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Cross-Cultural Validation of the Short Math Anxiety Scale Among Chinese High School Students

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Abstract: There is growing evidence that math anxiety is prevalent among Chinese high school students. The current study developed a Chinese version of the Short Math Anxiety Rating Scale (i.e., *CH-sMARS*) and examined its structural validity, construct validity, criterion validity, internal reliability, and 3-month-test-retest reliability. We recruited 696 and 329 high school students at Time 1 (April, 2020) and Time 2 (July, 2020), respectively, from two high schools in China. Results from exploratory and confirmatory factor analyses revealed a 16-item, three-factor structure. The factors were consistent with those in the original Short Math Anxiety Rating Scale (*sMARS*) – Mathematics Test Anxiety, Numerical Task Anxiety, and Mathematics Course Anxiety. Nine items were removed from the *sMARS* due to low factor loading across all three factors. The 16-item scale demonstrated good reliability and validity across all tests. The *CH-sMARS* offers a useful tool for measuring the multidimensional nature of math anxiety among Chinese high school students. Implications for practice and future research are discussed.
Keywords: Assessment, cross-cultural validation, factor analysis, mathematical anxiety, psychometrics

Introduction

Math anxiety refers to adverse emotional reactions toward numbers or the anticipation of doing math (Hembree, 1990). High school and college students are particularly vulnerable to math anxiety, which can impair performance on math tests and lead to the avoidance of math-related subjects, majors, or careers (Foley et al., 2017; Hopko, 2003). As a result, screening and diagnosing math anxiety have garnered scholarly attention over the past 70 years, during which various measurement tools have been developed. Examples include the *Taylor Manifest Anxiety Scale* (Taylor, 1953), the *Numerical Anxiety Scale* (Dreger & Aiken, 1957), the *Mathematics Anxiety Rating Scale* (MARS; Richardson & Suinn, 1972), the *Mathematics Anxiety Scale* (MAS; Betz, 1978), and a one-item math anxiety measure (Núñez-Peña et al., 2014). Among these, the MARS has been widely used for the diagnosis and treatment of math anxiety (Ma, 1999; Plake & Plake, 1982; Barroso et al., 2021; Szczygieł, 2022).

The MARS is a unidimensional measure of math anxiety consisting of 98 items. Richardson and Suinn (1972) reported its Cronbach's alpha to be .97 based on a sample of 397 undergraduate

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students in Missouri, U.S., and its 7-week test-retest reliability of .85 from a subsample of 35 students. The scale's construct validity was supported by finding that individuals with math anxiety showed decreased MARS scores following appropriate treatment (Richardson & Suinn, 1972). Despite its strong psychometric properties and widespread use (Furner, 2017; Ma, 1999; Plake & Plake, 1982; Barroso et al., 2021), Alexander and Martray (1989) criticized MARS for its lengthiness (i.e., 98 items) and the assumption of a unidimensional construct. In response, they developed a shortened version, the *Short Mathematics Anxiety Rating Scale* (sMARS), using a sample of 517 psychology majors. The25-item sMARS consists of three subscales – Mathematics Test Anxiety (15 items; α = .96), Numerical Task Anxiety (5 items; α = .86), and Mathematics Course Anxiety (5 items; α = .84). Subscale scores negatively correlated with participants' math attitude – higher math anxiety scores on each subscale were associated with more negative attitudes toward math. Alexander and Martray (1989) also reported a 2-week test-retest reliability of .86 based on a subsample of 62 students.

Bowd and Brady (2002) reexamined the factor structure of the sMARS using principal component analysis with 357 education major college students. They confirmed the 3-factor model, although the items loading differed slightly from those reported byAlexander and Martray (1989). Bowd and Brady (2002) attributed these variations to population differences.

Later, Baloğlu and Zelhart (2007) applied confirmatory factor analysis (CFA) to the sMARS using a sample of 559 college students from various majors. However, the results failed to confirm the original factor structure. They then conducted a principal component analysis with a loading threshold of.60 to guide item retention. This results in a 20-item, three-factor scale. Using a separate sample of 246 college students enrolled in math courses, Baloğlu and Zelhart (2007) confirmed this new structure, with inter-factor correlations ranging from .31 to .62. The three factors retained the same names as those reported by Alexander and Martray (1989).

Focusing on a different population, Moreno-García et al. (2018) tested the factor structure of the sMARS with high school students (n = 183). The results revealed a four-factor structure that retained all 25 items. The factors were labeled "Anxiety when preparing for a Mathematics test," "Anxiety when solving math problems," "Anxiety when presenting an exam in a Mathematics course," and "Anxiety towards Mathematics Books." Notably, the item loading patterns in their study differed from those reported by Alexander and Martray's (1989) and Baloğlu and Zelhart's (2007).

Besides the English version, the sMARS has been translated into Hebrew (Cohen & Rubinsten, 2017) and Spanish (Núñez-Peña et al., 2013). While Cohen and Rubinsten (2017) did not examine the factor structure of the Hebrew version, Núñez-Peña et al. (2013) conducted CFA using a sample of 342 psychology majors. Their results supported the original 25-item, three-factor structure of the sMARS. Correlations between factors ranged from .54 to .72, and the 7-week test-retest reliability was .72. Additionally, Núñez-Peña et al. (2013) reported that student math anxiety was negatively associated with enjoyment, confidence, and motivation toward math, and positively associated with both state and trait anxiety.

