Psicothema (2023) 35(4) 406-413

Psicothema

https://www.psicothema.com/es • ISSN 0214–9915

GRUPO EDITORIAL DE PSICOFUNDACIÓN

Colegio Oficial de Psicólogos del Principado de Asturias

Article

Development and Validation of the Brief Math Anxiety Scale (BMAS) in University Students

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ARTICLE INFO

Received: October 20, 2022
Accepted: February 06, 2023

Keywords:
Brief Math Anxiety Scale
Short Math Anxiety Rating Scale
Item response theory
Validity
Reliability

ABSTRACT

Background: This study developed the Brief Math Anxiety Scale (BMAS), a brief version of the Shortened Math Anxiety Rating Scale (sMARS), maintaining its original three-factor structure, by applying item response theory. **Method:** The sMARS was administered to 1,349 undergraduates, along with other questionnaires to measure their math ability, trait and test anxieties, and attitudes toward mathematics. **Results:** Results showed that the original scale could be reduced to nine items (three for each subscale). We provided evidence of good psychometric properties: strong internal consistency, adequate 7-week test-retest reliability, and good convergent/discriminant validity. **Conclusions:** In conclusion, the BMAS provides valid interpretations and reliable scores for assessing math anxiety in university students, and is especially useful in situations with time constraints where the longer form is impractical.

Desarrollo y Validación de la Brief Math Anxiety Scale (BMAS) en Estudiantes Universitarios

RESUMEN

Antecedentes: En este estudio se presenta el desarrollo de la *Brief Math Anxiety Scale* (BMAS), una versión breve de la *Shortened Math Anxiety Rating Scale (sMARS)* manteniendo su estructura original de tres factores, aplicando la teoría de respuesta al ítem. **Método:** La sMARS, así como otros cuestionarios para medir su capacidad matemática, la ansiedad rasgo y frente a los exámenes y las actitudes hacia las matemáticas, se administraron a 1.349 estudiantes universitarios. **Resultados:** Los resultados mostraron que la escala original podía reducirse a nueve ítems (tres para cada subescala). Proporcionamos evidencia de sus buenas propiedades psicométricas: consistencia interna excelente, adecuada fiabilidad test-retest a las 7 semanas y buena validez convergente/discriminante. **Conclusiones:** En conclusión, la BMAS proporciona interpretaciones válidas y puntuaciones fiables para evaluar la ansiedad matemática en estudiantes universitarios y es especialmente útil en situaciones con disponibilidad de tiempo limitado, donde la forma más larga no es aplicable.

Palabras clave:
Brief Math Anxiety Scale
Short Math Anxiety Rating Scale
Teoría de respuesta al ítem
Validez
Fiabilidad

Cite as: Núñez-Peña, M. I., & Guilera, G. (2023). Development and validation of the Brief Math Anxiety Scale (BMAS) in university students. *Psicothema, 35*(4), 406-413. https://doi.org/10.7334/psicothema2022.434
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In 1972, Richardson and Suinn defined math anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). Since then, the study of math anxiety has aroused great interest among researchers and educators, mainly due to its negative impact on performance in mathematics and to the need for people in modern societies to be well-trained in this area (for a review, see Suárez-Pellicioni et al., 2016). Moreover, it is a phenomenon that is highly prevalent in the population (Ramirez et al., 2018). Given that the first step to study math anxiety is to measure it, great effort has been devoted to develop instruments to obtain valid interpretations and reliable scores of this construct.

