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Factor structure and measurement invariance of the Subjective Vitality Scale: evidence from Chinese adolescents in Hong Kong

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Abstract

Purpose This study translates the Subjective Vitality Scale (SVS) into Chinese and examines its factor structure and measurement invariance in a sample of Chinese adolescents in Hong Kong.

Methods Chinese adolescents in Hong Kong were invited to participate in the study. Four models of the SVS (a 7-item model, two 6-item models and a 5-item model) were compared using confirmatory factor analysis (CFA). The internal consistency reliability was evaluated using Cronbach's alpha coefficients, and the criterion validity was assessed using bivariate correlations between subjective vitality and positive and negative affect. Finally, measurement invariance across genders and time points was examined to evaluate the invariance of the SVS model.

Results The results of the CFA analysis indicated that the 5-item measurement model fit the data better than the other three models. The Cronbach's alpha was above 0.70 (0.92), revealing excellent internal consistency reliability, and the SVS was significantly associated with positive affect and negatively associated with negative affect, indicating criterion validity. Finally, the measurement invariance analysis of the 5-item model displayed strict invariance across genders and time points.

Conclusions The results support the 5-item measurement model of the Chinese version of the SVS. This model has excellent internal consistency reliability, supports the criterion validity of the instrument and demonstrates strict invariance across genders and time points. In summary, the findings suggest that the 5-item Chinese version of the SVS is a reliable and valid instrument for assessing the subjective vitality of Chinese adolescents in Hong Kong.

Keywords Subjective vitality · Factor structure · Measurement invariance · Chinese adolescents · Validity · Reliability

Introduction

Health-related quality of life (HRQOL) is a multidimensional concept that involves physical, social and mental functioning and well-being [1, 2]. Previous studies of well-being, which is defined as optimal psychological functioning and experience, have adopted two distinct views of human nature: the hedonic view and the eudaimonic view [3]. Hedonism views well-being as consisting of pleasure or happiness [4]. In contrast, eudaimonism views well-being as consisting of fulfilling or realising one's true value and potential [5]. Feeling vital and energetic is one aspect of human well-being and of healthy functioning [1, 6]. Low vitality may be related to psychiatric or medical illnesses or indicative of frailty of one's biological or physiological systems [7].Therefore, researchers who adopt the eudaemonic view consider subjective vitality to be an indicator of psychological well-being. Subjective vitality is defined as a subjective feeling of aliveness and of having available energy [8]. Previous research has revealed that subjective vitality is both an important predictor and outcome of behavioural and health events [6]. It is robustly associated with satisfaction of autonomy, competence and relatedness [3]. Further, vitality levels have been found to be related to clinical conditions such as anaemia, congestive heart failure, chronic obstructive pulmonary disease, chronic fatigue syndrome, mortality risk and DNA damage, and to negative outcomes such as job loss, inability to work, poor physical performance and hospitalisation [9–11].

Two versions of a 7-item self-reported Subjective Vitality Scale (SVS) have been developed to measure subjective

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vitality [7]. The trait version reflects the idea that subjective vitality is a characteristic of individuals, whereas the state version assesses subjective vitality as a state rather than an enduring quality. The SVS has been widely used in previous studies and has proved to be valid and reliable across different sexes, age groups, populations, and levels of motivation and health [12]. It has also been validated in different languages including Spanish [13], Portuguese [14], Japanese [12] and Turkish [15]. Different items have been used in different versions of the SVS. Ryan and Frederic initially developed a 7-item SVS based on a series of studies [8]; however, Bostic et al. found that the negatively worded item 2 ("I don't feel very energetic") exhibited a relative low factor loading in their study, and they suggested removing it [16]. Thereafter, some researchers continued to use the 7-item version [15, 17, 18], whereas others used the new 6-item version of the SVS [19–22]. Recently, some researchers have used a 5-item version (with items 2 and 5 removed) [12, 23, 24], arguing that item 5 ("I look forward to each new day") may be a poor indicator of vitality, as it is more about optimism than energy [12]. Kawabata et al. found that the 5-item version of the SVS (omitting items 2 and 5) had the best fit with data collected from both Japanese and Singaporean undergraduate students [12].

