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Article

Psychometric Property of the Chinese Version of the Core Symptom Index: A Study Among Chinese Parents of Children with Autistic Spectrum Disorders

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Abstract: (1) Background: Parents of children with autism spectrum disorders often experience psychological distress, which can affect the quality of childcare they provide. It is crucial to screen for psychiatric symptoms among these parents. The Core Symptom Index (CSI) is a widely used tool for assessing general symptoms such as depression, anxiety, and somatic symptoms, with demonstrated validity and reliability across various populations. However, there is limited research on the validity and reliability of the CSI in the general Chinese population. This study aimed to investigate the psychometric properties of the Chinese version of the CSI among parents of children with autism spectrum disorders using Confirmatory Factor Analysis (CFA). (2) Methods: A total of 794 Chinese parents raising children with autism participated in this study. All completed the CSI, along with the social inhibition subscale of the Interpersonal Problems Inventory and the Couple Satisfaction Index. Factorial validity was assessed using CFA to determine how well the bifactor three-factor model fits the data. Various structural models were compared using model fit indices. Convergent and discriminant validity were examined by exploring correlations with the social inhibition subscale and the Couple Satisfaction Index. Invariance testing of the CSI was conducted across multiple groups based on gender, age, and education using CFA. The reliability of the CSI was evaluated using McDonald's omega coefficients. (3) Results: The bifactor model emerged as the best-fitting model for the data, suggesting that the total score of the CSI adequately represents overall psychiatric symptoms. The CSI exhibited significant correlations with the social inhibition subscale ($r = 0.41$, $p < 0.01$) and smaller correlation coefficients with the Couple Satisfaction Index ($r = -0.16$, $p < 0.05$), indicating both convergent and discriminant validity. Invariant tests supported scalar invariance levels based on gender and age but only partial invariance for education. The Chinese version of the CSI demonstrated high consistency, with McDonald's omega coefficients ranging between 0.86 and 0.95. (4) Conclusions: The bifactor model of the Chinese version of the CSI is validated, making it a suitable tool for measuring depression, anxiety, and somatization symptoms among parents of children with autism spectrum disorders. Further research on other Chinese populations is encouraged.

Keywords: psychometric property; CSI; bifactor; measurement; measurement invariance; psychological distress

1. Introduction

Autism Spectrum Disorder (ASD) is a significant global public health concern, imposing a substantial burden on affected families and society due to associated health challenges, especially during the COVID-19 pandemic [1,2]. Not only do the symptoms cause the parents to be distressed, anxious, and depressed, but also affect family cohesion and parental relationship [3–9].

To identify parents who are at risk of developing mental health issues, one practical approach is to utilize self-report questionnaires. The common psychiatric symptoms that can be captured by many screening scales include anxiety, depression, and somatization. One commonly used scale includes The Symptom Checklist-90 (SCL-90) is a widely used self-report questionnaire designed to assess psychological symptoms and distress[10]. It consists of 90 items that measure nine primary symptom dimensions: Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, and Psychoticism. However, due to its length and some symptoms shown to have poor discriminatory ability.

One of the brief version scales based on SCL-90 is the 18-item Brief symptom index (BSI) [11–13]. The Chinese version of the 18-item BSI has proven to be valid and reliable. A study has found that the three-factor and bi-factor models fitted the studied data best. [14]. Another brief psychiatric symptom scale used in the Chinese population was the Core symptom index (CSI), consisting of 15 measures of depression, anxiety, and somatization symptoms in epidemiologic studies. The CSI was originally developed among the Thai sample. Recent research has indicated that the CSI is psychometrically adequate. The first-order three-factor solution of the CSI appeared to fit the Thai sample adequately, however, and the bifactor model was shown to fit the Thai older sample the best allowing the CSI to be used as a single construct of psychiatric symptoms.

