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Abstract

The present study aimed to explore the latent structure of the 21-item Peters et al. Delusions Inventory (PDI-21) and to test the invariance of its factor structure over time and across samples. The PDI-21 was administered in two samples; one consisting of 1655 undergraduate students investigated in three waves, each separated by six months; and another consisting of 196 outpatients with schizophrenia. Exploratory factor analysis was performed to explore the internal structure of the PDI-21 based on number of beliefs and the grand total scores separately. The number of factors was determined by optimal implementation of parallel analysis. Confirmatory factor analysis, cross-time and cross-sample invariance analyses were carried out with Mplus. Both exploratory factor analysis and the optimal implementation of parallel analysis (based on the number of beliefs and the total score of the PDI-21) suggested a one-factor solution. However, the confirmatory factor analysis revealed a single-dimension structure based on number of beliefs only, which exhibited goodness of fit and stability across time and samples. Our study demonstrated a single-dimension structure of the PDI-21, which can be widely used in screening the number of delusional ideations both in clinical and

non-clinical populations.

Key words: the 21-item Peters et al. Delusions Inventory (PDI-21); Delusion; schizophrenia; longitudinal invariance; cross-sample invariance.

1. Introduction

Psychotic experiences (PE), such as delusions or hallucinations, previously thought to be only found in psychosis (Bell et al., 2006), have recently been found to be common in the general population (van Os et al., 2000; van Os et al., 1999; Verdoux and van Os, 2002a).Linscott and van Os (2013) reported a median prevalence of 7.2% and an annual incidence rate of 2.5% for psychotic experiences in the general population based on data from 61 cohorts. McGrath et al. (2015) further investigated the overall lifetime prevalence of any of these psychotic experiences in 31261 adults based on samples from 18 countries and found that the mean lifetime prevalence of ever having a delusional experience is 1.3%. With regard to the incidence of delusions, previous studies have suggested that 1-3% of the general population have delusions with comparable severity as clinical cases, 5-6% have delusions with lesser severity, and 10-15% have fairly regular delusional ideations (Freeman, 2006, 2007). These findings support the concept of psychosis continuum, where psychotic symptoms in clinical samples are considered to represent the extreme expression of the same trait in the general population (Strauss, 1969). Therefore, examining delusional thoughts in healthy individuals has been suggested as a way to understand the development of psychosis (van Os et al., 2009).

The 40-item Peters et al. Delusions Inventory (PDI; Peters et al., 1999) is a widely used tool for assessing delusional ideations. With items beginning with “Do you ever feel as if…”, it is suitable for single-symptom research in the general population, which has a wide variation in the level of delusion-like experiences. The wording of

the items also pertains to the trait of delusionality, which supplements clinical ratings that measure state. Another strength of the PDI lies in its inclusion of three dimensions (conviction, distress and preoccupation). According to Peters et al (1999), the PDI yields the following scores: (i) number of beliefs (based on the yes/no answer to each delusional ideation item), (ii) summed dimension scores for all endorsed beliefs, or average dimension score for each endorsed belief, and (iii) a grand total score, which is a summation of the number of beliefs and total dimension scores. Since the PDI grand total score is an aggregate score of the number of endorsed beliefs and delusional dimensions, an individual who endorses only a few highly distressing or preoccupying beliefs may have a similar PDI total score with an individual who endorses many non-distressing or non-preoccupying beliefs. Therefore, whilst earlier studies tended to report PDI grand total scores (Jones and Fernyhough, 2007), it has become more common for researchers to analyze the number of beliefs and dimension scores separately (Fonseca-Pedrero et al., 2012; Kim et al., 2013; So et al., 2015)

The number of beliefs and dimension scores of the PDI-40 have good internal consistency (Cronbach α coefficient from 0.88 to 0.94) and test-retest reliability (correlation coefficient from 0.67 to 0.82) in both patients with psychosis and the general population (Jung et al., 2008; Kao et al., 2012; Lincoln et al., 2010; Peters et al., 1999). A few years later, a shorter version was developed, with 21 items selected (Peters et al, 2004). Driven by the purpose to sample as wide a variety of delusions as possible, the PDI-21 covers 11 categories of delusional themes (persecution,

suspiciousness, paranoid ideation, religiosity, grandiosity, paranormal beliefs, thought disturbances, negative self, catastrophic ideation and thought broadcast, and ideation of reference and influence). The PDI-21 adopts the same scoring system as the PDI-40.

Although the PDI-21 has been widely used in studies of delusional ideation, and clinical cutoff scores have been developed using the PDI-21 number of beliefs score (Preti et al, 2007), there remains a debate whether the PDI-21 number of beliefs score constitutes one factor or multiple factors. Apart from the one-factor solution proposed by the original authors, Verdoux et al. (1998b) explored a seven-factor structure using principal component analysis (PCA) on the data of 444 French primary care patients with no history of psychiatric disorder. However, the seven-factor structure was challenged by Fonseca-Pedrero et al. (2012), which extracted two factors using the method of un-weighted least squares and parallel analysis based on the data of 660 Spanish college students. In spite of the similar goodness-of-fit of the two-factor solution with the one-factor solution, the authors still recommended the unidimensional solution of the PDI-21 because of the more parsimonious character of the number of beliefs score.

