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Chinese translation and validation of the Personalized Psychological Flexibility Index (PPFI) for medical college students

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Abstract

Background Psychological flexibility (PF) is defined as the ability to pursue valuable life goals despite the existence of distress. The Personalized Psychological Flexibility Index (PPFI) is a new measure of psychological flexibility that can address existing deficiencies. This study aimed to translate and validate the psychometric characteristics of the Chinese version of the PPFI among medical college students.

Methods The study was conducted in two phases. Phase 1 involved the translation and cross-cultural adaptation of the PPFI according to guidelines recommended by the International Society for Pharmacoeconomics and Outcomes Research (ISPOR). Phase 2 was a cross-sectional survey conducted on 945 medical college students in China. The psychometric performances of the scale were assessed using construct validity, divergent validity, criterion validity, incremental validity, internal consistency, and test-retest reliability.

Results The exploratory factor analysis (EFA, $n_1 = 440$) showed that the Chinese version of the PPFI consisted of 3 factors, with a total of 15 items. The confirmatory factor analysis (CFA, $n_2 = 440$) showed that the three-factor structure fit well ($\chi^2/df = 2.469$, SRMR = 0.051, RMSEA = 0.058, GFI = 0.94, CFI = 0.985). The total Chinese PPFI score had a moderate positive association with the Comprehensive Assessment of Acceptance and Commitment Therapy (CompACT, $r = 0.344$) and a negative association with the Acceptance and Action Questionnaire-II (AAQ-II, $r = -0.334$). Furthermore, the Chinese PPFI demonstrated good internal consistency (Cronbach's $\alpha = 0.826$) and test-retest reliability (ICC = 0.817, $p < 0.001$).

Conclusion The 15-item Chinese version of the PPFI is a reliable and valid tool for measuring PF in Chinese medical students. However, additional studies are needed to validate its psychometric properties in more generalizable samples and other contexts.

Keywords Personalized psychological flexibility index, Psychological flexibility, Translation, Reliability, Validity

Introduction

In the last two decades, the development of several psychotherapies, known as the “third wave” of cognitive behavioural therapy (CBT), has expanded the scope of evidence-based psychotherapy. A representative of the third wave of CBT, acceptance and commitment therapy (ACT), has attracted increasing interest for its possible treatment of anxiety, depression, stress, physical health problems and psychotic disorders [1]. ACT is an

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empirically based psychological intervention that uses multiple strategies to increase psychological flexibility [2]. Psychological flexibility is defined as the ability to pursue valuable life goals despite the existence of distress [3, 4]. Accordingly, it consists of six core components: acceptance, cognitive defusion, contact with the present moment, self as context, values, and committed action [4].

The psychological flexibility model is built on relational frame theory (RFT) and the philosophy of functional contextualism [5]. It focuses more on the functioning of individuals' psychological events than on 'changes in the original cognitive content' [6]. Thus, changing the psychological flexibility of an individual is not achieved by changing the content, type, or frequency of psychological events, but by changing the function of psychological events and their relationship to the individual. Individuals with higher levels of psychological flexibility are more willing to tolerate uncomfortable states if doing so facilitates meaningful goal pursuit [7]. Conversely, psychological inflexibility (PI) is described as a pattern in which behaviour is controlled by one's thoughts, feelings and other internal experiences, or to avoid these experiences at the expense of more effective and meaningful actions [8].

The commonly used measurements for psychological flexibility and psychological inflexibility include the Acceptance and Action Questionnaire (AAQ) [9], the second version of the AAQ (AAQ-II) [10], the Multidimensional Experiential Avoidance Questionnaire (MEAQ) [11], the brief version of the MEAQ (BEAQ) [12], the Comprehensive Assessment of Acceptance and Commitment Therapy processes (CompACT) [13], and the Multidimensional Psychological Flexibility Inventory (MPFI) [14]. Despite their advantages, these measurements often fail to capture the core elements of psychological flexibility and are almost indistinguishable from general negative emotions [7]. The AAQ has low internal consistency and poor divergent validity [11], and its factor structure stability has not been convincingly demonstrated [10]. The AAQ-II is currently the most widely used scale for measuring psychological flexibility, but it seems like more useful to measure experiential avoidance (EA), which is only one aspect of psychological flexibility theories and does not encompass its other elements [15]. Moreover, the AAQ-II has a higher correlation with psychological distress and negative emotions than capturing psychological flexibility [10]. Similarly, the MEAQ and BEAQ were both designed to capture experiential avoidance. A recent study indicated that the BEAQ had overlapped with anxiety and depression [16]. The MPFI, with 60 items, fails to connect with personal, meaningful life goals, a core concept of psychological flexibility [7].

In addition, a study showed that CompACT was more suitable for measuring the psychological inflexibility in clinical samples, but it lacks comprehensiveness when compared to the MPFI [16]. Our understanding of psychological flexibility seems to fluctuate due to ineffective measurements, so a tool that can accurately capture the core elements of psychological inflexibility is needed.

To address these gaps, Kashdan et al. created a new scale named the Personalized Psychological Flexibility Index (PPFI). The PPFI measures psychological flexibility by linking adaptive responses to distress and obstacles with personalized and valuable life goals [7]. Through self-reporting, participants are asked to focus on an important current personal goal when answering each item. The scale includes three dimensions: avoidance (avoiding negative emotions related to meaningful goals or postponing the pursuit of those goals), acceptance (acceptance of negative emotions related to the goals or temporary setbacks in goal pursuit), and harnessing (using problems and negative emotions to motivate yourself to pursue meaningful goals). The PPFI is related to the goal of personalization, can be customized according to the population needs, and has strong psychometric characteristics [17].