Although some studies have reported that the Chinese version of the SVS has satisfactory internal consistency reliability, these studies have reported no validity information for the factor structure or measurement invariance [19, 20, 22]. Measurement invariance is a statistical property of a measurement that evaluates whether the underlying construct of a measurement is equivalent across groups (multi-group invariance) and time points (longitudinal invariance) [25]. It is also a prerequisite for group comparisons; for example, meaningful comparisons of statistics can only be made if the measures are comparable across different groups or time points [26]. Therefore, it is imperative to determine which SVS model (i.e. 5-, 6- or 7-item) is the best measurement model for a Chinese sample and what is its measurement invariance. A psychometrically sound measure allows researchers to make appropriate comparisons between groups such as males and females, experimental and control groups and between pre- and post-test scores [26]. This study translated the SVS into traditional Chinese and further validated it with a representative sample of Chinese adolescents in Hong Kong in a physical education context. First, the SVS was translated from English to Chinese using a back-translation technique. Second, the four SVS measurement models (the 7-item model, two 6-item models and the 5-item model) and their internal consistency reliability were examined using Cronbach's alpha. Third, the criterion validity of the SVS was examined by correlating the subjective vitality scores with positive and negative affect in a physical education context. Finally, the measurement invariance of the SVS across genders and time points was examined.

Methods

Participants

The target population of this study was secondary school students from general government and government-aided secondary schools in Hong Kong. A sample of 4306 Chinese students (Grades 7–11) from 60 government and government-aided secondary schools in Hong Kong were invited to participate in the baseline assessment. From this group, 230 students from eight classes were randomly invited to complete the follow-up assessment 2 months later. At the baseline assessment, valid data were collected from 4232 students, and 182 of the 230 students successfully completed the follow-up assessment. The demographic details of the participants are presented in Table 1.

Procedures

Ethical approval was obtained from a local University Human and Animal Research Ethics Committee. The PE teachers were contacted to obtain their permission for data collection. Written informed consent was received from the students and their parents prior to the data collection, and detailed information about the study was provided. The participants were informed prior to the baseline assessment that the anonymity and confidentiality of their answers would be preserved at all times. The data collection administrator emphasised that the purpose of the questionnaire was to measure participants' general feelings about the PE class. Participation in the study was voluntary, and the participants completed the questionnaires at the end of the PE class in the absence of the PE teachers.

Table 1 Demographic statistics of participants

Variables	Wave 1 ($N=4232$)	Wave 2 ($N=182$)
Age (years)	14.11 ± 1.50 (range 11–19)	13.23 ± 1.06 (range 11–16)
Gender		
Male	2175 (51.40%)	92 (50.55%)
Female	2052 (48.48%)	90 (49.45%)
Missing	5 (0.12%)	–

Measures

Subjective vitality

The 7-item Chinese version of the SVS [8] was used to measure the subjective vitality of the students in a physical education context. Therefore, the state version of the SVS was used in this study. An example item is "I feel alive and vital". Reponses were measured on a 7-point Likert scale ranging from 1 (not at all true) to 7 (very true).

Positive and negative affect

A 10-item version of the International Positive and Negative Affect Schedule Short Form [27] was used to measure students' positive affect (5 items) and negative affect (5 items) in the physical education classes. Reponses were collected on a 5-point Likert scale ranging from 1 (never) to 5 (always). This scale has demonstrated good validity and reliability in the Chinese population [27].

Translation and back-translation

The translation and back-translation procedure was used in this study [28]. Specifically, two translators (a bilingual university faculty member with a doctorate in English and a bilingual translator with a doctorate in psychology) independently translated the scale from English into Chinese. Following discussion, they reached consensus on a preliminary Chinese version. The Chinese version scale was then independently translated back into English by another two translators (two bilingual faculty members, one with a Master's degree in English-language teaching and the other with a doctorate in psychology). A comparison of the back-translated English version with the original English version found that the meaning of the items was identical. Finally, 20 native Chinese adolescents were invited to complete the Chinese language version of the SVS. They reported that the instructions and items in the Chinese version of the SVS were easy to understand. However, to further enhance clarity and comprehension, slight modifications were made to the wording and syntax based on their suggestions. The data collected from these 20 participants were not included in the statistical data analysis.