In addition, although the grand total score of the PDI-21 was regarded as a useful global measure of delusional ideation which includes distress, preoccupation and conviction (Peters et al., 2004), few studies have explored whether its internal structure is similar to the number of beliefs score. Jones and Fernyhough (2007) administered the PDI-21 to 493 British undergraduates and extracted three factors

using principal axis factoring and parallel analysis based on the grand total score. However, only religiosity was found to be both internally reliable and meaningful. Therefore, the authors maintained that the single-factor scoring system of the PDI-21 was valid.

Taken together, it is possible that the inconsistency may be due to the different methods used in factor extraction. In the three existing studies examining the factor-structure of the PDI-21, one used PCA (Verdoux et al., 1998c), one used principal axis factoring (Jones and Fernyhough, 2007) and one used un-weighted least squares (Fonseca-Pedrero et al., 2012). From a psychometric and statistical perspective, the selection of method for analysis depends on the nature of data. In the case of dichotomous items for the number of beliefs score, it is generally acceptable to use a tetrachoric correlation matrix to estimate the number of factors, while the Pearson correlation matrix can be used in the analysis of the grand total score because of the continuous nature of the variable (Muthen, 1984; Timmerman and Lorenzo-Seva, 2011). Furthermore, parallel analysis (PA) may also be a suitable method to determine the dimensionality of a set of variables (Timmerman and Lorenzo-Seva, 2011) because of the rationale that meaningful components from real data with a valid underlying factor structure should have larger eigenvalues than parallel components derived from random data having the same sample size and number of variables (Ford et al., 1986; Lautenschlager, 1989). Thus, the eigenvalues from the real data correlation matrix should be compared with the average eigenvalues from the random correlation matrices and only the factors

corresponding to actual eigenvalues that are greater than the parallel average random eigenvalues will be retained (Lorenzo-Seva and Ferrando, 2006).

In addition, even though some previous studies have explored different structures of the PDI-21 (Fonseca-Pedrero et al., 2012; Jones and Fernyhough, 2007; Lopez-Ilundain et al., 2006; Peters et al., 2004; Verdoux et al., 1998b), none has estimated a confirmatory model. Furthermore, the invariance of the structure across different time points and samples has not been tested either. As a result, it is unclear whether the meaning of the latent variables and the relationship between the observed variables and the latent variables are similar under different conditions and in different groups (Vandenberg and Lance, 2000).

In view of the above, a rigorous and in-depth evaluation of the psychometric properties of the PDI-21 is indicated. The purpose of the present study was to examine the internal structure of number of beliefs and the grand total score of the PDI-21 first with Exploratory Factor Analysis (EFA), and then test the models derived from EFA using Confirmatory Factor Analysis (CFA). We also compared the invariance of their factor structures over time and across samples.

2. Methods

2.1 Participants

2.1.1 Student sample

The healthy participants in this study consisted of 1655 undergraduate students recruited from three universities in Beijing, Shanghai and Guangzhou. Based on the

cluster sampling principle, all 985 freshmen in the Guangzhou Medical University, 374 freshmen in the College of Economics and Management of the North China Electric Power University, and 296 freshmen in the College of Education of the Shanghai Normal University were recruited. All students were tested three times, separated by an interval of six months. In the end, 1554 undergraduate students completed the whole set of tests. Those who did not complete any one of three tests were excluded. The mean age of the 1554 undergraduate students was 18.81 years (*SD*=0.83) and the mean number of years of education was 12.31 (*SD*=0.71) at the time of initial testing. Sixty-four percent (*n*=990) of the sample were female (Table 1).

2.1.2 Patient sample

One hundred and ninety-six outpatients with a case-note diagnosis of schizophrenia according to the Diagnostic and Statistical Manual for Mental Disorders (DSM-IV) (APA, 1994) were recruited from the Community Health Service Centre of Chaoyang District, Beijing. Four patients with missing datawere excluded. Of the 192 patients, 101 (52.6%) were male and 91 (47.4%) were female. Their age ranged from 18 to 72 years with a mean of 42.95 (*SD*=9.41) years. The mean duration of illness and length of education were 18.37 (*SD*=10.04) and 11.68 (*SD*=2.59) years respectively (Table 1.).

This study was approved by the Ethics Committee of the Institute of Psychology, the Chinese Academy of Sciences. All participants gave written informed consent before entering the study.

2.2 Measures

The 21-Item Peters et al. Delusions Inventory (PDI; Peters et al, 2004) was used to assess the presence of delusional ideations. All 21 items employed a dichotomous response format (yes/no) such as “Do you ever feel as if you could read other people’s minds?”. If the answer was “yes”, participants needed to rate the degree of distress, preoccupation and conviction associated with the belief on a five-point Likert scale (1-5). Four separate scores can be obtained from the 21-item PDI: number of beliefs, a distress score, a preoccupation score and a conviction score. The possible range of number of beliefs is 0 to 21 and the range of scores for each of the three dimensions is 0 to 105, thus giving a possible grand total score range of 0 to 336 (Peters et al., 2004). Two psychologists (HS and YW) translated the PDI-21 into Chinese, and then the Chinese translation of the PDI-21 was back-translatedinto English by two native speakers (RC and SL). The translation was then verified by Chinese and English language specialists. The number of items and scoring method of the Chinese version of the PDI-21 was the same as the original version (Peters et al., 2004).