The importance of accurately measuring psychological flexibility is particularly relevant in high-stress environments, such as medical education. Medical college students often experience job burnout, which can impact their entire career given the widespread pressure in medical education and limited coping resources [18, 19]. Burnout can lead to poor physical [20, 21] and mental health, including decreased happiness [22], depression [23], anxiety [24] and suicide [25]. Studies have shown that psychological flexibility is associated with improved ability to manage mental and behavioural problems, and improved quality of life [26, 27], college adjustment [28], increased academic adjustment and life satisfaction [29], and reduced stress and depressive symptoms [30] in adolescents. In addition, ACT interventions have demonstrated effectiveness in reducing burnout and psychological distress while improving well-being and performance on final examinations by enhancing psychological flexibility in medical students [31, 32]. Therefore, accurately measuring the psychological flexibility of medical students is crucial for their growth and development.

The PPFI appears to be a new measurement of psychological flexibility that can overcome the existing deficiencies. Psychological flexibility may depend on specific cultural contexts [33]. Therefore, it is vital to study the psychometric properties of translated psychological flexibility measurements in different contexts. This study aims to evaluate the reliability and validity of the Chinese PPFI among medical college students, providing

clinicians and researchers with a more suitable measure of psychological flexibility, and offering a reference for evaluating and promoting the mental health of college students. To investigate the criterion validity of the Chinese PPFi, we selected the well-established AAQ-II and CompACT as standard tools. The AAQ-II is currently the most widely used scale for measuring experiential avoidance, a key component of psychological inflexibility, despite its limitations in capturing the full spectrum of psychological flexibility [10]. The CompACT was selected due to its comprehensive approach to assessing psychological inflexibility and its established validity in various populations [13]. Additionally, this study also aims to gain a deeper understanding of the PPFi items from a Chinese cultural perspective, explore potential new findings, and enhance researchers' comprehension of the PPFi and ACT.

Methods

Study design

The study was conducted in two phases: (1) translation of the English PPFi into simplified Chinese and a transcultural adaptation, and (2) validation of the Chinese PPFi through a cross-sectional survey using the AAQ-II, the CompACT, the Adolescent Self-rating Life Events Checklist (ASLEC), the Depression Anxiety Stress Scale-21 (DASS-21), the 5-item World Health Organization Well-Being Index (WHO-5), and the Satisfaction with Life Scale (SWLS) among medical college students. Ethical approval of the study was obtained from the Ethics Committee of Xi'an Jiaotong University (Ref: 2022–1436). Informed consent was obtained from all participants at the beginning of the online survey.

Participants and procedures

Translation and cultural adaptation of PPFi

The translation and cultural adaptation of the scale followed eight steps based on the guidelines recommended by the International Society for Pharmacoeconomics and Outcomes Research (ISPOR, 2005) [34]. In the initial preparation stage, we obtained the original English scale and translation authorization from the original author of the scale (Professor Kashdan) via email. In the forward translation process, two native bilingual translators independently translated the original English version into simplified Chinese version (v1, v2). These translators then discussed the translation with a third translator, who did not participate in the initial translation, to form a unified version (v3). In the back translation stage, the coordinated version was translated back to English (v4) by a bilingual scholar whose native language is English. The study team members then conducted a conceptual equivalence review

between the back-translated version and the original scale. At the stage of harmonization, the study team members formulated the first draft of the Chinese scale (v5) based on the results of back translation review and the Chinese expression. Cognitive debriefing was then conducted with eight medical college students to verify the comprehensibility and cognitive equivalence of the Chinese scale. All participants were asked to interpret the meaning of each item in their own words and provide reasons for their responses. Subsequently, the results of the cognitive interview were sorted, and the explanatory text and format of the scale were properly revised and finalized (v6). Finally, we proofread the final version. The translation and cultural adaptation process were shown in Fig. S1.

According to the translation and cultural adaptation guidelines recommended by ISPOR, the PPFi was successfully translated and adapted for the simplified Chinese language. Consistent with the original scale, the Chinese PPFi has three dimensions: avoidance, acceptance, and harnessing. Notably, we translated the word "task" into "related things" (items 1, 2), the word "let my commitment for this goal slide" into "reduce the effort to the goal and let nature take its course" (item 5), and the word "anger" into "dissatisfaction" (item 13). This seems to be more in line with the understanding and language habits of Chinese people.

Validation of the Chinese version of the PPFi

Participants

This study enrolled medical college students from Shaanxi Province, Liaoning Province, and Shanghai city in China through convenience sampling. These regions were selected to ensure a diverse representation of medical students from different geographical and cultural backgrounds within China. The inclusion criteria were voluntary university students from freshman to fifth year. All participants completed the online questionnaire through the WeChat applet. Before completing the questionnaire, they were provided with an explanation of the research purpose and significance. A total of 945 medical college students completed the online questionnaires. Of which 39 (4.12%) were excluded due to obvious regularity, and the other 26 (2.75%) were excluded for leaving the goal description blank. Therefore, 880 (93.12%) participants were included in the data analyses, with a mean age of 19.39 years old. Among them, 707 were female (80.3%) and 173 were male (19.7%). To ensure data validity, we performed a validity check by identifying and excluding any line-responding patterns in the data. The participant inclusion and grouping process is illustrated in Fig. 1, and the general demographic data is presented in Table 1.