The CSI has been used in various populations and settings, including the general population, older residents in long-term care facilities, clinical outpatients, late adolescents, and adults [15–19]. The CSI has shown that the bifactor model fits best with the Thai older sample. The use of the CSI among the Chinese population of parents of children with ASD has some merit. First, both the CSI and BSI address similar symptoms, including anxiety, depression, and somatization, but their brevity enhances compliance. The advantage of the CSI over the BSI is that it originates from a sample with a similar Asian culture (Chinese and Thai), reducing cultural biases, particularly in somatization[20–22].

A study of the CSI among 803 older participants revealed that the three-factor model exhibited a fair level of fit, with CFI and TLI values higher than 0.9 and an RMSEA value less than 0.08. Additionally, the SRMR was less than 0.06, and the ratio of χ^2 to df was greater than 3. The bifactor model of the CSI demonstrated the best-fit statistics across all models, producing a lower BIC value, indicating its statistical superiority. The common variance index showed that 61% was explained by the general factors in the bifactor model ($>.50$), whereas the specific factors accounted for only 11.5% to 16.5% of the common variance. The IECV indicated that items reflect a general dimension more than a specific dimension, with all items yielding a value above 0.5 except for four items. This suggests that most items were stronger measures of general factors than specific factors. The fit indices of the bifactor model were as follows: Chi-square = 138.91, df = 75; CFI = .991, TLI = .987, RMSEA = .033 [90% CI, .024-.041], SRMR = .030.

In addition to the factor structure, the concept of measurement invariance is crucial in evaluating the quality of a measurement. In the original Thai version, it was found that there was a problem of measurement invariance across sexes and education levels, which may be due to the older sample and the insufficient sample size. The CSI has been translated into Chinese and used with Chinese businessmen. However, the Chinese version of the CSI has yet to be evaluated regarding its psychometric properties. This study aims to explore the factor structure of the CSI, its internal consistency, convergent and discriminant validity, and measurement invariance. The authors hypothesize that both the three-factor model and the bifactor model would fit the data well. In the context of the CSI instrument in China, there is limited data on its validity and reliability across different Chinese populations. This raises the question of whether the CSI can be equally applied to

all groups in China. Thus, the objective of the study is to determine if the CSI exhibits consistent psychometric properties across different demographic groups in Chinese communities.

2. Materials and Methods

The study utilized a validation survey design involving couples who were parents of children with ASD. The sample consisted of 1,030 participants, and after excluding invalid data, the final sample size was 794 participants aged between 23 and 45 years. Ethical approval for this research was obtained from the Research Ethics Committee, the Faculty of Medicine, Chiang Mai University (Approval Number: PSY-2566-0523).

2.1. Participants

The participants comprised general Chinese parents with children diagnosed with ASD. An online survey was employed as the chosen means to generate the invitations and gather data. The inclusion criteria included (1) being spouses participating as a pair, (2) having one or more children with a diagnosis of ASD, and (3) being able to read and write Chinese proficiently and independently complete the research questionnaire. The exclusion criteria included one spouse refusing to participate and individuals being unable to participate online. Upon completion of the socio-demographic information, the participants proceeded with the subsequent measurements described below.

2.2. Measurements

2.2.1. Core Symptom Index (CSI)

CSI is utilized to assess general psychological symptoms. The CSI included four items for anxiety (items 12, 13, 14, 15), Five items expressing depression (items 2, 4, 5, 6, and 7), and six items measuring somatization symptoms (items 1, 3, 8, 9, 10, and 11). Respondents were instructed to provide answers based on their feelings within the previous week. The tool uses a 5-point Likert scale to rate each of its 15 items, where responses range from 1 (rarely) to 5 (almost always). As the score increases, the level of psychopathology is interpreted as a higher [17,19,23,24].

2.2.2. Interpersonal Problems Inventory (IIP)- Social Inhibition Subscale

The Interpersonal Problems Inventory (IIP-32) evaluates the challenges individuals encounter in their interactions with others[25]. Respondents assessed whether these problems arose while interacting with significant individuals in the past two weeks. Responses vary from 0 (not at all) to 4 (extremely). The inventory is divided into eight interpersonal problem subscales such as domineering, cold, and social inhibition. The social inhibition subscale consists of four indicating socially avoidant behavior. The Chinese version of the social inhibition subscale demonstrated Cronbach's Alpha coefficient of 0.78[26]. Based on its construct, social inhibition was used for the convergent validity of the CSI.