2.3 Data analysis

First, the age, gender, education, endorsement rate of delusional beliefs between the student group and the patient group were compared using independent-sample t tests and chi-square tests. Repeated measures ANOVA and independent-sample t tests were used to compare the differences in number of beliefs and PDI-21 grand total score across three time points and samples respectively. Then, the baseline

data of the 1554 undergraduates was randomized into two groups with 747 and 807 participants each. Data from the sample with 807 participants was used for EFA and data from the other group was used for CFA. EFA based on the tetrachoric correlation matrix of item response and the Pearson correlation matrix of the item total score were performed separately by FACTOR (Lorenzo-Seva and Ferrando, 2006), a stand-alone programme for windows used to perform different types of EFA, and the optimal implementation of PA (Timmerman and Lorenzo-Seva, 2011) was used to determine the number of factors. The method for factor extraction was unweighted least squares with Promin rotation.

Secondly, the original factor structures of the number of beliefs and the grand total score obtained from the EFA were then subjected to CFA in the 747 undergraduate student sample using Mplus version 6.12 (Muthén and Muthén, 1998). The methods of estimation for the CFA of number of beliefs and the grand total scores were the Weighted Least Squares Means-Variance (WLSMV) and Maximum Likelihood (ML). To evaluate the overall goodness-of-fit of the model, chi-square tests and other practical fit indices such as the Root Mean Square Error of Approximation (RMSEA), the Tucker-Lewis Index (TLI) and the Comparative Fit Index criterion (CFI) were used (Bentler, 1990; Hu and Bentler, 1998). The upper limit of the RMSEA was 0.08 and the lower limits of the TLI and the CFI were 0.09. Values of the TLI and the CFI equal to or more than 0.95 indicate high confidence in fit (Vandenberg and Lance, 2000).

Thirdly, the invariance of the model obtained from the above steps was tested

across time with Mplus version 6.12 (Muthén and Muthén, 1998). The comparison of across-time invariance was conducted between results from wave 2 and wave 3 testing. We adopted Vandenberg and Lance's (2000) standard for measuring invariance, which involves testing and comparing seven models that impose successive restrictions on model parameters. Model 1 tested configural invariance, in which neither factor loading nor threshold were constrained to be equal between the two waves. Model 2 tested metric invariance, which included the restrictions from Model 1 and the additional constraint of equal factor loading. Model 3 tested scalar invariance, which included the restrictions from Model 2 and the additional constraint of equal indicator thresholds across the two waves. Model 4 to 7 tested invariant uniqueness, invariant factor variances, invariant factor covariances, and invariant factor means respectively. The first three models involved a comparison of latent means which is theoretically perfectly reliable (Vandenberg and Lance, 2000), and so we proceeded to this step without imposing the subsequent constraints. The chi-square difference test ($\Delta\chi^2$) using DIFFTEST, the changes in the Comparative Fit Index criterion (*ΔCFI)* and the Tucker-Lewis Index (*ΔTLI*) between the more restrictive model and the less restrictive model were used to evaluate invariance. If the chi-square difference test ($\Delta\chi^2$) had a probability of lower than 0.05 and the changes in the *CFI* and the *TLI* were equal to or more than 0.01, the invariance hypothesis would be rejected (Cheung and Rensvold, 1999). However, since the chi-square is too susceptible to deviations between the groups' sample covariance matrices and sample size, even minor difference in the patterns between the two groups can

produce a statistically significant chi-square value (Bollen and Long, 1993; Hoyle, 1995; James et al., 1982; Vandenberg and Lance, 2000). As a result, we chose changes in the *CFI* and the *TLI* as the evaluating criteria of invariance in this study.

Subsequently, the best-fitted model was applied to the sample of 192 outpatients with schizophrenia. CFAs based on the number of beliefs and the grand total scores were performed separately. The across-group invariance analyses between the sample of 747 participants and the outpatients were also conducted. The standard for across-group invariance testing was similar to the across-time invariance analyses except that the default setup of the first model was equivalence in factor loading and indicator thresholds between the two groups. Thus, the default setup of the equivalence in factor loading and indicator thresholds were released step by step to test configural invariance and metric invariance. The *RMSEA*, the *TLI* and the *CFI* were also used to evaluate goodness-of-fit.

3. Results

3.1 Descriptive statistics

The mean number of beliefs and the mean grand total score of the PDI-21 among the 1554 undergraduate students and the patient group are shown in Table 1. With regard to the mean number of beliefs, repeated measurement analysis revealed that the within-subject effect was significant (F=15.646, p<0.001, η^2=0.010). Post-hoc pairwise comparisons between the three waves showed that the mean number of beliefs in the first wave and the second wave were both higher than the third wave

(*ps*<0.01). For the mean grand total score of the PDI-21, repeated measurement analysis also showed a significant within-subject effect (*F*=13.508, *p*<0.0001, η^2=0.009) and the results of post-hoc pairwise comparisons between the three waves were the same as the mean number of beliefs. As for the comparison of the scores between the student and patient group, independent sample t-tests between the student group and the patient group in the first wave showed that the difference in the mean number of beliefs, scores on the three dimensions and the mean grand total score of the PDI-21 were all significant (*ps* <0.0001) (see Table 1).