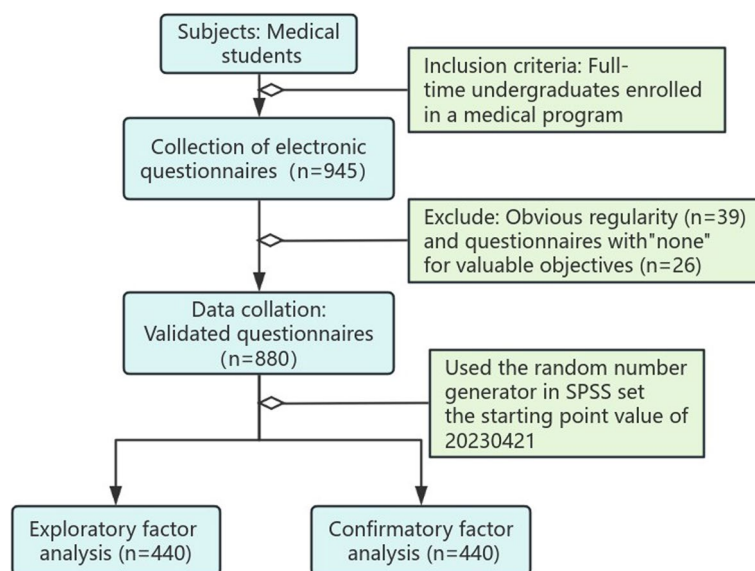


Fig. 1 Research subject inclusion and grouping flowchart

Table 1 Demographic features of the participants (n = 880)

Variables		n (%)
Gender	Female	707 (80.34)
	Male	173 (19.66)
Grade	Freshman	386 (43.86)
	Sophomore	214 (24.32)
	Junior	179 (20.34)
	Senior	99 (11.25)
	5th-grade	2 (0.23)
Residence	Urban	366 (41.59)
	Rural	514 (58.41)
Only child or not	Only child	296 (33.64)
	Not	584 (66.36)
Ethnicity	Han nationality	781 (88.75)
	Minority nationality	99 (11.25)
Family structure	Single-parent family	101 (11.48)
	Not single-parent family	779 (88.53)

Measures

Personalized Psychological Flexibility Index (PPFI)

The original PPFI was developed by Kashdan et al. to assess psychological flexibility, which is defined as the ability to pursue valued life goals despite the presence of distress [7]. The PPFI takes the background of the participant’s only important goal for the moment and requires the participant to write down “an important goal that you are working on” before self-reporting. The Chinese PPFI includes 15 items across three subscales, including avoidance, acceptance, and harnessing, using a 7-point Likert scale format ranging from 1 (strongly disagree) to

7 (strongly agree). The avoidance subscale was scored in reverse.

Acceptance and Action Questionnaire-II (AAQ-II)

The AAQ-II assesses experiential avoidance using seven items rated on a 7-point Likert scale ranging from 1 (never true) to 7 (always true) [10]. Higher scores reflect higher experiential avoidance. The Chinese version of the AAQ-II has shown acceptable reliability and validity among college students [35].

Comprehensive Assessment of Acceptance and Commitment Therapy (CompACT)

The CompACT assesses psychological inflexibility [13]. Items were scored on a 7-point Likert scale, ranging from 0 (“strongly disagree”) to 6 (“strongly agree”). The Chinese version has 15 items and three subscales, including openness to experience, behavioural awareness, and valued action. The Chinese CompACT has shown good internal consistency and test–retest reliability in financial staffs [36].

Adolescent Self-rating Life Events Checklist (ASLEC)

The ASLEC measures life events experienced by adolescents [37].The client will conduct self-assessment according to the events that happened in the last three months. If the events that did not happen are checked in the column of "did not happen", 5-point Likert scale rating will be given according to the psychological feelings at the time of the events, ranging from 1 (no impact) to 5 (extremely severe impact). It has five-factor structure including punishing, loss, interpersonal stressors,

learning stressors, and adaptation, with good validity and reliability among middle school students [38].

Depression Anxiety Stress Scale-21 (DASS-21)

The DASS-21 is a 21-item and simplified version of the original DASS-42 [39], measuring three negative emotional experiences including depression, anxiety and stress. All items were rated on a 4-point Likert scale ranging from 0 (strongly disagree) to 3 (strongly agree). The Chinese version has acceptable validity and reliability among college students [40].

5-item World Health Organization Well-Being Index (WHO-5)

The WHO-5 assesses subjective well-being with five items [41]. It used a 6-point Likert scale ranging from 0 (never) to 5 (all of the time). The Chinese version of the WHO-5 has been validated in college students, showing high reliability and validity [42].

The Satisfaction with Life Scale (SWLS)

The SWLS measures the cognitive component of adults' subjective well-being with five items rated on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree) [43]. The Chinese version of the SWLS has shown acceptable reliability and validity with good internal consistency and stability among college students [44].

Statistical analysis

Data were analyzed using SPSS 26.0, Amos 24.0 (IBM SPSS Statistics), and Mplus 8.3. The factor structure of the Chinese version of the PPFi was verified via both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). A random method was used to obtain half of the sample size for factor analysis. This study used the random number generator in SPSS, set to the starting point value of 20,230,421, and divided the sample into two groups for EFA and CFA separately.

Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) statistic were used to assess the appropriateness of performing factor analysis on items. The data were considered suitable for factor analysis if Bartlett's test was significant and the KMO statistic was ≥ 0.8 . Factor retention was based on the following three criteria: (1) eigenvalues ≥ 1 , (2) scree plot, and (3) interpretability of factors. In addition, only items with loadings ≥ 0.3 were retained [45]. Principal component analysis (PCA) was used for factor extraction, and the Varimax rotation method with Kaiser normalization was applied to enhance the interpretability of the factors. Based on Hu and Bentler's suggestions (1999) [46], several indicators were evaluated: the comparative fit index (CFI, good fit ≥ 0.90), the root mean square error of approximation (RMSEA, good fit ≤ 0.08), and the standardized root

mean square residual (SRMR, good fit ≤ 0.08). Values close to these cut-offs were considered acceptable fits.

The internal consistency was assessed via Cronbach's α . The test–retest reliability was assessed by the intraclass correlation coefficient (ICC) of the findings on the same group of participants ($n=50$) after two weeks. The composite reliability was extracted from the CFA. The divergent validity was evaluated by EFA, including the PPFi subscales, negative emotionality and experiential avoidance, to determine whether the PPFi was distinct from distress. The incremental validity was evaluated based on whether the PPFi could better predict certain outcomes compared to other popular measurements, including the AAQ-II and CompACT.