As reviewed above, the psychometric properties of the sMARS – particularly its structure validity – have received consistent scholarly attention over the past few decades. Collectively, findings suggest that the sMARS captures a multidimensional construct and demonstrates strong good construct, criterion validities, as well as adequate internal and test-retest reliabilities. Although item-loading patterns vary across studies, the underlying construct measured by the sMARS has remained largely consistent, with the exception of the findings from Moreno-García et al.'s (2018). Given this, continued psychometric testing of the sMARS in diverse populations is essential. Such work can help identify core items and structural features that remain stable across

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samples, ultimately supporting the refinement of the scale and enabling valid cross-population comparisons.

In response, the current study aims to (a) develop a Chinese version of the sMARS; and (b) examine its psychometric properties, including structural validity, construct validity, criterion validity, internal reliability (Cronbach's alpha), and test-retest reliability. We focused specifically on Chinese high school students, as there is growing evidence that math anxiety is prevalent in this population (Xiong, 2008; Peng et al., 2010). For example, Li and Tian (2014) surveyed 430 Chinese high school students and found a moderate negative correlation ($r = -.31$) between students' anxiety levels and their math grades. Similarly, Chen (2021) reported a correlation of $r = -.35$ among female high school students in China. Although several measures for assessing math anxiety among Chinese students exist (Li & Tian, 2014; Zhang & Zhu, 2011), a Chinese version of the sMARS remains valuable due to the scale's well-established conceptual framework and strong psychometric support. A translated version can further facilitate cross-cultural research (Ersozlu et al., 2022), enhance understanding of math anxiety, and promote more accurate applications of the sMARS. A translated version can facilitate cross-cultural research, enhance understanding of math anxiety, and promote more accurate application of the sMARS.

To assess construct validity, we used the *Mathematics Anxiety Scale* (MAS; Betz, 1978). Zhang and Zhu (2011) translated and validated a Chinese version of MAS, which was employed in the current study. For criterion validity, we included a measure of mindfulness. Mindfulness attends to one's ability to focus on the present moment without judgments (Brown & Ryan, 2003). Prior research has shown a negative correlation between mindfulness and math anxiety (David et al., 2022), and the effectiveness of mindfulness practices in reducing math or text anxiety (Brunyé et al., 2013; Bellinger et al., 2015; Samuel & Warner, 2019). For test-retest reliability, past studies have supported strong 2-week($r = .86$; Alexander & Martray, 1989), and 7-week ($r = .72$; Núñez-Peña et al., 2013). To extend this line of research, we examined test-retest reliability over a longer interval of 3 months across all subscales.

Methods

Participants and Procedures

Participants were recruited at two time points in 2020 – April (Time 1 [T1]) and July (Time 2 [T2]). At T1, the sample consisted of 696 students aged 10-18 years old (345 males and 351 females; M_{Age}=13.41; SD_{Age}=1.45). At T2, 329 students participated, also aged 10-18 years old (167 males and 162 females; M_{Age}=13.38; SD_{Age}=1.54). The smaller sample size at T2 might be partially attributed to the timing of data collection, which occurred near the end-of-semester examination period. During this time, the academic focus of teachers, parents, and students was typically directed toward exam preparation, potentially reducing their availability and willingness to participate in research activities. In contrast, T1 data collection took place earlier in the semester, a period generally associated with greater engagement in school-related activities, including research participation.

After matching the two datasets by ID, a subsample of 162 students who completed the survey at both time points was identified (77 males and 85 females; M_{Age}=13.33; SD_{Age}=1.56). A total of 534 students completed the survey only at Time 1 (T1), while 167 students completed it only at Time 2 (T2). Although the primary factors contributing to the attrition between the two time points remained unclear, possible explanations included the timing of survey administration and errors in ID entry, which hindered accurate matching across datasets. This attrition should be taken into account when interpreting the findings of scale reliability.

The study was approved by the Institutional Review Board (IRB) at a public university in the southeastern United States, with additional approvals obtained from two high schools in China. The lead researcher contacted the head teachers, who then distributed study information to parents via an official online platform regularly used for parent–teacher communication. Parents were instructed to click the study link if their children were interested in participating. Upon clicking the link, parents were asked whether their children were over 18 years old. If so, students completed the consent form themselves. Otherwise, parents reviewed and signed the online consent form, followed by student assent. Students then proceeded to complete the survey. Participation was voluntary and uncompensated. The survey was distributed in April 2020 and again in July 2020, remaining active for approximately one month each time. This study was not preregistered, and data and study materials are not publicly available.

Measurements

Short Math Anxiety Rating Scale (sMARS)

Developed from the MARS (Richardson & Suinn, 1972), the sMARS (Alexander & Martray, 1989) consists of 25 items and three factors: Mathematics Test Anxiety, Numerical Task Anxiety, and Mathematics Course Anxiety. Each item is rated using a 5-point rating scale from 1 (no anxiety) to 5 (high anxiety), and its psychometric properties were introduced earlier in the paper.