Statistical analysis

Mplus (Version 7.31) was used for the analysis. First, the four SVS measurement models (the 7-item model, two 6-item models and 5-item model) were examined using confirmatory factor analysis (CFA) with robust maximum likelihood (MLR) estimation. The fit of the models was compared and the performance of the items evaluated. Second, Cronbach's alpha coefficients were calculated to evaluate the internal consistency reliability of the SVS. Third, the criterion validity of the SVS was evaluated using bivariate correlations of subjective vitality with positive and negative affect. Finally, the measurement invariances across genders and time points were investigated using four models of multiple-group CFA: configural (M1), metric invariance (M2: weak invariance), scalar invariance (M3: strong invariance) and item uniqueness invariance (M4: strict invariance) [29].

Multi-fit indices were used to evaluate the adequacy of each model's fit to the data, including the Chi-square value, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA) accompanied by its 90% confidence interval (CI) and standardised root mean square residual (SRMR). Specifically, a threshold of >0.90 for the CFI and TLI, of close to (or less than) 0.08 for the SRMR and of up to 0.08 for the RMSEA represented an acceptable fit. CFI and TLI values exceeding 0.95, and SRMR and RMSEA values close to (or less than) 0.08 and 0.06, respectively, represented a good fit [30].

As the Chi-square difference test depends on sample size, the differences in the descriptive fit indices (ΔCFI, ΔRMSEA and ΔSRMR) were used in this study. According to Chen [31], when testing loading invariance, non-invariance is indicated by a change of ≥ 0.010 in the CFI supplemented by a change of ≥ 0.015 in the RMSEA or ≥ 0.030 in the SRMR; when testing intercept or residual invariance, non-invariance is indicated by a change of ≥ 0.010 in the CFI supplemented by a change of ≥ 0.015 in the RMSEA or ≥ 0.010 in the SRMR. Information criteria, specifically Akaike's Information Criteria (AIC), the Bayesian Information Criterion (BIC) and the sample size-adjusted BIC (ABIC) were also used to compare the models. A model with lower information criteria values was considered to fit the data better than the one with higher values.

Results

Demographic statistics, descriptive statistics and internal consistency reliability

The demographic statistics of the participants are presented in Table 1, and the descriptive statistics of the SVS items and internal consistency reliability of the four models are shown in Table 2. The Cronbach's alpha coefficient was below 0.70 for the 7-item model, indicating marginally satisfactory reliability, but was 0.921 for the 5-item model, indicating excellent reliability (>0.90). The Cronbach's alpha coefficient for the 5-item model was well above the coefficients of the two 6-item models. The inter-item and item-total correlations

presented in Table 3 indicate that items 2 and 5 had low to moderate correlations with the other 5 items and with the total scores. After removing these 2 items, the item-total correlations were much improved.

Measurement models

The model fit indices for the four models are presented in Table 4. The 7-item model demonstrated a good fit to the data; all of the standardised item factor loadings were statistically significant, ranging from 0.259 to 0.913 (Table 2). However, items 2 and 5 had problematically low factor loadings (< 0.40). The two 6-item models, with item 5 and item 2 removed, respectively, were further examined. Although both models had a better fit than the 7-item model, the factor loadings of these two items were still problematic. The 5-item model, with both problematic items removed, had a better fit than the other three models, with standardised factor loadings ranging from 0.741 to 0.913. More importantly, the AIC, BIC and ABIC values were much smaller in the 5-item model than in the other three models, indicating the superiority of the 5-item model.

Criterion validity

The bivariate correlations used to evaluate the criterion validity of the 5-item SVS suggested that subjective vitality was significantly associated with positive affect ($r = 0.48$) and negatively associated with negative affect ($r = -0.27$), providing initial support for the criterion validity of the SVS.