To assess the consistency of the scale across different groups, measurement invariance was tested using multi-group confirmatory factor analysis. We evaluated configural invariance, metric invariance, scalar invariance, and strict invariance. The criteria for assessing measurement invariance included changes in the comparative fit index (ΔCFI) and root mean square error of approximation ($\Delta RMSEA$). According to Cheung and Rensvold (2002) [47], a ΔCFI of ≤ 0.01 and a $\Delta RMSEA$ of ≤ 0.015 indicate that the model fit is equivalent across groups.

Results

Reliability of the Chinese PPFi

The reliability and validity of the scale were tested using data from 880 participants. The mean scores (SD) of the avoidance, acceptance, and harnessing subscales and the PPFi total scale were 23.42 (6.10), 25.89 (4.88), 21.14 (5.21), and 70.45 (11.28), respectively. The Cronbach's alpha of the total Chinese PPFi score was 0.826, indicating satisfactory reliability. The subscale score reliabilities were 0.853 for avoidance, 0.852 for acceptance, and 0.803 for harnessing. A follow-up of 50 college students was conducted after two weeks, and intraclass correlation analysis showed good temporal stability and test–retest reliability for the total PPFi (ICC = 0.817, $p < 0.001$), avoidance subscale (ICC = 0.768, $p < 0.001$), acceptance subscale (ICC = 0.697, $p < 0.001$), and harnessing subscale (ICC = 0.845, $p < 0.001$). The descriptive results of the other measurements along with their reliability test results are shown in Table 2.

Exploratory factor analysis for the Chinese PPFi

EFA was performed on half of the participants ($n=440$) obtained by a random method. The results of Kaiser–Meyer–Olkin (KMO = 0.859) and Bartlett's test of sphericity ($\chi^2 = 2774.348$, $p < 0.001$) indicated significant correlations between PPFi items, justifying factor analysis. Using principal component analysis (PCA), three components with initial eigenvalues > 1 were extracted,

Table 2 Basic descriptive statistics and reliability of the measurements ($n = 880$)

Measurements	M	SD	Cronbach's α
Chinese PPFI	70.45	11.28	0.826
AAQ-II	24.94	7.52	0.905
CompACT	70.15	10.02	0.809
ASLEC	33.86	22.20	0.946
DASS-21	34.13	12.31	0.962
WHO-5	19.93	5.58	0.946
SWLS	21.59	6.50	0.914

Chinese PPFI Chinese version Personalized Psychological Flexibility Index, *AAQ-II* Acceptance and Action Questionnaire-II, *CompACT* Comprehensive Assessment of Acceptance and Commitment Therapy, *ASLEC* Adolescent Self-rating Life Events Checklist, *DASS-21* Depression Anxiety Stress Scale-21, *WHO-5* 5-item World Health Organization Well-Being Index, *SWLS* Satisfaction with Life Scale

explaining 62.1% of the total variance. The scree plot indicated that three latent variables were acceptable, as shown in Fig. 2. The EFA with Varimax rotation and Kaiser Normalization yielded factor loading and common factors scores (Table 3).

Confirmatory factor analysis (CFA) for the Chinese PPFI

CFA was conducted with the other half of the sample ($n = 440$), testing three possible models: a single latent variable model, a two-factor model with acceptance and harnessing as one latent variable and the avoidance as

the second, and a three-factor model. The basis for constructing the one-factor model was to examine whether all items loaded onto a single underlying construct of psychological flexibility, which assumes that psychological flexibility is a unidimensional construct. The two-factor model was constructed to assess whether the items could be grouped into two broader dimensions, with acceptance and harnessing forming one factor and avoidance forming another, based on the theoretical distinction between engagement in valued actions and avoidance behaviors.

No cross-loadings or correlated errors were specified, and Table 4 shows the model fit indices. The maximum likelihood ratio tests showed that the three-factor model had a better fit than the single-factor model ($\chi^2 = 1674.662$, $df = 90$, $p < 0.001$) and the two-factor model ($\chi^2 = 869.304$, $df = 89$, $p < 0.001$). In addition, we selected the best model by comparing the expected cross-validation index (ECVI) of the default model, independence model and saturated model. Compared to the other two values, the three-factor model had the lowest ECVI (0.810 [0.547, 6.984]), indicating a better fit for different samples.

Although the above data indicated that the three-factor model is superior to the single-factor and dual-factor models, the analysis results of AMOS showed that there were still some model fit indices that did not meet the recommended threshold, and some fit indices