Mathematics Anxiety Scale (MAS)

Based on Betz's MAS (1978), Zhang and Zhu (2011) translated the English version of MAS into Chinese. The Chinese MAS, similar to the original MAS, consists of 10 items using a 10-point rating scale from 1 (completely disagree) to 10 (completely agree). Five items are positively worded (e.g., "I have usually been at ease during math tests") and thus reversely coded. A higher score indicates more anxiety toward mathematics. The Chinese MAS had a Cronbach α of .89. Its split-half reliability was .65. In the current study, Cronbach α was .87 in the sample from T1 and .64 from T2.

Five Facet Mindfulness Questionnaire (FFMQ-15)

The present study used the 15-item FFMQ (Baer et al., 2012) to test criterion validity. Each item on the FFMQ-15 was rated on a 5-point rating scale from 1 (never or very rarely true) to 5 (very often or always true). The original study reported internal consistency (Cronbach α) ranging from .80 to .85 (Baer et al., 2012). Gu et al. (2016) found that the factor structure and the convergent validity of the FFMQ-15 were consistent with the full-length edition, and the FFMQ-15 was sensitive to Mindfulness-Based Cognitive Therapy. Meng et al. (2020) translated the FFMQ-15 into Chinese and reported Cronbach α to be .73 and .85 in two separate samples. The FFMQ-15 was negatively correlated with depression and anxiety measures. In the current study, Cronbach α was .73 at T1 and .78 at T2.

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Translation Process

In developing the Chinese version of the sMARS, we followed the forward-backward translation process recommended by the World Health Organization (n.d.). During the forward translation stage, the sMARS was independently translated into Chinese by the third author and an English teacher from China, both fluent in Chinese and English. The goal of the translation was to ensure conceptual and cultural equivalence, rather than linguistic equivalence. The translators and the leading author reviewed and discussed both translated versions in comparison with the original scale to reach a preliminary consensus on the Chinese version of the sMARS.

One major discrepancy identified involved items written in the passive voice in the original version. In Chinese culture, active voice is generally preferred, which was reflected in the translation. For example, item #18 "Being given a set of subtraction problems to solve" was translated as "需要完成一系列减法数学题" ("Need to solve a set of subtraction problems").

During the backward-translation stage, the second author, who in bilingual, translated the Chinese version back to English, paying particular attention to items that were originally in passive voice. As in the forward translation, the focus was on achieving conceptual and cultural equivalence. This back-translated version was then compared to the original English version to identify any discrepancies or concerns. No specific issues were found, and a consensus was reached on the final version of a Chinese sMARS (CH-sMARS) used in this study.

Statistical Analysis

A CFA was conducted on the sample from T1 through AMOS_23. Prior to the analysis, the dataset was screened for multivariate outliers by checking the Mahalanobis distances and corresponding *p*-values of all items in the sMARS. Tabachnick and Fidell (2007) suggested that any *p*-value less than .001 indicates an outlier. A total of 48 outliers were identified and removed, resulting in a final dataset of n = 648. We then tested the dataset against the assumption of multivariate normality (MVN) using Mardia's (1970) MVN test. As the results did not support MVN, we employed the Bollen-Stine bootstrap approach (Bollen & Stine, 1993) to obtain the *p*-value of the model chi-square (χ_M^2). Additionally, we examined the model fit indices of χ_M^2/df (degrees of freedom), root mean square error of approximation (RMSEA), Bentler comparative fit index (CFI), and standardized root mean square residual (SRMR).

χ_M^2 is often overestimated when (a) the assumption of MVN is not supported (Curran et al., 1996); or (b) the sample size is large (Bergh, 2015). To reduce the influence of overestimation, we examined the statistic of χ_M^2/df, which implies a reasonable model-data fit when its value is less than 5.00 (Marsh & Hocevar, 1985). RMSEA reflects a scaled difference between model covariance matrix and observed covariance matrix. As RMSEA approaches zero, the fit between the model and the data improves. MacCallum et al. (1996) suggested RMSEA = .08 as a threshold for mediocre fit. CFI measures the fit of a model relative to a baseline model that assumes zero covariances among observed variables. A CFI value of .95 or higher indicates a good model-data fit (Markus, 2012). Lastly, SRMR reflects the mean absolute correlation residual between the observed and the model-implied correlations among all observed variables; a value of .08 or less supports a good model-data fit (Kline, 2011).

Using CFA, we tested Alexander and Martray's (1989) 3-factor, 25-item model; Moreno-García et al.'s (2018) 4-factor, 25-item model; and Baloğlu and Zelhart's (2007) 3-factor, 20-item model. When models were not confirmed, an EFA (in SPSS_22) was conducted to re-explore the factor structure of the sMARS. Specifically, the results of Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were checked firstly to examine the necessity of processing EFA, which requires KMO to be at or above 7.0 (Kaiser, 1974) and Bartlett's test to yield a significant result ($p \leq .05$) (Dziuban & Shirkey 1974). When EFA was appropriate, we employed principal axis factoring (PAF; assuming latent factors) with a Promax rotation (allowing factors to be correlated) to extract factors. To determine the number of retained factors, we followed Kaiser's Rule of eigenvalue > 1.0 and conducted a visual inspection of the scree plot (Gorsuch, 1997; Pett et al., 2003). We then reran the EFA with the retained factors to examine the item-loading pattern. Velicer and Fava (1998) found that item loadings of .60 and higher typically yielded good sample-to-population pattern fit. Thus, an item was considered to load on a factor if its loading was at or above .60 and exceeded its loadings on other factors by at least .10 (Kline, 2011). Moreover, following Kline (2011), we required that each item loads on only one factor and that each factor includes at least three items.