The proportion of undergraduates who responded affirmatively to the PDI-21 items ranged between 4.7% (item 21) and 54.8% (item 3) and the average endorsement frequency was 15.57%, whereas the endorsement frequency of schizophrenia patients was between 9.9% (item 11) and 59.4% (item 3) with a mean of 25.35% (see Figure 1). The distribution of the number of beliefs was similar in both groups (see Figure 2). A total of 79.6% of the undergraduates responded positively to at least one item, while 83.3% of the schizophrenia patients did. 28.1% of the schizophrenia patients and 8.7% of the undergraduates scored more than eight points on the PDI-21, which is the threshold for discriminating cases from non-cases (Preti et al., 2007).

3.2 Reliability analysis

Cronbach *α* coefficient of the number of beliefs in the three waves in the student group was 0.865, 0.908 and 0.879 respectively; while it was 0.911 in the patient group. Regarding the PDI-21grand total score, Cronbach α coefficient of the three

waves in the student group was 0.883, 0.906 and 0.905 respectively, while it was 0.911 in the patient group.

3.3 Exploratory factor analysis

Data from the 807 undergraduate students in wave 1 was used for EFA. The mean age of the 807 undergraduate students was 18.81 years (*SD*=0.80) and the mean number of years of education was 12.28 (*SD*=0.74). 62.7% (*n*=506) of the 807 sample were females. For the number of beliefs of the PDI-21, the Kaiser-Meyer-Olkin (*KMO*) Test of Sampling Adequacy was 0.91 and the Bartlett's Test of Sphericity was 4307.6 ($p<0.001$), indicating that some common factors could explain most of the information of the scale and the assumptions for factor analysis were met. Although the results of factor analysis yielded eight eigenvalues greater than 1, the final advised number of dimensions by parallel analysis was one. This means that only one eigenvalue was larger than the mean of the randomly generated eigenvalues, as well as the 95th percentile eigenvalues, which accounted for 25.9% of the variance.

For the analysis of the PDI-21 grand total score, the *KMO* Test of Sampling Adequacy was 0.91 and the Bartlett's Test of Sphericity was 4776.2 ($p<0.001$). The number of eigenvalues greater than 1 was four, but the final advised number of dimensions by parallel analysis was still one, which accounted for 36.6% of the variance. The results of parallel analyses including real-data percentage of variance, mean of random percentage of variance, and 95th percentile of random percentage of variance are presented in Table 2.

3.4 Confirmatory factor analysis

Data from the sample with 747 undergraduate students in wave 1 was used for CFA. The mean age of the 747 undergraduate students was 18.81 years (*SD*=0.86) and the mean number of years of education was 12.34 (*SD*=0.76). 65.1% (*n*=486) of the 747 sample were females. Confirmatory factor analyses based on the data of number of beliefs and the grand total score in 747 undergraduate students and 192 schizophrenia patients using the one-factor solution was performed separately, and the results are presented in Table 3. The *CFI* and the *TLI* based on the data of the number of beliefs were more than 0.90 in both the student and patient groups, and the *RMSEA*s were all smaller than 0.08, indicating good fit of the model. However, the indices of CFAs based on the grand total score of the PDI-21 were not ideal in both samples.

3.5 Across-time invariance tests

The fit indices for the models testing across-time invariance of the one-factor structure of number of beliefs of the PDI-21 are presented in Table 4. Although the chi-square statistics were significant, all of the practical fit indices exceeded the recommended criteria, which indicated good model-data fit of the one-factor structure across the two time points. The fit indices of the one-factor structure in the invariance routine showed that the overall structure (Model 1), factor loading (Model 2) and indicator thresholds (Model 3) across the two time-points were all satisfactory (all *CFI* and *TLI* values were higher than 0.95). Although the chi-square differences ($\Delta\chi^2$) between Model 2 and Model 3 had a probability smaller than 0.05, the changes in the *CFI* and the *TLI* were all less than 0.01, supporting the invariance

of the latent means of the one-factor structure.

3.6 Across-sample invariance tests

The one-factor structure of number of beliefs of the PDI-21 was compared between the 747 students in wave 1 and 192 schizophrenia patient sample. The comparisons of age and gender between the two groups were both significant (*t* value and chi-square was 35.417 and 20.119 respectively, *ps*<0.0001). In across-sample invariance tests, the *TLI* and the *CFI* were all greater than 0.90 and the changes of the two indices between the more restrictive model and the less restrictive model were all smaller than 0.01 in the invariance routine, indicating measurement invariance of the one-factor structure across the two samples (see Table 5).

4. Discussion

The aim of the present study was to explore the latent structure of the PDI-21 in detecting different delusional beliefs and test its measurement invariance across time and samples. Our results revealed a single-dimension structure of the number of beliefs and the grand total score of the PDI-21. However, only the single-dimension structure of the number of beliefs was confirmed with goodness-of-fit and stability across time and samples. We demonstrated the reliability of the single-dimension structure of the PDI-21 in detecting the number of delusional beliefs, which appears to be applicable in both non-clinical and clinical populations.