2.2.3. Couple Satisfaction Index

The Couple Satisfaction Index is a brief self-report assessment comprising 16 items designed to gauge the level of contentment within couples, irrespective of their relationship status (married, cohabiting, or dating). Scores range from 0 to 80, utilizing a 6-point Likert scale, with responses ranging from 0 (strongly disagree) to 5 (strongly agree). Higher scores denote greater levels of relationship satisfaction.[27]. The internal consistency of the Chinese version of the CSI is underlined by a Cronbach's alpha value of 0.93. Based on its construct, the couple satisfaction index was used for the discriminant validity of the CSI.

2.3. Statistical Analysis

To determine the factorial validity of the Core Symptom Index (CSI) dimensions, confirmatory factor analysis (CFA) was used to compare models to identify the best fit for the data. Different CFA models were estimated to find the optimal factor structure for the Chinese adult sample, including (a) a unidimensional model integrating all items into one factor; (b) the theoretical hypothesized three-factor model (with items 1, 3, 8, 9, and 11 loading on the somatization factor; items 2, 4, 5, 6 and 7 on the depression factor; and items 12, 13, 14, and 15 on the anxiety factor); and (c) a three-factor bi-factor model adding a global factor to the three-factor model. Model fits were assessed using chi-squares, root-mean-square error of approximation (RMSEA), the Tucker Lewis Index (TLI), and the comparative fit index (CFI). Conventional guidelines indicate that an RMSEA value ≤ 0.08 implies an acceptable model fit, and a value ≤ 0.05 indicates a good model fit. Meanwhile, CFI and TLI values ≥ 0.90 indicate an adequate model fit[28].

Multi-group CFAs were used to examine the measurement invariance of the CSI across gender, age, and educational level. Four types of invariances were assessed using multi-group CFA: configural, metric, scalar, and strict invariance. Configural invariance, which sets no parameters across groups, tests whether the latent variables have the same factor structure and pattern across groups, establishing a baseline model for further invariance testing. Metric invariance, based on configural invariance, sets loadings across groups to measure if each observation has the same factor loadings on the corresponding latent variables across groups. Scalar invariance sets both loadings and intercepts equivalence for each group to test if different groups have the same observation points, indicating whether there is a difference between groups. Strict invariance increases this by setting the error variance equivalence restriction. If verified, it means that differences in observed score variances across groups fully reflect differences in latent variable variances[29]. Fit indices were evaluated for each model and compared to the more restrictive model in the multi-group CFA. ΔCFI and ΔTLI less than or equal to 0.01 and $\Delta RMSEA$ less than or equal to 0.015 indicate evidence of invariance[30]. Regarding reliability, internal consistency was estimated using Omega coefficients, with a cutoff score of > 0.70 considered acceptable. Convergent validity was assessed by Pearson's correlation coefficients on the CSI, couple satisfaction index, and social inhibition subscale to compare the magnitude of the relationship between the construct of the measuring instruments. To examine the extent of the difference between the two constructs signifying discriminant validity, t-tests were performed. Data were processed and statistically analyzed using IBM SPSS 26, IBM Amos version 26, and Mplus 8.11.

3. Results

3.1. Descriptive Analysis

The participants' sociodemographic characteristics are shown in Table 1. The total number of participants was 794, with an equal distribution of men and women. The participants' ages ranged from 23 to 45 years. The majority of participants were employed (94.1%), lived in urban areas (68.4%), had at least a high school level of education (86.9%), and had a monthly family income between 3001 and 10000 RMB (83.7%). The descriptive statistics of the CSI items are shown in Table 2, indicating that all item's characteristics are within an acceptable range.