Based on the model(s) retained after EFA, a CFA was performed for cross-validation using the T2 sample. Similarly, outliers ($n = 21$) were removed by inspecting Mahalanobis distances, and MVN was assessed via Mardia's test. We used the same model fit statistics as in the T1 sample – χ^2_M (with Bollen-Stine bootstrapped p-value if MVN was not supported), χ^2_M/df, RMSEA, CFI, and SRMR. We also examined the modification index (MI) to guide model revision. This index reflects the expected decrease in the χ^2_M value when a new link is added between two previously unassociated observed/latent variables (Kline, 2011). Finally, the model fit statistics were reexamined and reported based on the revised model.

For the final retained model, we assessed Cronbach's alphas and 3-month test-retest reliabilities for the subscales and total scale in both samples. We also examined Pearson bivariate correlations between the revised sMARS and the MAS in both samples to test the construct validity. Finally, we report the Pearson bivariate correlations between the revised sMARS and the FFMQ-15 in both samples to assess criterion validity.

Results

Table 1 displays the results of CFA based on model structures specified by Alexander and Martray (1989), Baloğlu and Zelhart (2007), and Moreno-García et al. (2018). None of the indexes supported the model-date fit. Turning to EFA, the result of KMO was .95, and Bartlett's test yielded $p < .001$. Both results supported the appropriateness of conducting EFA. The results of EFA yielded three factors with eigenvalues larger than one (i.e., 11.60, 3.36, and 1.05) and accounting for 64% of the total variance among items. In comparison, a visual inspection of the Scree plot supported a 2-factor model (i.e., two dots appeared before the line flattened out; see Figure 1). Based on the results, both 2- and 3-factor models were retained for further tests. Table 2 disclosed item-loading patterns for both 2- and 3-factor models after rerunning EFA. In a 2-factor model, items 1, 4, 7, 8, 9, 12, and 15 loaded on Factor I, while items 16, 17, 18, 19, 20, 21, 22, 23, 24, and 25 loaded on Factor II. The correlation between factors was .56. In a 3-factor model, items 1, 4, 7, 8, 9, 12, and 15 were loaded on Factor I, items 17, 18, 19, and 20 were on Factor II, and items 21, 22, 23, 24, and 25 were on Factor III. The correlations among factors ranged from .44 to .75.

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Table 1

CFA Results of the CH-sMARS Based on Previous Models

Model	χ^2_M	*df*	*p**	χ^2_M/df	RMSEA	CFI	SRMR
3-Factor-25-Item[a]	1854.80	272	.005	6.82	.10	.88	.08
3-Factor-20-Item[b]	1129.31	167	.005	6.76	.09	.91	.08
4-Factor-25-Item[c]	2637.09	269	.005	9.80	.12	.82	.11

Note. *Bollen-Stine *p*-value. [a]Alexander & Martray (1989). [b]Baloğlu & Zelhart (2007). [c]Moreno-García et al. (2018).