Whether the internal structure of the PDI-21 is single- or multiple-dimensional

continues to be a focus of debate. We ran the parallel analysis based on the tetrachoric correlation matrix and extracted a single-dimension structure for the number of delusional beliefs. The use of the tetrachoric correlation matrix could avoid the detrimental effects of analysis of dichotomous variables with a linear factor model (Timmerman and Lorenzo-Seva, 2011), thus allowing a more accurate determination of the number of factors. In addition, although some researchers have explored several different structures of number of beliefs such as 2, 3 or 7-factor solutions in different cultures (Jones and Fernyhough, 2007; Kim et al., 2013; Lopez-Ilundain et al., 2006; Verdoux et al., 1998b) besides the unidimensional scoring system proposed by Peters et al. (2004), few studies have conducted CFA to confirm the goodness-of-fit of the model. We applied this single-dimension structure in both non-clinical and clinical samples, and the results of the CFAs further verified the goodness-of-fit of the single-dimension structure of the PDI-21 in detecting the number of delusional beliefs.

Furthermore, the measurement invariance of the single-dimension structure of the number of beliefs of the PDI-21 across time and samples was tested. The goodness of fit indices supported the invariance of factor structure, factor loading, and indicator thresholds of the PDI-21 number of beliefs across two different time points, indicating that the meaning of latent variables and the relationship between the observational variables with latent variables and the reference points were equivalent across the two time points. This is important because across-time invariance suggests that the observed changes are likely to be due to a true change

in the latent variable rather than changes in item functioning (Long et al., 2007), thus ensuring a comparable definition of the latent construct over time. Furthermore, results from the across-sample comparison between the undergraduate student sample and the schizophrenia patient sample confirmed the measurement invariance of the scale. This means that the same meaning of the PDI-21 was measured in the same manner both in the non-clinical and clinical samples. Although many previous studies have reported delusional ideations in the general population (van Os et al., 2000; van Os et al., 1999; Verdoux and van Os, 2002b) and compared the difference in the number of beliefs of the PDI-21 in both non-clinical and clinical groups (Peters et al., 2004), none had tested whether the substantive constructs measured by the PDI-21 were identical in the two groups. The present finding confirms the equivalence and provides a logical prerequisite to compare between different samples at different stages of the illness spectrum.

Regarding the grand total score of the PDI-21, we also found a similar single-dimension structure using EFA and PA. However, the results of the CFAs based on the grand total score of the PDI-21 did not exhibit goodness-of-fit both in the student and patient samples. In clinical practice, it is commonly observed that patients with psychotic disorders differ from controls not only by having higher ratings on the number of beliefs but also on the distress, preoccupation, and conviction scales (Peters et al., 1999; Verdoux et al., 1998a). Furthermore, the dimension scores were also proposed as a possible measure of change during psychotherapeutic interventions. Results of several studies have shown a treatment

time effect on the scores of the PDI-21, particularly on the preoccupation and conviction dimensions (Khazaal et al., 2015; Khazaal et al., 2011). In view of the above, although some researchers considered the grand total score a useful index (Peters et al., 2004), our results confirmed the importance to report the number of beliefs and dimension scores separately.

The descriptive statistics revealed a similar distribution of the number of beliefs and endorsement rate of delusional beliefs in the non-clinical and clinical samples. Furthermore, among the 21 items, item 3 had the highest endorsement rate in both samples, which is similar to previous studies (Peters et al., 2004; Scott et al., 2008). In addition, the prevalence of delusional ideations in undergraduate students was 79.6%, which was close to the rate of the patient sample (83.3%). Further comparisons on distress scores, preoccupation scores and conviction scores revealed significant differences between the two groups. These results again corroborated with the concept of psychosis continuum (Strauss, 1969). Similar to other findings of psychotic-like experience measurements, such as the Physical Anhedonia (PA) Scale and the Social Anhedonia (SA) Scale (Chapman et al., 1976), psychosis-prone individuals demonstrated mild or transient forms of psychotic-like experiences, while at-risk individuals or individuals with schizotypal personality disorder reported more frequent and severe psychotic-like experiences (Chan et al., 2012; Chapman and Chapman, 1980; Gooding et al., 2005). Although some psychosis-prone individuals such as schizotypes will remain undetected by clinical diagnostic criteria, they are still likely to display deficits on laboratory-based measures. Therefore, applying the

psychometric high-risk method using scales like the PDI-21 may be a viable strategy in identifying individuals at risk of developing schizophrenia-spectrum disorders.

This study has several limitations. First, the undergraduate student sample we used in this study may not be representative of the whole non-clinical population and may have limited the generalizability of our results. Furthermore, the absence of a high risk sample with individuals with schizophrenia spectrum personality disorders (SSPD) or relatives of schizophrenia patients limited our conclusion of the invariance of the PDI-21 across different stages of the schizophrenia illness spectrum. Secondly, although the original purpose of the PDI-21 according to Peters et al. (2004) was not to measure a limited number of well-defined subscales with high internal reliability but rather to sample as wide a variety of delusions as possible, it may still be necessary to use novel psychometric approaches such as the Item Response Theory (IRT) to evaluate this measure. Lastly, although the main aim of this study was to explore the latent structure of the PDI-21 in the Chinese population and test its measurement invariance, it is still necessary to test the validity and clinical utility of this instrument in the Chinese settings, especially the sensitivity and specificity issues of the Chinese version of the PDI-21 has not yet examined in the present study. Given that we did not administer psychosis proneness scale to the present sample, we could not examine whether participants with high score in psychosis proneness scale would also exhibit a corresponding high score in the PDI score. Further study should recruit large clinical and subclinical samples to specifically examine the sensitivity and specificity of the PDI-21 checklist. At the same time, the PDI-21 is a

measure based on self-reported information, which on the one hand is convenient and practical as a screening tool, but on the other hand affects the validity of the findings. As such, a comprehensive assessment including not only a self-rated instrument but also an observer-rated instrument is needed to test the validity of the scale.