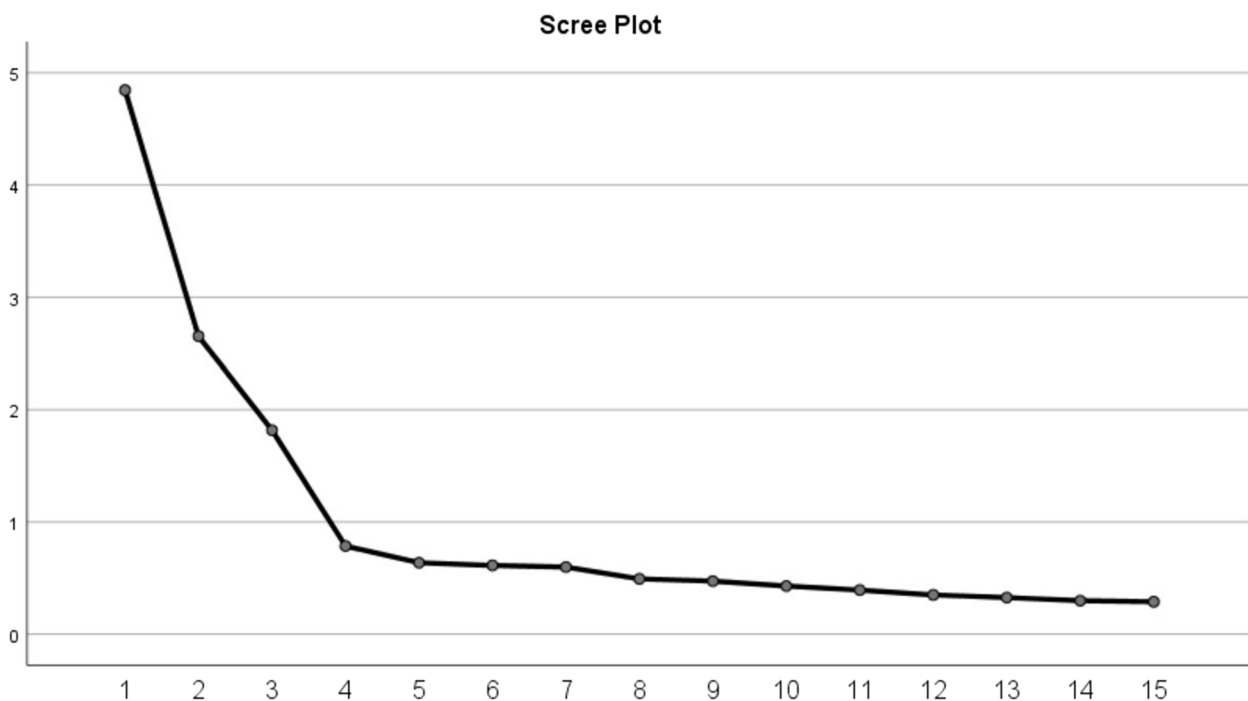


Fig. 2 Exploratory factor analysis scree plot

Table 3 Chinese PPFI standardized factor loadings and item descriptive statistics

items	Descriptive statistics		Exploratory Factory Analysis						
	M	SD	Factor 1	Factor 2	Factor 3	h ²	I-T	I-Ts	
1 I avoid the most difficult goal-related tasks	4.72	1.60	0.781	0.154	-0.004	0.633	0.577	0.795	
2 I put off pursuing this goal when I could be doing a more enjoyable task	4.18	1.66	0.749	0.119	-0.016	0.576	0.546	0.777	
3 When I feel stressed pursuing this goal, I give up	5.30	1.33	0.775	0.283	-0.046	0.682	0.671	0.804	
4 I get so caught up in thoughts and feelings that I am unable to pursue this goal	4.76	1.52	0.791	0.190	0.094	0.671	0.650	0.815	
5 When I feel discouraged, I let my commitment for this goal slide	4.46	1.56	0.793	0.021	0.096	0.638	0.561	0.779	
6 I accept the setbacks when pursuing this goal	5.48	1.10	0.227	0.763	0.118	0.648	0.635	0.785	
7 While pursuing this goal, I try to accept my negative thoughts and feelings rather than resist them	5.34	1.15	0.183	0.830	0.064	0.727	0.625	0.834	
8 I am willing to experience negative thoughts and emotions related to this goal	5.03	1.33	0.124	0.792	0.127	0.658	0.611	0.828	
9 I accept things I cannot change about this goal	5.16	1.23	0.048	0.791	0.073	0.633	0.543	0.787	
10 While pursuing this goal, I can observe unpleasant feelings without being drawn into them	4.87	1.32	0.198	0.721	0.216	0.605	0.653	0.791	
11 When faced with obstacles related to this goal, my frustration serves to energize me	4.17	1.33	0.202	0.201	0.707	0.581	0.591	0.733	
12 I find worrying helpful to solving goal-related problems	4.25	1.45	0.098	-0.001	0.748	0.569	0.448	0.763	
13 When people distract me from this goal, I use any anger that arises to stay focused	4.12	1.36	0.079	-0.017	0.754	0.576	0.433	0.756	
14 I get motivated by guilt when I fail to meet my own expectations pursuing this goal	4.68	1.34	0.182	0.041	0.702	0.528	0.485	0.721	
15 I find unpleasant emotions useful for reaching this goal	3.92	1.48	-0.015	-0.058	0.767	0.593	0.371	0.754	

Factor 1 was items 1 to 5 (avoidance), factor 2 was items 6 to 10 (acceptance), and factor 3 was items 11 to 15 (harnessing)

h², communality; I-T, item-total correlations; I-Ts, item-total correlations between each item and its subscale

Table 4 Model fit indices of confirmatory factor analysis for the Chinese PPFI

	χ^2	df	χ^2/df	SRMR	RMSEA (90%CI)	GFI	CFI	NFI	TLI	IFI
One-factor model	1674.662	90	18.607	0.185	0.200 (0.189, 0.212)	0.568	0.459	0.448	0.369	0.462
Two-factor model	869.304	89	9.767	0.119	0.141 (0.112, 0.154)	0.719	0.734	0.714	0.686	0.735
Three-factor model	289.666	87	3.329	0.058	0.073 (0.064, 0.081)	0.914	0.931	0.905	0.917	0.931
Final model ^a	207.387	84	2.469	0.051	0.058 (0.048, 0.068)	0.940	0.958	0.932	0.947	0.958

All the models were estimated with zero cross-loadings and correlated errors

χ^2 chi-square index, SRMR standardized root mean square residual, RMSEA root mean square error of approximation, GFI goodness of fit, CFI comparative fit index, NFI normed fit index, TLI Tucker-Lewis Index, IFI incremental fit index

^a Final model, is the three-factor solution model with three correlated errors for (3↔6), acceptance (6↔7), and harnessing (11↔14) subscales

suggested marginal model fit. The modification indices suggested that we can reduce the chi-square value of the model by adding an error correlation between two items, making the results closer to the recommended threshold. After correlating errors for items 3 and 6 ($r=0.20$), items 6 and 7 ($r=0.34$), and items 11 and 14 ($r=-0.25$), the model fit indices reached an acceptable level. Figure 3 shows the final CFA model with standardized factor loadings and three error correlations. Factor correlations between avoidance (reverse-scored) and acceptance ($r=0.27$), avoidance and harnessing ($r=0.06$), and acceptance and harnessing ($r=0.45$)

indicated moderate shared variances and acceptable separability.