Figure 1

Scree Plot of the CH-sMARS

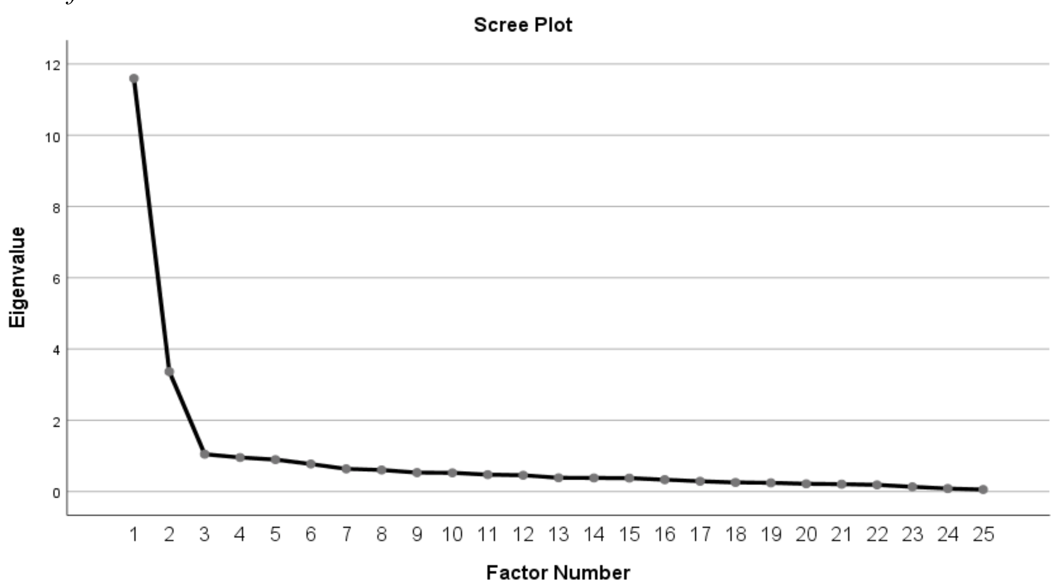


Table 2

EFA Results of the CH-sMARS

Items	2-Factor		3-Factor		
	1	2	1	2	3
1. 为一次数学测试进行复习 [Studying for a math test]	**.686**	.073	**.672**	.016	.077
2. 参加高考的数学科目考试 [Taking math section of college entrance exam]	.558	-.255	.570	-.098	-.176
3. 参加数学课上的一次小考 [Taking an exam (quiz) in a math course]	.561	.284	.514	.031	.306
4. 参加数学课期末考试 [Taking an exam (final) in a math course]	**.779**	-.006	**.754**	-.059	.075
5. 拿起数学课本开始写家庭作业 [Picking up math textbook to begin working on homework assignment]	.303	.473	.216	.015	.548
6. 下次数学课要交的作业里有很多难题 [Being given homework assignments of many difficult problems that are due the next class meeting]	.548	.067	.516	-.048	.145
7. 想到一周之后的数学测验 [Thinking about an upcoming math test 1 week before]	**.765**	.056	**.746**	-.007	.086
8. 想到一天之后的数学测验 [Thinking about an upcoming math test 1 day before]	**.922**	-.112	**.940**	.002	-.123
9. 想到一小时之后的数学测验 [Thinking about an upcoming math test 1 hour before]	**.917**	-.187	**.942**	-.021	-.185
10. 意识到你必须要上一定数量的数学课以达到学业要求 [Realizing you have to take a certain number of math classes to fulfill requirements]	.503	.237	.493	.113	.150
11. 拿起数学书开始预习一节老师布置的很难的章节 [Picking up math textbook to begin a difficult reading assignment]	.358	.405	.340	.182	.264
12. 收到数学课期末成绩单 [Receiving your final math grade in the mail]	**.694**	-.104	**.713**	.010	-.126
13. 翻开数学或统计书并看到一整页的问题 [Opening a math or stat book and seeing a page full of problems]	.446	.248	.427	.093	.187
14. 开始为一次数学测验复习 [Getting ready to study for a math test]	.581	.298	.553	.102	.238
15. 数学课上，老师宣布“突击”测验 [Being given a “pop” quiz in a math class]	**.736**	.008	**.729**	.002	.019
16. 买完东西之后阅读收银条 [Reading a cash register receipt after your purchase]	-.133	**.719**	-.143	.372	.398
17. 需要完成一系列加法数学题，要求用纸笔计算 [Being given a set of numerical problems involving addition to solve on paper]	-.068	**.865**	.035	**.831**	.034
18. 需要完成一系列减法数学题 [Being given a set of subtraction problems to solve]	-.151	**.966**	-.031	**.973**	-.006
19. 需要完成一系列乘法数学题 [Being given a set of multiplication problems to solve]	-.122	**.975**	-.009	**.946**	.034
20. 需要完成一系列除法数学题 [Being given a set of division problems to solve]	-.120	**.941**	.001	**.958**	-.018
21. 买一本数学教科书 [Buying a math textbook]	-.063	**.819**	-.146	.228	**.699**
22. 看着老师在黑板上计算代数等式 [Watching a teacher work on an algebraic equation on the blackboard]	.145	**.686**	.014	.020	**.801**
23. 报一门数学课 [Signing up for a math course]	.101	**.707**	-.065	-.058	**.927**

24. 听另一个学生解释一个数学公式 [Listening to another student explain a math formula]	.029	**.790**	-.096	.101	**.826**
25. 走进数学课的教室 [Walking into a math class]	.155	**.626**	.037	.018	**.730**

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Promax with Kaiser Normalization. Rotation converged in 6 iterations.

Given the retained models, the corresponding CFA results are presented in Table 3. In a 2-factor model, no statistics supported the model-data fit. In a 3-factor model, two statistics supported the model-data fit (χ^2_M/df = 3.66, and SRMR = .05), and others did not (χ^2_M = 370.03 [df = 101, Bollen-Stine p = .005], RMSEA = .09, CFI = .94). An analysis of MI of the 3-factor model produced 23 pairs of error variances that could be statistically associated to improve mode-data fit. Among them, one (e4 and e5 in Figure 2) with the highest MI value (54.10) drew our specific attention. They corresponded to item 8 ("想到一天之后的数学测验" i.e., "Thinking about an upcoming math test 1 day before") and item 9 ("想到一小时之后的数学测验" i.e., "Thinking about an upcoming math test 1 hour before"). At a surface level, this error correlation might at least account for the similarity of sentence structure and content; both refer to a short passage of time before an upcoming math test. After correlating the items, the results of CFA further supported the model-data fit (see Table 3).

Thus far, we obtained a confirmed Chinese version of the sMARS (CH-sMARS), entailing three factors with one correlated error variance. The factors were named the same as in the original sMARS – Mathematics Test Anxiety (Factor I), Numerical Task Anxiety (Factor II), and Mathematics Course Anxiety (Factor III). A comparison of items included in different versions of the sMARS was disclosed in Table 4.