In conclusion, the PDI-21 is a single-dimension screening tool in evaluating the number of delusional beliefs, which has good factor invariance over time and across samples. It can be used in detecting delusional beliefs in both clinical and non-clinical populations.

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Declaration of Interest

None.

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Highlights

1. The PDI-21 demonstrated a single-dimension of its structure in the Chinese setting

2. Only the single-dimension structure of the number of beliefs showed stability across time and samples

3. The Chinese version of the PDI-21 can be used in detecting delusional beliefs in the Chinese settings

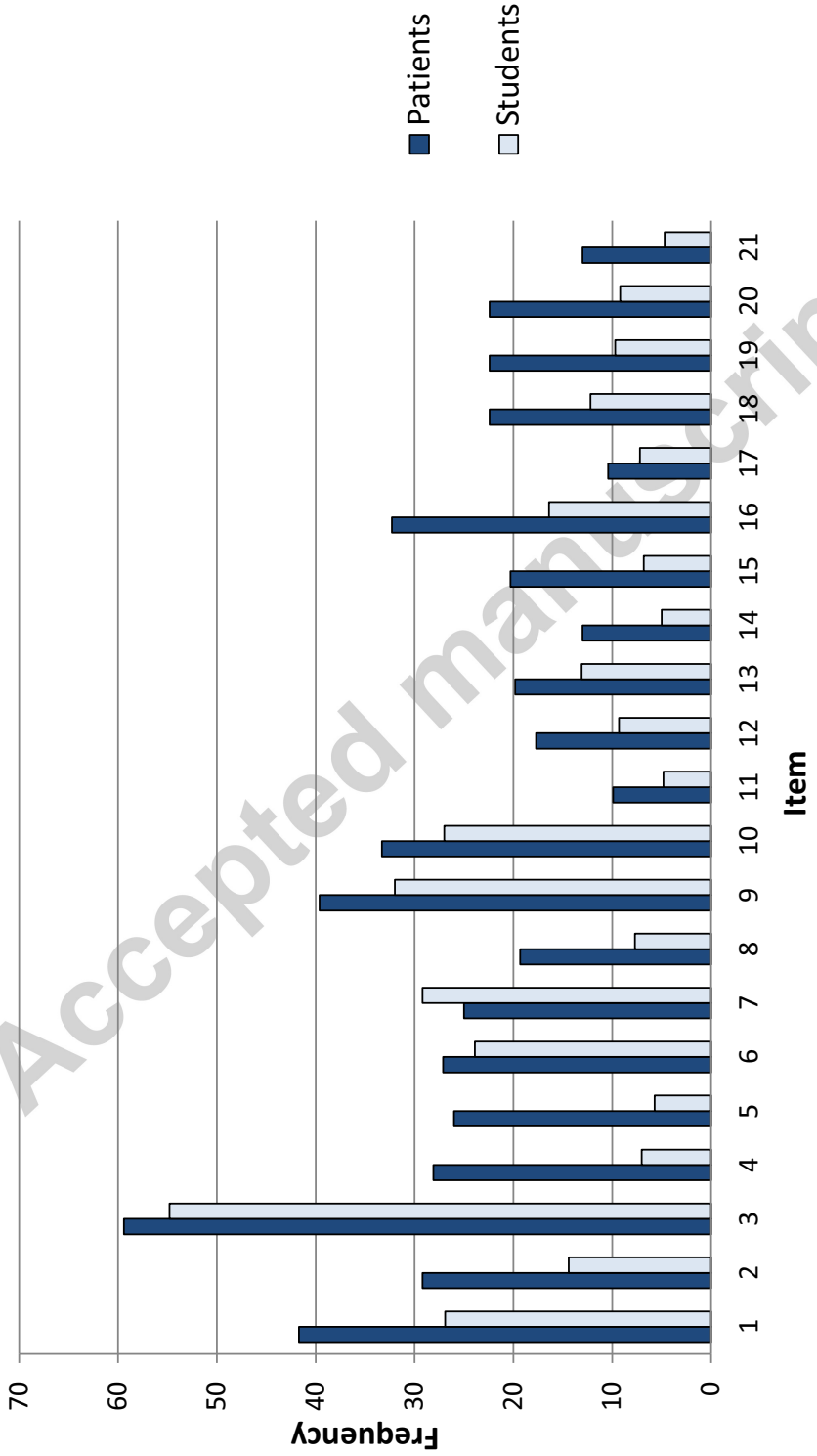

Figure 1. Endorsement rate of delusion beliefs on items of PDI-21

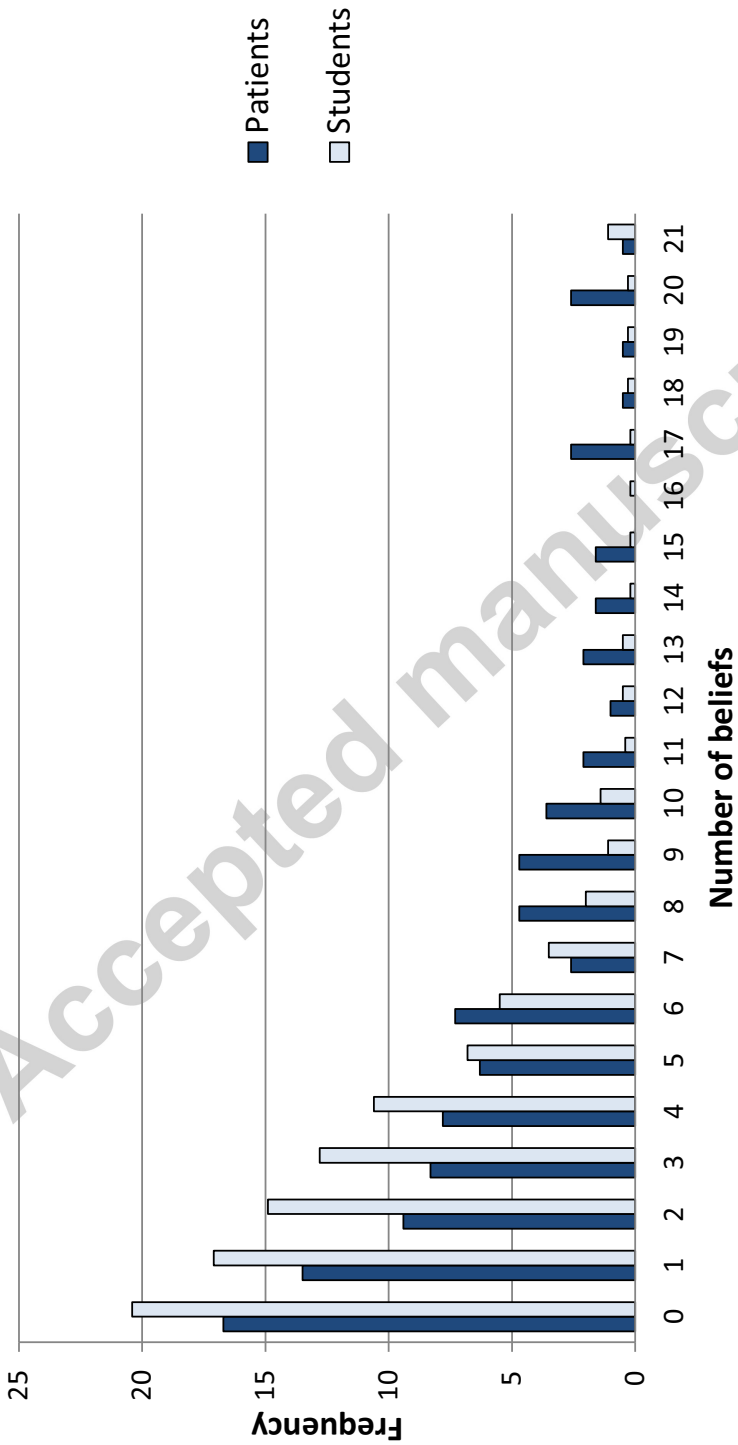

Figure 2. Distributions of number of beliefs of PDI-21 in students and patients

Table 1

Descriptive statistical data for sociodemographic information and the mean comparisons of the 21-item Peters' Delusions Inventory across two samples