The 98-item Math Anxiety Rating Scale (MARS; Richardson & Suinn, 1972) was the pioneering work to measure math anxiety. In this instrument, respondents are asked to rate on a scale of 1 to 5 how anxious they would feel in different situations involving the use of math (e.g., walking into a math class). However, the MARS was time consuming, so many scales were developed to measure math anxiety with the aim of providing instruments quicker to administer. Among them, the most frequently employed in recent years are the *Shortened Math Anxiety Rating Scale* (sMARS; Alexander & Martray, 1989) and the *Abbreviated Math Anxiety Scale* (AMAS; Hopko et al., 2003), both developed for undergraduate students from the initial MARS and adapted into many languages. The sMARS is a 25-item scale that measures three anxiety dimensions: *math test anxiety* (i.e., anxiety about taking a mathematics test), *numerical task anxiety* (i.e., anxiety in informal, everyday situations) and *math course anxiety* (i.e., anxiety during mathematical classes). It has shown good psychometric properties both in its original English version (e.g., its two-week test-retest reliability is .86) and in its adaptation to other languages. The one drawback of the sMARS, however, is that it includes 25 items, so it is not a good option when the time for completing the questionnaire is limited, for example, in research or educational contexts where a large amount of people has to be assessed and the sMARS is not administered in isolation but as part of a battery including several tests. This drawback is overcome by the AMAS, a 9-item questionnaire that can be administered in less than 5 minutes. It has also good psychometric properties (e.g., a two-week test-retest reliability of .85 in its original version), but it has the limitation that it only includes two of the subscales of the sMARS; namely, *learning math anxiety*, related with the process of learning mathematics, and *math evaluation anxiety*, related with mathematics in testing situations. These two subscales measure math anxiety in formal math settings, so a math anxiety relevant aspect, which is anxiety outside the math academic context, is not covered by the AMAS. Notice that Richardson and Suinn (1972) included this aspect in their math anxiety definition (see above), which is used as reference in many math anxiety studies (e.g., Tomasetto et al., 2020), and that math anxiety can be experienced in everyday settings, for example, when reading a cash register receipt after a purchase or when totaling up a dinner bill that you think overcharged you (e.g., Ashcraft & Moore, 2009). Moreover, the negative impact of math anxiety is not only found in academic tasks but also in other daily life tasks as drug calculations for nursery staff (McMullan et al., 2012), medical risks interpretation (Rolison et al., 2016, 2020) or making financial decisions (McKenna & Nickols, 1988).

In light of the above, the objective of this study was twofold. Firstly, to generate a brief version of the sMARS with its three-factor structure using Item Response Theory (IRT). The IRT comprises a framework that allows a deep and rich analysis of the performance of each item of a measurement instrument (e.g., its contribution to test reliability) and, consequently, offers an excellent analytical approach for the optimal development of short versions of an instrument (Edelen & Reeve, 2007). We will refer to this new reduced questionnaire as *Brief Math Anxiety Scale* (BMAS). Our second aim was to evaluate the performance of the BMAS scores in terms of dimensionality, internal consistency, temporal stability, and relationship with other variables. We also introduce BMAS percentile scores so that educators and researchers interested in studying this type of emotion in samples similar to that of the present study can identify individuals high in math anxiety.

To this end, in the present study, we administered to a large sample of university students (n = 1,349) the sMARS, as well as other questionnaires to measure their math ability, trait and test anxieties, and attitudes toward mathematics, which allowed us to provide evidence for the validity of the interpretation of the BMAS scores. Finally, since the BMAS measures trait math anxiety, the temporal stability of the scores of this scale was assessed by administering it to a subsample twice, separated by seven weeks.