Table 3

CFA Results of 2- and 3-Factor Models, and a Revised 3-Factor Model

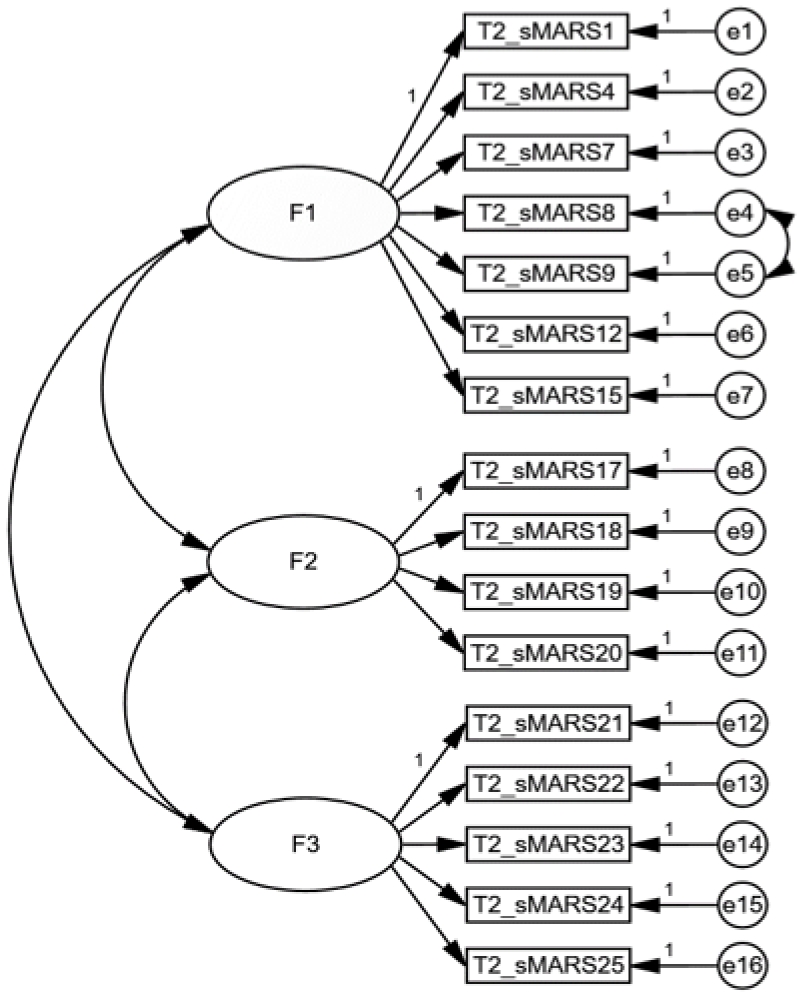
Model	χ^2_M	*df*	*p**	χ^2_M/df	RMSEA	CFI	SRMR
2-Factor-17-Item	857.87	118	.005	7.27	.14	.85	.09
3-Factor-16-Item	370.03	101	.005	3.66	.09	.94	.05
3-Factor-16-Item** (Revised)	304.61	100	.005	3.05	.08	.96	.04

Note. *Bollen-Stine p-value

**In the revised CH-sMARS, the error variances of item 8 ("想到一天之后的数学测验" i.e., "Thinking about an upcoming math test 1 day before") and item 9 ("想到一小时之后的数学测验" i.e., "Thinking about an upcoming math test 1 hour before") were correlated.

Figure 2

Factor Structure of the Retained 3-Factor-16-Item of the CH-sMARS



Note. F1 = Mathematics Test Anxiety; F2 = Numerical Task Anxiety; F3 = Mathematics Course Anxiety. T2_sMARS1 represented item #1 in the sMARS based on the sample from Time 2 (T2). “e” represented error variance.

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Table 4

A Comparison of Items Included in Different Versions of the sMARS

Items	CH-sMARS	A & M[a]	B & Z[b]	MG[c]
1. Studying for a math test	MTA	MTA	MTA	APM
2. Taking math section of college entrance exam	–	MTA	MTA	AMC
3. Taking an exam (quiz) in a math course	–	MTA	MTA	AMC
4. Taking an exam (final) in a math course	MTA	MTA	MTA	AMC
5. Picking up math textbook to begin working on homework assignment	–	MTA	–	AMB
6. Being given homework assignments of many difficult problems that are due the next class meeting	–	MTA	–	AMB
7. Thinking about an upcoming math test 1 week before	MTA	MTA	MTA	APM
8. Thinking about an upcoming math test 1 day before	MTA	MTA	MTA	APM
9. Thinking about an upcoming math test 1 hour before	MTA	MTA	MTA	APM
10. Realizing you have to take a certain number of math classes to fulfill requirements	–	MTA	MTA	APM
11. Picking up math textbook to begin a difficult reading assignment	–	MTA	–	AMB
12. Receiving your final math grade in the mail	MTA	MTA	MTA	AMC
13. Opening a math or stat book and seeing a page full of problems	–	MTA	–	AMB
14. Getting ready to study for a math test	–	MTA	–	APM
15. Being given a "pop" quiz in a math class	MTA	MTA	MTA	APM
16. Reading a cash register receipt after your purchase	–	NTA	NTA	ASM
17. Being given a set of numerical problems involving addition to solve on paper	NTA	NTA	NTA	ASM
18. Being given a set of subtraction problems to solve	NTA	NTA	NTA	ASM
19. Being given a set of multiplication problems to solve	NTA	NTA	NTA	ASM
20. Being given a set of division problems to solve	NTA	NTA	NTA	ASM
21. Buying a math textbook	MCA	MCA	MCA	AMB
22. Watching a teacher work on an algebraic equation on the blackboard	MCA	MCA	MCA	ASM
23. Signing up for a math course	MCA	MCA	MCA	AMB
24. Listening to another student explain a math formula	MCA	MCA	MCA	ASM
25. Walking into a math class	MCA	MCA	MCA	APM

Note. MTA = Mathematics Test Anxiety; NTA = Numerical Task Anxiety; MCA = Mathematics Course Anxiety; APM = Anxiety when preparing for a Mathematics test; AMC = Anxiety when presenting an exam in a Mathematics course; AMB = Anxiety towards Mathematics Books; ASM = Anxiety when solving math problems.
Items noted as "–" were deleted ones.
[a]Alexander & Martray (1989).
[b]Baloğlu & Zelhart (2007).
[c]Moreno-García et al. (2018).