Table 1. 1 Sociodemographic characteristics of the participants.

Variable		n	%
Sex	Female	397	50
	Male	397	50
Educational level	Elementary	7	0.9
	Junior high school	91	11.5

Employment	high school	314	39.5
	Bachelor	376	47.4
	Master	6	0.8
	Employed	747	94.1
	Unemployed or housekeeper	47	5.9
Residence area	Urban	543	68.4
	Rural	251	31.6
Family monthly income (RMB)	3000 and below	78	9.8
	3001-6000	352	44.3
	6001-10000	313	39.4
	More than 10000	51	6.4

1 RMB ≈ 0.14358 USD (2022).

Table 2. Descriptive statistics and skewness and kurtosis of the CSI items (*n* = 794).

CSI Item	Mean	SD	Median	Variance	Skewness	Kurtosis	Minimum	Maximum
1. Ringing or Buzzing in the ear(s)	0.893	1.029	1	1.151	1.028	0.042	0	4
2. Suicidal idea	0.655	.972	0	0.944	1.402	1.057	0	4
3. Palpitation	1.053	1.027	1	1.053	0.776	-0.068	0	4
4. Crying	1.34	1.130	1	1.275	0.455	-0.781	0	4
5. Self-blaming	1.628	1.149	2	1.319	0.076	-1.097	0	4
6. Feeling lonely	1.329	1.124	1	1.261	0.407	-0.799	0	4
7. Depressed	1.531	1.152	2	1.325	0.119	-1.105	0	4
8. Trouble catching your breath	0.966	1.026	1	1.05	0.812	-0.22	0	4
9. Hot or cold spells	0.927	1.068	1	1.138	0.973	0.069	0	4
10. Feeling numb or tingling	0.888	1.088	0	1.183	1.028	0.106	0	4
11. Fullness in the head or nose	0.967	1.064	1	1.13	0.808	-0.387	0	4
12. Discomfort when in the crowd	1.229	1.163	1	1.35	0.476	-0.944	0	4
13. Upset when being left alone	1.307	1.182	1	1.394	0.407	-1.017	0	4
14. Feeling agitated	1.348	1.151	1	1.322	0.352	-0.937	0	4
15. Feeling the urge to do things,	1.543	1.187	2	1.407	0.106	-1.07	0	4

3.2. CFA Models

As shown in Table 3, except for the unidimensional model, the remaining three models demonstrated a good fit to the data (CFIs > 0.90, TLIs > 0.90). The bi-factor models provided the best fits to the data of this sample. The three-factor bi-factor model provided the best fit ($\chi^2 = 440.364$, $df = 75$, CFI = 0.956, TLI = 0.939, RMSEA = 0.078, SRMR = .039 (Table 3).

Table 3. Comparison of Fit Indices among the CSI models.

Model	χ^2	DF	χ^2/DF	RMSEA	SRMR	TLI	CFI
Unidimensional model	1280.517	90	14.228	0.129	0.064	0.834	0.858
First order Model	667.659	85	7.854	0.093	0.050	0.914	0.930
Higher order factor Model	652.186	84	7.764	0.092	0.049	0.915	0.932
Bifactor Model	440.364	75	5.871	0.078	0.039	0.939	0.956

DF= degree of freedom, RMSEA = Root-Mean-Square Error of Approximation, SRMR = Standardized Root Mean Square Residual, TLI = Tucker Lewis Index, CFI = Comparative Fit Index

Factor loadings were between 0.124 and 0.351 for the anxiety factor, between -.396 and .214 for the depression factor, between .137 and .524 for the somatization factor, and between .612 and .805 for the general factor, confirming the bifactor three-factor solution model (Table 4). However, the factor loading of the item D6 was not significant, implying that

Table 4. Standardized factor loadings for the CSI bi-factor model.