We had several predictions concerning the relationships we expected to find between BMAS's scores and the scores of the other variables we measured (e.g., psychological constructs). First, we predicted BMAS scores to be negatively related to math ability scores. In two recent meta-analyses, Zhang et al. (2019) and Barroso et al. (2021) reported significant negative correlations between math anxiety and math performance of –.32 and –.28 respectively. Other meta-analysis reported similar correlations (e.g., Hembree, 1990; Namkung et al., 2019, in school-aged students). We used the Addition Test from the French kit (French et al., 1963) to measure math ability for two reasons: firstly, because math anxiety is expected to affect negatively to a higher degree to complex arithmetic that requires the uses of procedures of calculation (Faust et al., 1996) and, secondly, because in this test participants have to calculate the result of a series of additions including three one- or two-digit numbers, so the use of procedures is needed to solve them. Second, moderate positive associations were expected between the BMAS scores and trait and test anxiety scores. In the Hembree's meta-analysis (Hembree, 1990), the mean correlation between math anxiety and trait anxiety scores was .38, and it was .52 between math anxiety and test anxiety scores. Because these correlations are moderate, math anxiety is usually taken as a different construct of trait and test anxiety (Suárez-Pellicioni et al., 2016). Third, we expected a strong negative correlation between the BMAS scores and the degree of students' enjoyment, motivation, and self-confidence in mathematics, as these negative relationships are usually reported. In Hembree's meta-analysis, these correlations were –.47, –.64 and –.65 respectively. Finally, given that females usually report greater levels of math anxiety than do males (e.g., Devine et al., 2012; Else-Quest et al., 2010), we predicted the former would have higher BMAS scores.

Method

Participants

Participants were 1,547 undergraduate students enrolled in different lower level Psychology courses at the University of Barcelona. In the present study were included those 1,349 participants with complete data on the sMARS. There were 1,052 females (78.0%) and 297 males (22.0%), with a mean age of 21.92 years (*SD* = 5.15, range = 18-63).

Instruments

Shortened Math Anxiety Rating Scale (sMARS; Alexander & Martray, 1989). The scale measures trait math anxiety by presenting 25 situations which may cause mathematical anxiety grouped into three factors: *math test anxiety, numerical task anxiety, and math course anxiety.* These factors include 15, 5 and 5 items, respectively. Items are answered on a 5-point scale from 1 (*not at all*) to 5 (*very much*); thus, total score ranges between 25 and 125, where higher scores indicate higher levels of math anxiety. In the present study was administered the Spanish version developed by Núñez-Peña et al. (2013), whose good psychometric properties have been demonstrated (Cronbach's α = .94 and 7-week test-retest reliability = .72).

State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983). This test measures general anxiety with two subscales: the STAI-S to evaluate state anxiety and the STAI-T to evaluate trait anxiety. In this study we only used the STAI-T subscale, which assesses, by answering 20 items describing different emotions, how participants feel in general. Answers are given on a 4-point Likert scale ranging from 0 (*almost never*) to 3 (*almost always*), so the total score ranges from 0 to 60. The Spanish version of the STAI-T (Spielberger et al, 2008) was used in the present study (Cronbach's α = .95, and 20-day test-retest reliability with college students = .86).

German Test Anxiety Inventory (GTAI; Hodapp, 1991). This is a 30-item questionnaire that measures test anxiety. Respondents are asked to indicate how they feel when sitting an exam using a 4-point Likert scale ranging from 1 (*hardly ever*) to 4 (*nearly always*), so the total score ranges from 30 to 120. It has four subscales: Emotionality, Worry, Interference, and Lack of confidence. In the present study, the Spanish adaptation of GTAI was used, the scores of which have an excellent alpha coefficient of .90 (Sesé et al., 2010).

Addition test from the French kit (French et al., 1963). This is a test make up of 60 different additions that include three one- and two-digit numbers vertically presented. They are organized in six rows in a page. Participants are asked to obtain the result of as many additions as possible in a time limit of 2 minutes, answering quickly and accurately. The score for the test was the number of correctly solved additions.

Questions about mathematical enjoyment, self-confidence, and motivation for mathematics. These questions were: "How much do you enjoy mathematics?", "How much are you self-confident in mathematics?" and "How much motivation do you have towards mathematics?", respectively. Participants were asked to answer to each question on a 5-point Likert scale from 1 (*not at all*) to 5 (*very much*).

Procedure

The study was performed in accordance with the Declaration of Helsinki. Data were collected during different academic years beginning in the 2015-2016 and ending in the 2018-2019. All participants voluntarily gave written consent after being informed about the purpose of the study. They completed the sMARS and the other questionnaires as a part of a voluntary class activity, in a session that lasted approximately 15-20 minutes. A subsample of 106 students was tested again on the sMARS seven weeks after the first administration of the test.