Reliability and Validity Tests

Based on the CH-sMARS, the results showed that in the sample from T1 ($n = 648$), internal reliabilities (Cronbach α) were .93, .91, .97, and .91 for the total scale and Factor I through III, respectively. In the sample from T2 ($n = 308$), the corresponding internal reliabilities (Cronbach α) were .95, .89, .97, and .93. Overall, the CH-sMARS disclosed good internal consistency among items. The 3-month test-retest reliabilities were .37 ($p < .001$), .44 ($p < .001$), .33 ($p < .001$), and .36 ($p < .001$) over the total scale and Factor I through III, respectively. The CH-sMARS and its subscales demonstrated moderate degrees of consistency over a time passage of 3 months.

Turning to validity tests, the findings revealed similar correlation patterns between scores on the CH-sMARS and the MAS in both samples. As a whole scale, the CH-sMARS and the MAS had a correlation of .46 (T1) and .49 (T2). The Mathematics Test Anxiety subscale and the MAS had a correlation of .50 (T1) and .52 (T2). The Numerical Task Anxiety subscale and the MAS had a correlation of .27 (T1) and .30 (T2). The Mathematics Learning Anxiety subscale and the MAS had a correlation of .33 (T1) and .42 (T2). The above results supported the construct validity of CH-sMARS.

Finally, as a whole scale, the CH-sMARS and the FFMQ-15 had a correlation of -.15 (T1) and -.24 (T2). The Mathematics Test Anxiety subscale and the FFMQ-15 had a correlation of -.14 (T1) and -.20 (T2). The Numerical Task Anxiety subscale and the FFMQ-15 had a correlation of -.11 (T1) and -.21 (T2). The Mathematics Learning Anxiety subscale and the FFMQ-15 had a correlation of -.12 (T1) and -.22 (T2). Those results were all statistically significant ($p < 0.005$) and presented small correlations that illuminate a negative relationship between math anxiety and mindfulness of participants (criterion validity).

Discussion

The present study examined the factor structure and psychometric properties of a Chinese version of the sMARS (CH-sMARS). We identified a 16-item, 3-factor scale that demonstrated adequate construct validity (with the MAS), criterion validity (with the FFMQ-15), good internal reliability, and varied 3-month test-retest reliabilities of the total scale and subscales.

The scale structure aligned with Alexander and Martray's (1989) original finding and several subsequent analyses (Baloğlu & Zelhart, 2007; Bowd & Brady, 2002; Núñez-Peña et al., 2013). Overall, the CH-sMARS confirmed a three-factor model of math anxiety, i.e., anxiety toward math tests, math numerical tasks, and math courses. However, the factors extracted from the current study were more robust than those in the previous ones as we employed a factor extraction method that assumed a latent factor structure (e.g., Baloğlu & Zelhart, 2007; Bowd & Brady, 2002; Harrington, 2019; Wolkman et al., 2024).

While the 3-factor structure was retained, items in the CH-sMARS's "*Mathematics Test Anxiety*" subscale primarily targeted math exams and in-class tests. In contrast, previous versions (see Table 4) included a broader range of scenarios, such as applying math in daily life (e.g., "Reading a cash register receipt after your purchase") or doing math-related homework (e.g., "Picking up math textbook to begin a difficult reading assignment"). This emphasis on math examinations in the CH-sMARS aligns with the principles of exam-oriented education – a defining characteristic of China's educational tradition. According to Meng et al. (2021), exam-oriented education positions good performance in examinations as the central goal of education. In contrast, quality-oriented education values both outcomes and learning processes, fostering cognitive and non-cognitive development such as creativity and problem-solving skills (Meng et al., 2021).

While quality-oriented education is gaining traction in China, the exam-focused model still holds considerable influence, especially given that the Gaokao – the National College Entrance Examination – serves as the primary gateway to higher education. The current focus of the "*Mathematics Test Anxiety*" subscale on examination-related scenarios reflects this educational reality. As such, this subscale may be particularly valuable for identifying test anxiety in Chinese students when the primary objective is to enhance math exam performance.

Moreover, the findings supported the construct validity of the CH-sMARS, showing moderate to high positive correlations with the MAS in both samples. Specifically, the *Mathematics Test Anxiety* subscale had the highest association with the MAS, followed by the *Mathematics Course Anxiety* subscale; the *Numerical Task Anxiety* subscale showed the weakest but still moderate association. Those findings were expected as items in the MAS explicitly attended to math tests and learning, but not on numerical tasks.

Regarding criterion validity, the CH-sMARS and its subscales showed small but statistically significant negative associations with a mindfulness measure, indicating that higher levels of mindfulness were associated with lower levels of math anxiety. This finding aligned with prior correlational and intervention studies linking mindfulness to reduced math or test anxiety (Bellinger et al., 2015; Brunyé et al., 2013; David et al., 2022; Samuel & Warner, 2019).