Measurement invariance across genders and time points

Invariance constraints across gender and time were separately and progressively added to the 5-item measurement

Table 2 Summary of the factor loadings, item means, SD, SMC and Cronbach's alpha coefficients

SVS item			7-Item model		6-Item model (-5)		6-Item model (-2)		5-Item model (-5, -2)	
	M	SD	FL	SMC	FL	SMC	FL	SMC	FL	SMC
Item 1	4.667	1.650	0.778	0.605	0.777	0.603	0.778	0.605	0.776	0.603
Item 2	4.745	1.690	0.363	0.132	0.357	0.127	–	–	–	–
Item 3	4.404	1.620	0.853	0.728	0.854	0.729	0.856	0.732	0.856	0.733
Item 4	4.547	1.627	0.913	0.833	0.914	0.835	0.913	0.833	0.913	0.834
Item 5	5.545	1.567	0.259	0.067	–	–	0.250	0.063	–	–
Item 6	4.573	1.507	0.740	0.548	0.740	0.548	0.741	0.549	0.741	0.549
Item 7	4.486	1.612	0.887	0.788	0.888	0.788	0.886	0.785	0.886	0.785
Cronbach's alpha			0.671		0.767		0.799		0.921	

Table 3 Inter-item and item-total correlations

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Total score (7-item)	Total score (5-item)
Item 1	1.000						0.619	0.747
Item 2	0.035	1.000					0.259	–
Item 3	0.702	0.018	1.000				0.723	0.816
Item 4	0.703	0.020	0.792	1.000			0.729	0.858
Item 5	0.023	0.001	0.000	0.015	1.000		0.161	–
Item 6	0.671	0.024	0.740	0.816	0.007	1.000	0.711	0.713
Item 7	0.576	0.037	0.617	0.660	0.001	0.702	0.634	0.842

Table 4 Fit indices for different models

Model	χ^2	df	CFI	TLI	RMSEA (90% CI)	SRMR	AIC	BIC	ABIC
7 Item	472.91	14	0.939	0.909	0.088 (0.081–0.095)	0.055	95,914.03	96,047.39	95,980.66
6 Item (-5)	163.96	9	0.976	0.961	0.064 (0.055–0.073)	0.019	80,397.33	80,511.64	80,454.44
6 Item (-2)	148.96	9	0.979	0.965	0.061 (0.052–0.069)	0.017	80,025.78	80,140.09	80,082.89
5 Item (-5,-2)	105.56	5	0.982	0.963	0.069 (0.058–0.081)	0.016	64,489.79	64,585.05	64,537.38

Table 5 Fit indices for the invariance models

Model	χ^2	df	CFI	TLI	RMSEA (90% CI)	SRMR	AIC	BIC	ABIC
Gender									
Female ($N=2175$)	37.46	5	0.989	0.977	0.055 (0.039–0.072)	0.012	32838.01	32923.28	32875.62
Male ($N=2052$)	74.57	5	0.973	0.947	0.082 (0.066–0.099)	0.020	31555.19	31639.59	31591.94
M1 (configural model)	153.94	11	0.974	0.952	0.078 (0.068–0.090)	0.034	64459.66	64643.79	64551.64
M2 (metric invariance)	136.70	14	0.978	0.968	0.064 (0.055–0.074)	0.024	64395.87	64560.95	64478.33
M3 (scalar invariance)	153.81	18	0.975	0.972	0.060 (0.051–0.069)	0.025	64390.66	64530.35	64460.44
M4 (item uniqueness invariance)	139.44	23	0.979	0.981	0.049 (0.041–0.057)	0.024	64404.43	64512.37	64458.35
Time									
Time 1 ($N=182$)	6.185	5	0.996	0.993	0.036 (0.000–0.114)	0.019	2999.17	3047.23	2999.73
Time 2 ($N=182$)	6.086	5	0.994	0.989	0.035 (0.000–0.113)	0.024	3057.34	3105.40	3057.89
M1 (configural model)	32.61	29	0.995	0.992	0.026 (0.000–0.064)	0.029	6034.94	6150.29	6036.27
M2 (metric invariance)	35.47	33	0.996	0.995	0.020 (0.000–0.059)	0.038	6029.55	6132.07	6030.73
M3 (scalar invariance)	43.12	37	0.991	0.989	0.030 (0.000–0.063)	0.043	6029.61	6119.32	6030.64
M4 (item uniqueness invariance)	48.46	42	0.990	0.990	0.029 (0.000–0.060)	0.052	6028.78	6102.47	6029.63

model. Table 5 presents the goodness-of-fit indices and information criteria for the independent and invariance models. All of the models displayed a very good fit to the data. A comparison of the more and less constrained models across genders and time points showed no decrease in model fit (as measured by ΔCFI, ΔRMSEA and ΔSRMR), and all of the fit indices exceeded the recommended cut-off values. The invariance was further supported by the information criteria showing consistent decreases (BIC, AIC and ABIC) in model comparison. These results supported the identification of weak, strong and strict measurement invariance in the 5-item model across genders and time points.