Data Analysis

The total sample (n = 1,349) was randomly divided into two subsamples: a) the developmental sample (n = 675), which was used to develop the BMAS, and b) the validation sample (n = 674), which was used to assess its psychometric properties. A description of the main sociodemographic characteristics of these samples can be found in Table S1 of the Supplementary material at https://osf.io/zdu3r/?view_only=c7d277ac266544c69ce5720d102f96a4.

Development of the BMAS

In the developmental sample, each subscale of the sMARS was tested for unidimensionality using Confirmatory Factor Analysis (CFA) in order to assess to what extent the assumption of unidimensionality was met and an item response theory model could be fitted. Due to the ordinal nature of item responses, the unweighted least squares (ULS) estimation method was used. The Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR) goodness of fit indices were obtained. Since there are no recommended interpretation criteria for models with ordinal items (Shi & Maydeu-Olivares, 2020; Xia & Yang, 2019), the goodness of fit indices were interpreted following the guidelines proposed by Hu and Bentler (1999), suggesting values of CFI ≥ .95, TLI ≥ .95, RMSEA ≤ .06, and SRMR ≤ .08 as indicators of good fit. In each sMARS' subscale, a Graded Response Model (GRM) was fitted to the data (see the fit comparison of alternate models in Table S2 of the Supplementary material at https://osf.io/zdu3r/?view_only=c7d277ac266544c69ce5720d102f96a4). The performance of the 15, 5 and 5 items of the corresponding sMARS' subscales was evaluated in order to select those items to be further included in the BMAS ensuring an adequate content coverage of math test, numerical task, and math course anxiety. The criteria used to select the three best performing items within each subscale, resulting in a brief version of nine items, were based on: a) differential item functioning (DIF) between males and females, where those items identified as displaying DIF were not selected; b) the discrimination parameter, selecting those items with higher values; and c) item information function, retaining those more informative items.

The statistical analyses were carried out with the R statistical program, using the packages lavaan (Rosseel, 2012) for the CFA, mirt (Chalmers, 2012) for fitting the GRM, and lordif (Choi et al., 2011) for the DIF analysis using ordinal logistic regression.

Validation of the BMAS

The psychometric properties of the brief version were assessed in the validation sample. The dimensionality was studied fitting two competing models, i.e., a 3-factor structure as in the original sMARS and a unidimensional structure, using the ULS estimator. The model fit of both models was assessed with the CFI, the TLI, the RMSEA, and the SRMR, according to the interpretation criteria specified above. Internal consistency was assessed by means of Cronbach's alpha (α) and McDonalds omega (ω). Test–retest reliability was assessed with intra-class correlation coefficient (ICC) between the scores of the scale administered at the two different time points, under the two-way mixed model. Also was obtained the minimum detectable change (MDC) with a 95% confidence interval, which informs about the minimum change necessary to assert that the observed change between two moments reflects real changes outside of measurement error. The Spearman correlations between the BMAS scores and measures of other constructs (i.e., trait anxiety, test anxiety, arithmetic ability, and attitudes towards mathematics) were obtained in four opportunity subsamples, all of them proceeding from the original validation sample. Finally, scores were compared by Student's t test between men and women.

The R packages lavaan (Rosseel, 2012) and semTools (Jorgensen et al., 2018) were used, respectively, for the CFA and for the internal consistency analyses.

With the total sample, both BMAS subscales and total scores were described (i.e., mean and standard deviation) and transformed into percentiles separately according to gender.