Measurement invariance model of the Chinese PPFI

Using the equivalence testing method provided by Wang et al. [48], a measurement equivalence analysis was performed on the entire sample ($n=880$) by Mplus 8.3. The configural invariance model showed acceptable fit, allowing for further equivalence analysis. Factor load equivalence (metric invariance model), index intercept equivalence (scalar invariance model), and error variances equivalence (strict invariance model) all

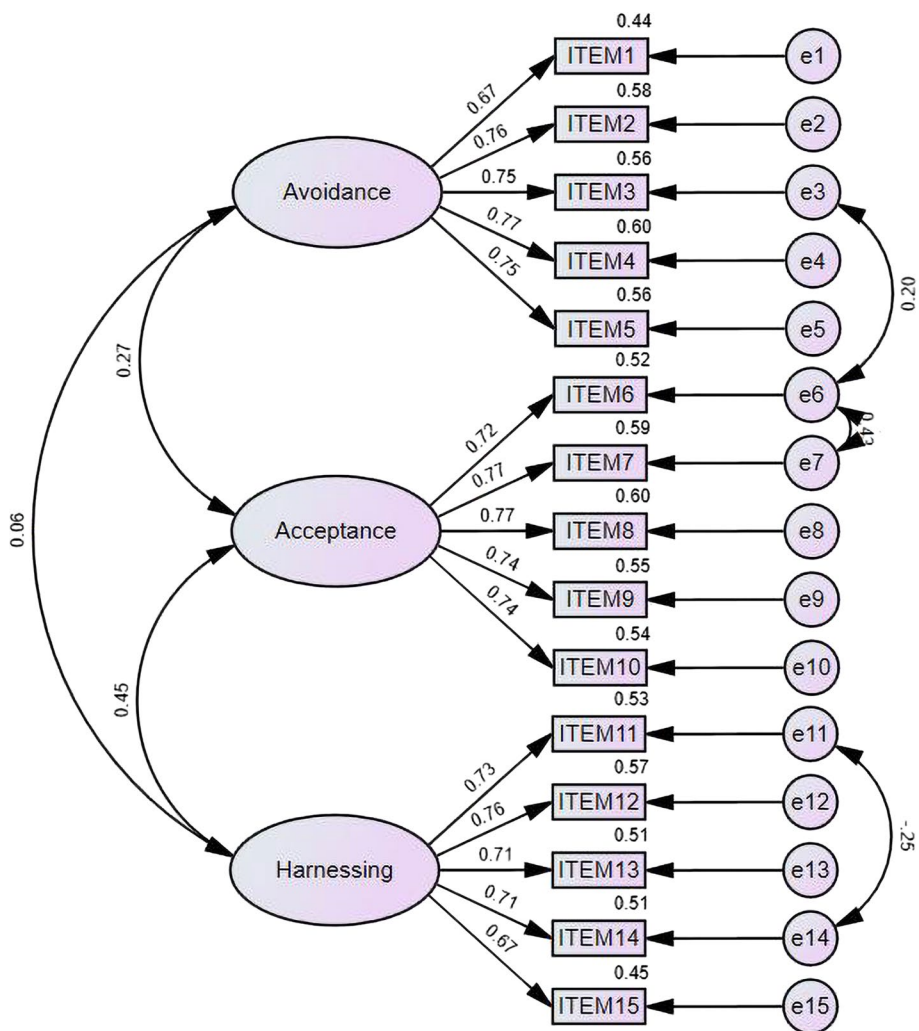


Fig. 3 Confirmatory factor analysis of the three-factor model

showed sufficiently small ΔCFI and $\Delta RMSEA$ (< 0.015) [49]. The multi-group model indicated no significant difference in the understanding the Chinese PPFi items between male and female groups, demonstrating consistent measurement across genders (Table 5).

Divergent validity of the Chinese PPFi

The total PPFi score had a moderate negative correlation with the total DASS-21 score ($r = -0.309$). The PPFi subscales of avoidance and acceptance showed moderate negative correlations with negative emotions, while the harnessing subscale had no significant correlation

Table 5 Model fit statistics and invariance testing across gender

Model	χ^2	df	CFI	TLI	SRMR	RMSEA (90%CI)	ΔCFI	$\Delta RMSEA$
Male ($n = 173$)	159.526	86	0.929	0.914	0.058	0.070 (0.053, 0.087)		
Female ($n = 707$)	405.402	86	0.927	0.911	0.057	0.072 (0.065, 0.080)		
Configural model	564.928	172	0.927	0.911	0.057	0.072 (0.066, 0.079)		
Metric invariance	574.015	184	0.928	0.918	0.059	0.069 (0.063, 0.076)	0.001	0.003
Scalar invariance	587.413	199	0.928	0.924	0.061	0.067 (0.060, 0.073)	0.001	0.002
Strict invariance	589.687	205	0.929	0.927	0.063	0.065 (0.059, 0.072)	0.001	0.002

($P > 0.05$), suggesting acceptable divergent validity (Table 6). EFA on a model constructed with variables including AAQ-II, depression, anxiety, stress, and the PPFi subscales ($KMO = 0.814$, $\chi^2 = 3582.583$, $p < 0.001$) extracted two components (initial eigenvalues: 3.493, 1.292), indicating the model was composed of two factors, described as negative emotionality and psychological flexibility. The standardized factor loadings are presented in Fig. 4 and Table S1, along with the factor correlation, implying that the PPFi can be differentiated from negative emotionality.