Discussion

Although the SVS has been widely used and validated in various languages, the factor structure and measurement invariance of a Chinese version have not previously been investigated. This study translated the SVS into Chinese and examined the factor structure and the gender and time invariance for a sample of Chinese adolescents in Hong Kong. This study confirmed that the 5-item SVS model had satisfactory internal consistency reliability. Its criterion validity and strict measurement invariance were supported, suggesting that the 5-item Chinese version of the SVS is a reliable and valid instrument for measuring subjective vitality in Chinese adolescents.

Item 2 ("I don't feel very energetic") was found to be problematic, with a low factor loading (< 0.40) across the 7- and 6-item models. This result was consistent with previous findings in samples of undergraduate student populations in different countries [12, 16]. Item 5 ("I look forward to each new day") also functioned poorly in this study, as indicated by a low factor loading and weak associations with other items and with the total scale score. These results support the argument of Kawabata et al. that this item is more reflective of optimism than energy [12]. Although both 6-item models, with either item 2 or item 5 removed, outperformed the 7-item model, both were notably inferior to the 5-item model. Consistent with previous studies [12], this provided further evidence for the superiority of the 5-item SVS model.

The 5-item model was previously tested with samples of Japanese and Singaporean undergraduates, where weak invariance was partially supported, with items 7 and 6 freely correlated with each other [8]. However, to the best of our knowledge, no previous study has examined whether the measurement model is invariant across genders and time. This study found that the 5-item SVS model had weak, strong and strict measurement invariance across gender and time. Weak invariance measures whether the change in each item score corresponds to the change in the factor score across groups or occasions, suggesting that participants interpret the items similarly across groups or occasions [32]. Strong invariance measures whether the values for observed variables reflect the values for the latent variables in the same way across groups or occasions. Evidence of strong invariance suggests that the mean scores of the participants in different groups or at different time points are comparable. Finally, strict invariance measures whether meaningful and unbiased comparisons can be made across groups or occasions. Evidence of strict invariance means that any difference between groups is a true difference rather than a measurement artefact. The results of this study suggested that the scores derived from the 5-item SVS were comparable across gender and time. In other words, the 5-item SVS can be used for both male and female Chinese secondary school students in Hong

Kong, and more importantly can capture changes in feelings of subjective vitality over time. A psychometrically sound SVS can ensure the accuracy of the measurement of subjective vitality in HRQOL research.

Although this study provided initial psychometric assessment of the Chinese version of the SVS, several limitations should be noted. First, convenience sampling was used, and only students from government and government-aided secondary schools were invited to participate in the study. Thus, the conclusion may not be generalised to secondary school students from private schools in Hong Kong. Second, the study used the state version of the SVS to assess the state of subjective vitality among students in a PE context. Future studies are encouraged to investigate the psychometric properties of the trait version of the SVS in a Chinese population. Third, a small sample size was used to analyse measurement invariance over time, which may cause volatile results. Future studies are encouraged to use a larger sample to investigate time invariance. Fourth, only two time points were investigated in this study, and researchers should consider additional time points in future studies. No specific time interval was used in previous longitudinal invariance studies, so the time interval used in this study was 2 months. Future researchers may explore whether time intervals are a potential confounding factor. Instrument validation is a continuous process that involves multiple steps. More studies are needed to accumulate further evidence on the accuracy and usefulness of the 5-item measurement model of the Chinese version of SVS.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study was approved by Committee on the Use of Human and Animal Subjects in Teaching and Research, Hong Kong Baptist University. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants and their parents who participated in the study.

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