		Students group (*n*=1554)	Patients group (*n*=192)	t/χ^2	*p*	*Effect size*
Age, years, mean (*S.D.*)		18.77 (1.14)	42.95 (9.41)	-35.480	<0.0001	-0.875
Gender, *n* (%)	Male	564 (36.3)	101 (52.6)	19.280	<0.0001	
	Female	990 (63.7)	91 (47.4)			
Education, years, mean (*S.D.*)		12.30 (0.81)	11.68 (2.59)	3.270	0.001	0.159
Average endorsement frequency, %		15.57	25.35	293.871	<0.0001	
Wave 1	Number of beliefs, mean (S.D.)	3.27 (3.71)	5.32 (5.31)	-5.207	<0.0001	-0.218
	Distress scores, mean (S.D.)	7.18 (9.90)	13.99 (15.09)	-6.094	<0.0001	-0.258
	Preoccupation score, mean (S.D.)	7.56 (10.24)	15.67 (16.68)	-6.579	<0.0001	-0.281
	Conviction scores, mean (S.D.)	9.14 (11.20)	18.44 (19.49)	-6.477	<0.0001	-0.281
	Grand total scores, mean (S.D.)	27.16 (34.20)	53.42 (54.87)	-6.479	<0.0001	-0.276
Wave 2	Number of beliefs, mean (S.D.)	3.28 (4.33)				
	Grand total scores, mean (S.D.)	27.20 (36.35)				
Wave 3	Number of beliefs, mean (S.D.)	2.68 (3.90)				
	Grand total scores, mean (S.D.)	22.59 (33.17)				