As for reliability tests, the CH-sMARS showed strong internal consistency, with Cronbach's αs values ranging from .89 to .97 across samples. Those values indicate that the items reliably measured dimensions of math anxiety among high school students. Additionally, while previous research reported high test-retest reliabilities of the sMARS over short intervals (2 weeks: Alexander & Martray, 1989; and 7 weeks: Núñez-Peña et al., 2013), the current study extended this to 3 months and still found moderate correlation across subscales of the CH-sMARS. Those findings suggested that math anxiety remained relatively stable in the absence of targeted interventions.

Traditional teaching methods – such as direct instruction and drill-based practice – have been widely adopted in Chinese education and are known contributors to math anxiety (Irmayanti et al., 2025; Norwood, 1994). To mitigate math anxiety among Chinese students (especially high schoolers), alternative approaches (e.g., storytelling, Irmayanti et al., 2025) should be further developed and explored.

Several of these findings underscored the importance of examining how math anxiety manifested across cultural contexts. Comparing our results with studies using other versions of sMARS across different cultures can help clarify how math anxiety is shaped by cultural influences. This, in turn, can guide the development of more culturally sensitive interventions. The CH-sMARS provided a valuable tool for advancing this line of research and tailoring support strategies to better align with local educational values and needs.

Implication

The current study supports the psychometric soundness of the CH-sMARS, suggesting that Chinese high school teachers can use this brief 16-item scale to assess students' math anxiety from a multidimensional perspective. The inclusion of three distinct subscales allows for a more targeted approach in identifying and addressing specific areas of concern for intervention. Notably, all 16 items in the CH-sMARS are included in prior validated versions of the sMARS (Alexander & Martray, 1989; Baloğlu & Zelhart, 2007; Moreno-García et al., 2018; see Table 4). This overlap underscores the importance of further cross-validation of the CH-sMARS, with the potential to establish a culturally invariant measure of math anxiety. A universally applicable tool would be particularly valuable for enabling cross-cultural comparisons and enhancing our understanding of math anxiety in diverse populations. Additionally, validating this 16-item scale across different educational levels – elementary, middle school, and college – in China would support its application in longitudinal research, allowing for the examination of math anxiety of Chinese students across key developmental stages throughout the educational lifespan.

In addition to testing the current 16-item version, the present study identified paired error variances between item 8 and item 9. These items not only attend to math anxiety regarding test (a core aspect of the construct) but also underlies a short time-passage of an upcoming math test (not a core aspect of the construct). To diminish such influence, we suggest creating a new item "想起即将到来的数学测试" (i.e., Thinking about an upcoming math test) to replace the two. Researchers may further test this revision in their cross-validations.

Future research also needs to explore the sensitivity of the CH-sMARS – namely, how effectively the scale detects changes in math anxiety over time. Mixed-method approaches using biological and qualitative data can shed light on this issue. For example, combining empirically supported interventions (e.g., mindfulness practice; Samuel & Warner, 2019) with qualitative interviews and physiological measures (e.g., skin conductance response; Levy & Rubinsten, 2021) would help triangulate (i.e., cross-validate) the findings obtained from the CH-sMARS.

Lastly, but importantly, research should continue to explore factors and interventions that influence anxiety related to math tests, numerical tasks, and/or math course. Although the three facets are correlated with each other, they reflect distinct features of math anxiety. This line of inquiry could inform more tailored strategies for reducing students' math anxiety.

Beyond research, educators and policymakers in China should implement targeted policies to monitor and address students' math anxiety, including that of high schoolers. One effective strategy is the routine administration of surveys (e.g., once or twice per semester) to assess students' anxiety related to math learning and testing. Linna et al. (2024) found that Chinese students reported higher learning-related math anxiety than test-related anxiety. Further, Ho et al. (2000) distinguished between affective and cognitive math anxiety, where affective anxiety refers to negative emotions toward math, and cognitive anxiety involves worries and mental burden. Their findings suggested that Chinese students experience lower affective but higher cognitive math anxiety than their U.S. counterparts. Therefore, assessments should capture various dimensions of math anxiety. Lastly, these surveys should examine related outcomes, such as math performance and student well-being (Zhang et al., 2019), as these factors are critical for designing effective interventions.

To mitigate math anxiety, school administrators and teachers should begin by raising students' awareness of its manifestations and consequences. Awareness campaigns through educational flyers, pamphlets, and workshops can serve as initial steps in addressing this issue. Follow-up efforts may include targeted interventions, such as mindfulness exercises and peer-led or counselor-facilitated support groups, to help students manage their anxiety. Furthermore, parental involvement is crucial in fostering a supportive math-learning environment at home. Providing parents with resources and strategies to encourage positive attitudes toward math can play a vital role in alleviating students' anxiety, particularly in high school settings.

Limitation

While the current study has important implications, several limitations are noted. First, the sample is from only one high school in one geographic area of China, which limits the generalizability of the findings. Next, due to participant attrition across the two survey time points, findings of scale reliability may have been over- or under-estimated, as the underlying reasons for attrition remain unknown. Finally, the self-report nature of the scale can limit its validity, such as the influence of social desirability.

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Declarations of interest

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