Item	Description	Anxiety	Depression	Somatization	Global
A12	Discomfort when in the crowd	.124**			.805***
A13	Upset when being left alone	.315***			.814***
A14	Feeling agitated	.300***			.770***
A15	Feeling the urge to do things	.351***			.751***
D2	Suicidal idea		.214***		.705***
D4	Crying		-.343***		.676***
D5	Self-blaming		-.396***		.694***
D6	Feeling lonely		-.100**		.809***
D7	Depressed		-.506***		.715***
S3	Palpitation			.137***	.691***
S8	Trouble catching your breath			.261***	.750***
S9	Hot or cold spells			.524***	.697***
S10	Feeling numb or tingling			.512***	.612***
S1	Ringling or Buzzing in the ear(s)			.374***	.649***
S11	Fullness in the head or nose			.359***	.690***

A= anxiety, D = depression, S = somatization, **p< .01, ***p<.001

3.4. Convergent and Discriminant Validity

The results of the analysis of the correlation matrix between the social inhibition subscale (SI), the Couple Satisfaction Index, and the Core Symptom Index (CSI) and its subscales. In terms of convergent validity, there was a significant correlation between the CSI (total score) and the SI (r = .41, P < .001). On the contrary, their correlation with the Couple Satisfaction Index is extremely low

or to some extent almost non-existent ($r = -.16, p < .05$). In addition, significant differences in the CSI scores between high and low levels of social inhibition were observed ($t(658) = 8.975, p < .001$), whereas significant differences in the CSI scores between high and low levels of couple satisfaction index were not observed ($t(705) = 1.902, p = .058$). All results indicate that CSI has convergent and discriminant validity.

3.5. Invariance Test

To ensure that the three-factor bi-factor model adequately fits each group, we initially assessed its fit separately for males and females, younger and older individuals, and those with higher and lower levels of education. The results indicated a good fit of the bi-factor model for both groups. Subsequently, we tested the metric invariance model, where item factor loadings were constrained to be equal. These results suggested minimal gender differences in model fits. Finally, scalar invariance was examined by further constraining the thresholds to be equal across gender, age, and education groups. Scalar invariance was achieved with negligible changes in fit indices ($\Delta CFI \leq 0.01, \Delta TLI \leq 0.01$, and $\Delta RMSEA < 0.015$). However, the invariance test for the education group was not fully established, revealing only partial invariance where items A15, D4, D5, S1, S8, and S9 relaxed the constraint (Table 5).

Table 5. Invariance test results of CSI’s multi-group CFA.

Model	$\chi^2(df)$	<i>p</i> -value	CFI	TLI	RMSEA	ΔCFI	ΔTLI	$\Delta RMSEA$	Interpretation
Sex									
Configural	591.335(152)	<.001	.948	.928	.060				
Metric	642.640 (177)	<.001	.945	.935	.058	.003	.007	.002	Accept
Scalar	643.091 (178)	<.001	.945	.935	.057	.000	.000	.001	Accept
Age									
Configural	581.098 (150)	<.001	.950	.930	.060				
Metric	637664 (664)	<.001	.946	.936	.058	.004	.006	.002	Accept
Scalar	685.727 (191)	<.001	.943	.937	.057	.003	.001	.001	Accept
Education									
Configural	549.041 (150)	<.001	.950	.931	.058				
Metric	654.799 (176)	<.001	.940	.929	.059	.010	.002	.001	Accept
Scalar	827.039 (191)	<.001	.921	.913	.065	.019	.016	.006	Reject
Partial invariance	751.414 (186)	<.001	.930	.921	.062	.010	.008	.003	Accept

Note: $\chi^2(df)$: Chi-Square value and degrees of freedom, CFI: Comparative Fit Index, TLI: Tucker-Lewis Index, SRMR: Standardized Root Mean Square Residual, RMSEA: Root Mean Square Error Approximation.

3.3. Reliability

The internal consistency of the total Core Symptom Index using the omega coefficient of the overall scale was 0.946. For the anxiety, depression, and somatization subscales, the coefficients were 0.897, 0.863, and 0.897, respectively.