Table 2

Results of parallel analyses based on number of beliefs and grand total scores of the 21-item Peters' Delusions Inventory

	Number of beliefs			Grand total scores		
Variable	Real-data % of variance	Mean of random % of variance	95 percentile of random % of variance	Real-data % of variance	Mean of random % of variance	95 percentile of random % of variance
1	25.9*	10.1	11.0	36.6*	9.6	11.0
2	7.7	9.1	9.9	8.9	9.0	10.2
3	6.2	8.4	9.0	6.8	8.5	9.6
4	5.8	7.7	8.3	5.4	8.0	8.9
5	5.3	7.2	7.7	5.1	7.5	8.3
6	5.2	6.7	7.1	4.8	7.1	7.7
7	5.0	6.2	6.6	4.1	6.6	7.1
8	4.9	5.8	6.2	4.0	6.1	6.6
9	4.7	5.4	5.8	3.6	5.6	6.2
10	4.4	5.1	5.4	3.3	5.2	5.7
11	4.0	4.7	5.0	3.2	4.7	5.4
12	3.9	4.3	4.7	2.8	4.3	5.0
13	3.8	3.9	4.3	2.3	3.8	4.5
14	3.6	3.5	3.9	2.0	3.4	4.0
15	2.8	3.1	3.6	1.9	2.9	3.6
16	2.2	2.7	3.2	1.8	2.5	3.2
17	2.0	2.3	2.8	1.4	2.0	2.7

18	1.6	1.8	2.3	1.0	1.6	2.2
19	0.8	1.2	1.8	0.7	1.1	1.7
20	0.1	0.6	1.2	0.5	0.6	1.2
21	0.0	0.0	0.0	0.0	0.0	0.0

Notes: $^{*}p<0.05$

Table 3

Fit indices of CFAs based on number of beliefs and grand total scores of the PDI-21 in students and patients

Samples	Types of scores	χ^2	*df*	*RMSEA*	*90% CI*	*CFI*	*TLI*	*p*
Students (*n*=747)	Number of beliefs	416.136	189	0.040	0.035-0.046	0.933	0.926	<0.0001
	Grand total score	1126.174	189	0.081	0.077-0.086	0.860	0.845	<0.0001
Patients (*n*=192)	Number of beliefs	355.349	189	0.068	0.057-0.078	0.948	0.943	<0.0001
	Grand total score	779.537	189	0.128	0.118-0.137	0.684	0.649	<0.0001

Notes: RMSEA=Root Mean Square Error of Approximation; *CI*=confidence interval; *CFI*= Comparative Fit Index criterion; *TLI*=Tucker-Lewis Index

Table 4

Fit indices from the analyses testing the longitudinal invariance of the number of beliefs of PDI-21 in students

Model	χ^2	*df*	*RMSEA*	*90% CI*	*CFI*	*TLI*	$\Delta\chi^2$	*Δdf*	*ΔCFI*	*ΔTLI*	*p*
Wave 2	624.873	189	0.039	0.035-0.042	0.970	0.967					<0.0001
(*n*=1554)											
Wave 3	884.247	189	0.049	0.046-0.052	0.908	0.898					<0.0001
(*n*=1554)											
Model 1	1618.701	797	0.026	0.024-0.028	0.965	0.962					<0.0001
Model 2	1606.400	817	0.025	0.023-0.027	0.966	0.964	29.675	20	0.001	0.002	0.0753
Model 3	1639.607	837	0.025	0.023-0.027	0.965	0.964	53.575	20	-0.001	0.000	0.0001

Notes: RMSEA=Root Mean Square Error of Approximation; *CI*=confidence interval; *CFI*= Comparative Fit Index criterion; *TLI*=Tucker-Lewis Index; Model 1=equality of the overall structure; Model 2=Model 1 plus equality of the factor loadings; Model 3 = Model 2 plus equality of the indicator thresholds.

Table 5

Fit indices from the analyses testing the cross-sample invariance of number of beliefs of PDI-21

Samples	Model	χ^2	*df*	*RMSEA*	*90% CI*	*CFI*	*TLI*	$\Delta\chi^2$	*Δdf*	*ΔCFI*	*ΔTLI*	*p*
Patients (*n*=192)	*CFA*	355.349	189	0.068	0.057-0.078	0.948	0.943					<0.0001
Students (*n*=747)	*CFA*	416.136	189	0.040	0.035-0.046	0.933	0.926					<0.0001
	Model 1	768.879	378	0.047	0.042-0.052	0.937	0.930					<0.0001
	Model 2	787.402	398	0.046	0.041-0.050	0.937	0.934	58.740	20	0.000	0.004	<0.0001
	Model 3	862.907	418	0.048	0.043-0.052	0.928	0.928	127.899	20	-0.009	-0.006	<0.0001

Notes: RMSEA=Root Mean Square Error of Approximation; *CI*=confidence interval; *CFI*= Comparative Fit Index criterion; *TLI*=Tucker-Lewis Index; Model 1=equality of the overall structure; Model 2=Model 1 plus equality of the factor loadings; Model 3 = Model 2 plus equality of the indicator thresholds