Table 6 Correlations for the Chinese PPFi with other scales: divergent validity

Measures	Total PPFi	Avoidance ^a	Acceptance	Harnessing
Negative Emotionality				
DASS-21	-0.309***	-0.344***	-0.228***	-0.054
Depression	-0.322***	-0.343***	-0.233***	-0.077**
Anxiety	-0.266***	-0.307***	-0.204***	-0.026
Stress	-0.300***	-0.337***	-0.218***	-0.050
Well-being				
WHO-5	0.366***	0.265***	0.307***	0.195***
SWLS	0.326***	0.203***	0.260***	0.226***
Psychological flexibility				
CompACT	0.344***	0.177***	0.337***	0.222***
Psychological inflexibility				
AAQ-II	-0.334***	-0.439***	-0.182***	-0.038

PPFi Personalized Psychological Flexibility Index, DASS-21 Depression Anxiety Stress Scale-21, WHO-5 5-item World Health Organization Well-Being Index, SWLS Satisfaction with Life Scale, CompACT Comprehensive Assessment of Acceptance and Commitment Therapy processes, AAQ-II Acceptance and Action Questionnaire-II

^a Avoidance subscale is reverse coded such that higher scores indicate less avoidance and greater psychological flexibility

** P -values < 0.05

*** P -values < 0.01

Criterion validity of the Chinese PPFi

Correlations of the total score of PPFi, and three subscales, with scores on the AAQ-II and the CompACT are presented in Table 6. The total PPFi score had a moderate positive association with the CompACT ($r = 0.344$) and a negative association with the AAQ-II ($r = -0.334$). The acceptance subscale also showed a moderate positive correlation with the CompACT ($r = 0.337$). Consistently, the avoidance and acceptance subscales had a low to moderate negative correlation with the AAQ-II. In summary, the Chinese PPFi is consistent with the CompACT and significantly negative correlated with the AAQ-II, capturing psychological flexibility effectively.

Incremental validity of the Chinese PPFi

Hierarchical regression analysis, with WHO-5 and SWLS scores as dependent variables, was used to evaluate incremental validity. The AAQ-II and CompACT were placed in block 1, and the Chinese PPFi was placed in block 2. The results showed that after controlling for AAQ-II or CompACT, the PPFi significantly increased the explanatory power for subjective well-being and life satisfaction. The standard regression coefficients (β) for AAQ-II or CompACT decreased, indicating the PPFi has higher incremental validity (Table 7).

Discussion

The job burnout of medical students is closely linked to mental health issues, such as anxiety and depression. It is essential to accurately evaluate the psychological flexibility of medical students. The PPFi is the first measurement to capture the psychological flexibility related to meaningful life goals for individuals [7]. It is more closely related to positive psychological structures and distinct from negative emotions [50]. However, the PPFi is still in its early stages and requires further evaluation and cross-cultural validation. This study developed a Chinese

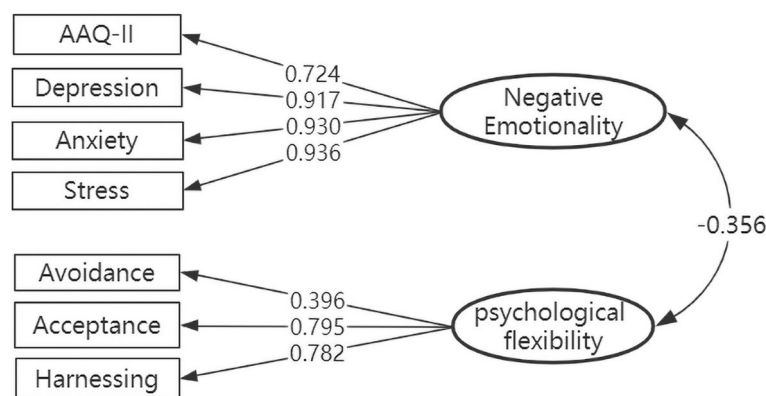


Fig. 4 Exploratory factor analysis differentiating Chinese PPFi subscales from negative emotionality

Table 7 Hierarchical regression analysis of the Chinese PPFi

Dependent	Independent (s)	Model 1		Model 2		
		Adjusted		Adjusted		
WHO-5	AAQ-II	-0.359*	0.128*	-0.266*	-	0.068*
	PPFI	-	-	0.277*	0.195*	-
	CompACT	0.336*	0.112*	0.238*	-	0.071*
SWLS	PPFI	-	-	0.284*	0.182*	-
	AAQ-II	-0.382*	0.145*	-0.307*	-	0.045*
	CompACT	0.267*	0.070*	0.175*	-	0.063*
	PPFI	-	-	0.266*	0.132*	-

Note.*P-values < 0.001

PPFI Personalized Psychological Flexibility Index, CompACT Comprehensive Assessment of Acceptance and Commitment Therapy, AAQ-II Acceptance and Action Questionnaire-II

version of the PPFi and investigated its psychometric properties among Chinese medical college students. The results indicate that the Chinese PPFi is an effective tool for evaluating the psychological flexibility in this population. The Chinese PPFi is consistent with the original scale [7] and the Persian version scale [51] in content and factor structure, with high internal consistency and test-retest reliability. The model has good convergent validity, acceptable divergent validity with negative emotions, and higher incremental validity than the AAQ-II and CompACT.

The reliability indices support the Chinese PPFi as a reliable measure of the psychological flexibility, comparable to the initial research results. The results of EFA indicate that the Chinese PPFi is a three-factor scale: avoidance, acceptance and harnessing. Moreover, consistent with the original scale [7] and the Persian version [51], after rotation using principal component analysis, the factor load of each item was higher than 0.7 (0.702–0.830). In the CFA, we found that the three-factor model had a better fit than the single-factor and two-factor models. In addition, in the invariance test of the Chinese PPFi, we aimed to examine whether the structure of the scale is consistent across different gender groups [48]. We constructed multiple models and found that the scale can be applied indiscriminately to both male and female populations, laying the foundation for its widespread use.