Results

Development of the BMAS

Prior to applying the GRM, three CFA, one for each sMARS' factors, were performed to test whether the constructs measured by the subscales were in fact unidimensional. Regarding the fit indices, it was observed that both the *numerical task anxiety* and the *math course anxiety* subscales presented good fit to a one-factor structure, but the overall goodness of fit of the *math test anxiety* subscale was relatively poor (*math test anxiety*: CFI = .980, TLI = .976, RMSEA = .097, SRMR = .082; *numerical task anxiety*: CFI = 1.000, TLI = 1.000, RMSEA = .000, SRMR = .021; and *math course anxiety*: CFI = .999, TLI = .997, RMSEA = .034, SRMR = .030). Nevertheless, all item loadings of the *math test anxiety* subscale were positive and statistically significant, with standardized values ranging from .482 to .893, suggesting that the subscale is measuring a construct unidimensional enough for allowing the GRM to be applied (see Table S3 of the Supplementary material at https://osf.io/zdu3r/?view_only=c7d277ac266544c69ce5720d102f96a4).

DIF analyses based on ordinal logistic regression revealed that three items from the *math test anxiety* (i.e., item 5, 9, and 10) and one item from the *math course anxiety* subscale (i.e., item 21) displayed DIF (see Figure S1 of the Supplementary material at https://osf.io/zdu3r/?view_only=c7d277ac266544c69ce5720d102f96a4). Consequently, these items were discarded from being included in the BMAS.

The performance of the items was studied estimating the discrimination (α) and difficulty or threshold parameters (β) (see Table S4 of the Supplementary material at https://osf.io/zdu3r/?view_only=c7d277ac266544c69ce5720d102f96a4). The discrimination parameter refers to the power of an item to distinguish individuals with low and high latent trait levels, while each item difficulty ($\beta_1 - \beta_4$)) indicates the latent trait level needed to have a 50% chance of selecting a particular response category or higher. According to Baker (2001), all discrimination parameters were superior to the required minimum of .65. Furthermore, those three items in each subscale that better differentiate between individuals with low and high levels of math anxiety were the items 1, 4, 8, 17, 18, 19, 22, 24, and 25, which all showed very high discrimination parameters (α ≥ 1.70). An examination of the difficulty parameters indicated that their values were ordered ascendingly, indicating that to choose a higher response category (such as *very much*), higher levels of the latent trait are required. Based on the discrimination and difficulty parameters, an item trace line was obtained for each item, which shows the respondent's probability of choosing a particular response category (from the first response option P1 to the last response option P5) as a function of the latent trait (see Figure S2 of the Supplementary material at https://osf.io/zdu3r/?view_only=c7d277ac266544c69ce5720d102f96a4). A visual inspection of the item trace lines revealed that most of the items showed that their response curves were ordered and did not overlap. Thus, item response categories performed adequately for most of the items, including the nine items listed before. Finally, the item information functions were obtained (see Figure S2 of the Supplementary material at https://osf.io/zdu3r/?view_only=c7d277ac266544c69ce5720d102f96a4), which show the amount of information that each item explains as a function of the latent trait level. They showed that within each subscale some items were more informative than others and at different levels of the latent trait.

Taking into account these results all together, the best nine performing items (i.e., items 1, 4, 8, 17, 18, 19, 22, 24, and 25) were included in the BMAS, which was subsequently analyzed in the validation sample. The items of the BMAS can be read in Table 1.

