* in its total scores over time, as well as unacceptable Spearman correlation coefficients (both at 1 and 2 years) and inadequate κ concordance among the prevalences of CHR-P subjects who scored above the PAUSS cut-off value during the follow-up period. This lack of longitudinal stability in PAUSS scores could be due to “state-like” psychotic symptoms rather than “enduring” ASD features [55]. In this sense, the PAUSS may represent a psychopathological indicator of psychotic symptoms (particularly, negative and disorganized ones) rather than ASD characteristics. Therefore, it would not be able to accurately capture the clinical aspects of ASD and, consequently, would not be suitable for assessing them.

Alternatively, the observed results could also reflect contamination of ASD measurement by concurrent psychopathology, rather than evidence that this derived score does not measure ASD features at all. Otherwise, ASD characteristics in CHR-P individuals may manifest as either transient (state) and/or enduring (trait) attributes [21]. Therefore, further research on larger CHR-P samples and with longer follow-up periods exceeding two years is needed. Furthermore, future investigations should explore how to disentangle symptom overlap between attenuated psychosis and ASD in assessment procedures, including using gold-standard ASD instruments alongside the PANSS. This may also help address the inherent issue of whether the observed results reflect limitations of the PAUSS specifically or the broader difficulty of assessing autistic traits during active phases of psychopathology.

Limitations

First, the PARMS service operates in a real-world setting, focusing primarily on providing optimal, evidence-based interventions for adolescents and young adults at CHR-P within community mental health centers. It is not specifically focused on the diagnosis and treatment of ASD, although the AQ was introduced in the assessment battery

for psychopathological reasons. However, because the AQ is a self-administered screening instrument for measuring enduring autism-spectrum features, its psychometric weakness in individuals with early psychosis are well-documented [61]. Further research is needed comparing our results with gold-standard diagnostic scales for ASD, even in a subset of items.

Second, we used the α statistic to analyze the internal consistency of the PAUSS rather than statistical methods that would be appropriate for ordinal measures, such as the Omega coefficient [62]. This is to allow psychometric comparisons with previous results reported in FEP studies. However, the ω value for the PAUSS total scale was also appropriate (i.e., 0.842; 95% CI = 0.819–0.872).

Third, it should be considered that a PAUSS threshold based on the sample median cannot constitute an externally validated or clinically meaningful cut-off for ASD features. It provides a relative division of a particular sample rather than identifying participants with clinically relevant ASD characteristics. Consequently, this limitation may influence the classification of PAUSS-positive individuals, Cohen’s kappa results, and longitudinal analyses. However, we decided to use the median value for the PAUSS cut-off following the methodology proposed by Komatsu and colleagues [21], whose research is still the only one published in the literature to propose a method of dichotomizing CHR-P subjects with or without clinically relevant ASD features. This allowed us to compare our findings with those reported by the authors and analyze the statistical significance of different PAUSS thresholds. In any case, we should always consider that CHR-P participants above this threshold are individuals having relatively higher PAUSS scores rather than specifically having elevated ASD features. Therefore, all analysis based on this classification should be presented as exploratory.

Other key weaknesses are related to the lack of control groups including ASD patients without psychosis and to the relatively small sample size, particularly of subjects who scored above the cut-off values on both the PAUSS and the AQ. Additionally, no specific diagnosis of ASD was made using the DSM-5 criteria at the time of presentation, despite previously reported overlap. This could influence the results and the factor configuration of the PAUSS. However, this could also suggest that mental health professionals working in CHR-P services underestimate the symptoms and the diagnosis of ASD, especially in adolescence. In this regard, training courses are needed to promote the neurodevelopmental paradigm for ASD and psychosis.

Sixth, it may be difficult to interpret the results on the longitudinal course/stability of the PAUSS without exploring its short-term stability. In fact, high short-term stability is a useful prerequisite to measure longitudinal changes.

Furthermore, the interpretation of the longitudinal results of PAUSS scores is further complicated by the 1- and 2-year time intervals. Indeed, in a CHR-P population undergoing clinical care, real changes in psychopathology, functioning, treatment, or clinical status are likely to occur. Therefore, it cannot be automatically inferred that the measured construct remained stable during the follow-up.

Seventh, the AQ has significant limitations as a screening tool when comparing it against “gold standard” diagnostic interviews and semi-structured observation tools. Indeed, there are many reasons for this discrepancy, such as the fact that the DSM criteria are not fully covered by the AQ and the AQ includes many behaviors that are not part of the DSM criteria but are often associated features of ASD [63]. Thus, it is difficult to interpret the modest association of the PAUSS with the AQ.

Eight, when interpreting our results, the potential influence of selective attrition must also be considered. Indeed, in this study, service disengagement involved 85 CHR-P participants (25 in the first year of treatment). This may reduce the statistical power of our longitudinal analyses and the generalizability of our findings, introducing potential bias related to the clinical characteristics of participants who did not complete the follow-period (e.g., uncooperativeness, lower illness awareness, more severe psychopathology, worse clinical outcomes), some of which may be linked to ASD attributes.

A further limitation is that our subjects were drawn from a single CHR-P service in Italy. Therefore, future multicenter studies are needed, especially to confirm our data factor analysis. Finally, no scales were administered to measure schizotypy and its psychopathological relationship with ASD features.

Conclusions

Although the PAUSS is a commonly used index to measure ASD characteristics in psychosis, the findings of this research highlight that it may not be a valid tool for assessing ASD features in adolescents and young adults at CHR-P. Indeed, it could more likely detect attenuated psychotic symptoms and their transient psychopathological severity, rather than being an indicator of enduring ASD attributes. This may be plausible, especially considering that the PAUSS is derived from PANSS items and that several items overlap conceptually with negative and disorganized symptoms. In this regard, our results showed weak convergence between PAUSS and AQ scores, low agreement between PAUSS- and AQ-based classifications, a longitudinal decline in PAUSS scores, limited discrimination of the AQ-defined state and a factor solution dominated by

seven items, with G5 performing separately. These findings raise questions about interpreting the PAUSS as a pure and stable measure of ASD features. However, they do not directly demonstrate that the PAUSS measures the severity of psychotic symptoms. In this direction, despite the overlap among items, statistically significant positive correlations were found between the PAUSS score and the subscores of PANSS negative and disorganized dimensions ($\rho=0.894$, $p=.001$; and $\rho=0.799$, $p=.001$, respectively).

However, a more cautious formulation would be that PAUSS scores may be substantially influenced by state-related psychotic, negative, or disorganized symptoms. Indeed, the poor ability of the PAUSS in discriminating between ASD features and concurrent attenuated psychotic symptoms could also reflect contamination of ASD measurement by concurrent psychopathology, rather than evidence that its derived score does not measure ASD attributes at all. Furthermore, all of our conclusions must be tempered by the association of PAUSS with an imperfect comparator and the absence of an independent specialist autism assessment. Therefore, the PAUSS should never replace careful psychopathological judgment and the use of appropriate instruments for the diagnosis of ASD (e.g., the ADOS).

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Data availability The data that support the findings of this research are available on reasonable request from the corresponding author. The data are not publicly available due to privacy and/or ethical restrictions.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical approval This research complied with the 1964 Helsinki Declaration (and its later amendments) and obtained local ethical approvals (AVEN Ethics Committee protocol no. 559/2020/OSS*/AUSLPR).

Consent to participate All CHR-P participants (including guardians in the case of minors) gave their written informed consent prior the participation in this study.

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