4. Discussion

This study's purpose was to examine the psychometric properties of the Chinese version of the Core Symptom Index (CSI) in a sample of Chinese parents raising children with autism. To the best of our knowledge, this is the first study to investigate the psychometric properties of the CSI in the Chinese population. In summary, the bifactor three-factor solution model fits the data of the Chinese parents adequately. Convergent validity and discriminant validity were also supported as evidence of the CSI construct validity. Our findings, consistent with an earlier study with the Thai sample[19], confirm that the bifactor three-factor model best explains the data for the Chinese version. These findings also support the similar measurement of the BSI-18, suggesting the impact of the general factor on the uniqueness of specific anxiety, depression, and somatization symptoms[14,31]. From another perspective, the bifactor model allowed the CSI to be best conceptualized as a primarily unidimensional instrument despite the presence of some multidimensionality, a significant insight for future research.

Regarding the measurement invariance of the CSI across groups, the findings differ from the study with the Thai sample, where the 'crying' item is not invariant for the older population, and self-blaming was not invariant across levels of education. In line with the present study, "Self-blaming" was a source of problems. The fact that the rest of the items of "A ringing or Buzzing in the ear(s)," "Trouble catching your breath," "Hot or cold spells," and "Feeling the urge to do things" constituted non-invariance across education may be due to cultural influence. It is to be noted that most of the items are from somatization; even though the Thai and Chinese share similar cultures, the responses to somatization symptoms in both samples differed. The related studies showed that somatization symptoms measured by the same CSI were significantly lower in Thai compared to in Chinese samples (mean \pm SD was 1.04 ± 2.7 for Thai and 4.38 ± 4.32 for Chinese, $t(534) = 10.38$, $p < .001$), respectively[15,16]. While we can use CSI despite non-achieved scalar invariance, researchers must be mindful of its limitations and caution in its interpretation and application, particularly in cross-group comparisons. Regarding reliability, the omega coefficient demonstrated that the CSI offers good internal consistency, consistent with the studies among Thai samples[19].

Clinical Significance

The CSI can evaluate parents of autistic children using both the total score and the general score along with specific scores. The bifactor model suggests that the CSI can serve as a one-dimensional factor, enabling the application of a total score for assessing general psychological distress. Considering that somatization symptoms are one of how Chinese individuals may manifest psychological issues, they are influenced by cultural factors such as ethnic identity and cultural values[32,33]. Furthermore, despite the similarities between Thai and Chinese cultures and their differences from Western culture, they are not entirely identical. Somatization items from Western scales (e.g., BSI-18) or the CSI (Thai) may not align perfectly with Chinese respondents. Therefore, it is advisable to replicate these findings in other Chinese populations to confirm whether the CSI includes somatization items that may require further modification.

Limitations

Be aware of the following limitations that must be addressed. Firstly, the study sample was restricted to individuals aged 23 to 45 years old and parents of children with ASD. As a result, the findings may not be generalizable to other age groups or populations. Secondly, the data was collected during the COVID-19 pandemic, and the policy of home isolation in China may have influenced individuals' responses to the items. Thirdly, classical test theory has been criticized by modern measurement theory scholars for the "inherent defects" of the mathematical models it is based on. Therefore, there is a necessity to test the CSI according to modern measurement theory. In the future, further verification of the difficulty and discrimination of the Chinese version of the CSI in Item Response Theory may be necessary. Lastly, data collection did not cover the primary

healthcare field, so its applicability may be limited to certain specific populations or disease conditions.

5. Conclusions

This study indicates that the CSI serves as a reliable and valid instrument for measuring general psychological distress among Chinese parents of autistic children, making it an effective screening tool for psychological symptoms. The bi-factor model accurately captures the underlying structure of the CSI. Moreover, the CSI demonstrates measurement invariance across diverse backgrounds, indicating that CSI scores can accurately reflect variations in psychological symptoms among Chinese parents of autism. Additionally, this study underscores the significance of evaluating the general factor and adopting a holistic approach to understanding parental distress, rather than solely focusing on individual dimensions.

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