To fit the model closer to the recommended threshold, this study followed the method of Akbari et al. [51] and adjusted the three-factor model for the larger modification index (MI) in the CFA results, allowing for residual correlations between e3 and e6 ($r=0.20$), e6 and e7 ($r=0.34$), and e11 and e14 ($r=-0.25$). The adjusted model fitting indices significantly improved, with residual correlations among items 6, 7, and 14 being similar to the results verified by the Persian version PPFi. The

differences in residual correlations may be influenced by traditional Chinese culture, particularly the personality development of contemporary college students, which is deeply rooted in traditional culture, especially Confucian culture. For example, item 3 (“When I feel stressed pursuing this goal, I give up”), item 6 (“I accept the setbacks when pursuing this goal”), and item 7 (“While pursuing this goal, I try to accept my negative thoughts and feelings rather than resist them”) are related to the Confucian concept of “will” [52]. This concept emphasizes the ability to face challenges resolutely and not give up easily due to difficulties and negative emotions in the process of pursuing a goal. The residual correlation between item 11 (“When faced with obstacles related to this goal, my frustration serves to energize me”) and item 14 (“I get motivated by guilt when I fail to meet my own expectations pursuing this goal”) may reflect the additional motivation experienced by participants after encountering negative emotions in their goal pursuit of. However, there is limited empirical research on the PPFi currently, and further studies are needed to substantiate this view.

In terms of construct validity, our findings showed that the total score of the Chinese PPFi and the scores of avoidance and acceptance subscales were significantly negatively correlated with scores of the depression, anxiety and stress, consistent with previous studies [7, 51]. However, the harnessing subscale was only weakly correlated with the scores of depression, which was also consistent with the results of the original scale [7]. This may be because severe depression can inhibit individuals from converting pain into strength. In addition, the Chinese PPFi had a moderate significant correlation with the scores of the AAQ-II and CompACT, which was consistent with a previous systematic review [16]. The AAQ-II mainly captures negative emotions and psychological inflexibility, while the PPFi and CompACT effectively

measure psychological flexibility. We found that the total score and the subscales scores of the Chinese PPFi were significantly positively correlated with the scores of subjective well-being (WHO-5) and life satisfaction (SWLS), demonstrating good convergent validity. These findings indicate that individuals with higher levels of psychological flexibility may experience higher happiness and life satisfaction. Finally, our results indicate that the Chinese PPFi is different from negative emotions (including AAQ-II, depression, anxiety and stress), which is consistent with previous studies [7, 51]. This further supports that PPFi captures meaningful aspects of life in the definition of psychological flexibility, distinct from general distress.

Hierarchical regression analysis revealed that the Chinese PPFi has better incremental validity than the AAQ-II and CompACT. When well-being (WHO-5) was the dependent variable, the PPFi as an independent variable increased the explained variance by 6.8% and 7.1% compared with AAQ-II and CompACT, respectively. When life satisfaction (SWLS) was the dependent variable, the explained variance increased significantly by 4.5% and 6.3%. Overall, the significantly positive correlation between PPFi and measures of happiness and life satisfaction underscores the importance of psychological flexibility for both physical and mental health [3].

In summary, the PPFi provides a nuanced understanding of psychological flexibility by capturing both positive and negative aspects, unlike other scales that primarily focus on psychological inflexibility. The adaptation and validation of the PPFi in different cultural contexts enhance the theoretical framework of psychological flexibility and its universal applicability. Additionally, the study provides empirical evidence that psychological flexibility, as measured by the PPFi, is distinct from general distress and negative emotions, thereby reinforcing its conceptual integrity. From a practical standpoint, the validated Chinese PPFi offers a reliable and culturally relevant tool for assessing psychological flexibility among Chinese medical students. Moreover, insights gained from the result of PPFi can inform the development of targeted interventions aimed at enhancing psychological flexibility, thereby improving mental health and well-being.

However, this study has several limitations. First, the participants were medical college students from three cities of China, which might not represent the characteristics of the broader Chinese population. Future studies should confirm the psychometric properties of the Chinese PPFi with more generalizable samples in other contexts. Second, this study relied solely on cross-sectional self-reported outcomes, preventing the assessment of changes over time. Future research

should employ longitudinal designs to potentially facilitate the wider application of the scale. Third, cultural factors may influence how psychological flexibility is expressed and experienced. Future research should investigate how cultural variables interact with psychological flexibility and whether the PPFi needs further adaptation to capture culturally specific aspects of this construct.

Conclusion

The results of the study provided preliminary evidence of the good psychometric properties of the PPFi among Chinese medical college students. The Chinese version of the PPFi has a stable three-factor structure, good reliability and acceptable validity. Therefore, it is a valid instrument for measuring the psychological flexibility of Chinese medical college students.

Abbreviations

AAQ-II	Acceptance and Action Questionnaire Edition-II
ACT	Acceptance and Commitment Therapy
ASLEC	Adolescent Self-rating Life Events Checklist
BEAQ	Brief Version of Experiential Avoidance Questionnaire
CBT	Cognitive Behavioural Therapy
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CompACT	Comprehensive Assessment of Acceptance and Commitment Therapy Processes
DASS-21	Depression Anxiety Stress Scale-21
EA	Experiential Avoidance
ECVI	Expected Cross-Validation Index
EFA	Exploratory Factor Analysis
GFI	Goodness of Fit Index
ICC	Intraclass Correlation Coefficient
ISPOR	International Society for Pharmacoeconomics and Outcomes Research
MEAQ	Multidimensional Experiential Avoidance Questionnaire
PCA	Principal Component Analysis
PF	Psychological Flexibility
PPFi	Personalized Psychological Flexibility Index
RMSEA	Root Mean Square Error of Approximation
SRMR	Standardized Root Mean Square Residual
SWLS	Satisfaction with Life Scale
WHO-5	5-Item World Health Organization Well-being Index

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s40359-024-02121-w>.

Supplementary Material 1.

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Authors' contributions

LY and XL conceived and designed the study. TT, LY and QG participated in the forward translation of the original scale. YJ, TT, JS conducted the cross-sectional survey. YJ, TT conducted the data analysis with supervision from LY and DW. YJ and LY first drafted the paper and all the authors revised and approved it. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval of the study was obtained from the Ethics Committee of Xi'an Jiao tong University (Ref: 2022–1436). Consent from each participant was obtained at the beginning of the online survey.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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