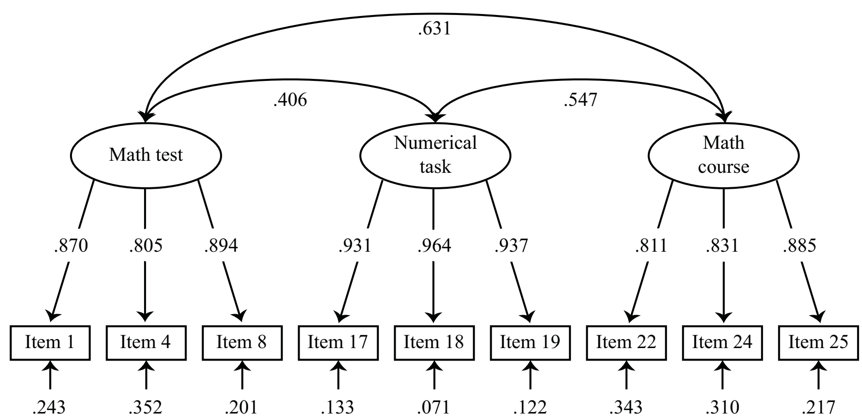
Validation of the BMAS

The original three-factor structure of the sMARS (i.e., *math test anxiety, numerical task anxiety*, and *math course anxiety*) was tested in the BMAS by using CFA and was compared to a more parsimonious unidimensional structure. Goodness of fit indices suggested that the trifactor model adjusted well (CFI = 1.000, TLI = 1.000, RMSEA = .000 [95% CI: .000 - .014, SRMR = .023) and showed better performance than the competing unidimensional model (CFI = .897, TLI = .863, RMSEA = .195 [95% CI: .183 - .208], SRMR = .154). The path diagram of the model with the corresponding estimations is shown in Figure 1.

Table 1
Brief Math Anxiety Scale (BMAS)

BMAS: brief version of the sMARS [BMAS: versión breve del cuestionario sMARS]					
Instructions: The items in this questionnaire refer to experiences that may cause tension or apprehension. For each item indicate how anxious would make you marking the option with an X. Respond quickly, but make sure you think the answer. It is very important you answer all the items. [Instrucciones: Los ítems de este cuestionario se refieren a experiencias que pueden causar tensión o aprensión. Para cada ítem señala cuán ansioso/a te pondría cada una de ellas, marcando la opción con una X. Responde de forma rápida, pero asegúrate de pensar bien la respuesta. Es muy importante responder a todos los ítems.	Not at all [Nada]	A little [Muy poco]	A fair amount [Algo]	Much [Bastante]	Very much [Mucho]
1. Studying for a math test [Estudiar para un examen de matemáticas]	1	2	3	4	5
4. Taking an exam (final) in a math course [Hacer el examen final de matemáticas]	1	2	3	4	5
8. Thinking about an upcoming math test 1 day before [Pensar en el examen de matemáticas que tendré en 1 día]	1	2	3	4	5
17. Being given a set of numerical problems incolving addition to solve on paper [Que me den una serie de problemas numéricos que incluyan sumas para que los resuelva con papel y lápiz]	1	2	3	4	5
18. Being given a set of substraction problems to solve [Que me den a resolver una serie de restas]	1	2	3	4	5
19. Being given a set of multiplication problems to solve [Que me den a resolver una serie de multiplicaciones]	1	2	3	4	5
22. Watching a teacher work on an algebraic equation on the blackboard [Ver al profesor resolviendo una ecuación algebraica en la pizarra]	1	2	3	4	5
24. Listening to another student explain a math formula [Escuchar a otro alumno que explica una fórmula matemática]	1	2	3	4	5
25. Walking into a math class [Entrar en una clase de matemáticas]	1	2	3	4	5

Figure 1
Path Diagram of the Three-Factor Structure of the Brief Math Anxiety Scale



Both Cronbach's alpha and McDonalds omega indices were higher than .80 for the three subscales (i.e., *math test anxiety*: α = .89 and ω = .83; *numerical task anxiety*: α = .96 and ω = .93; *math course anxiety*: α = .88 and ω = .84), suggesting that the scores of the BMAS are internally consistent. Similarly, Cronbach's alpha for the total score was .87. Temporal stability of scores was tested in a subsample of 50 participants. The ICCs indicated that test-retest reliability of scores was adequate since they reached a value of .75, .63, and .77, respectively, for the *math test anxiety*, numerical task anxiety, and *math course anxiety* subscales. For the total score, the ICC reached a value of .74. Similarly, the MDC was of 3.16, 4.41, and 3.77 points, respectively, for the three subscales, and 8.65 points for the total score.

Spearman correlation of the BMAS scores (for both its overall score and those of its subscales) with the other measures and the sMARS are given in Table 2. It can be seen that all the correlations showed the directions and magnitudes expected. Firstly, as for trait and test anxiety scores, they were positively associated both to the BMAS total scores and to the three subscales scores: higher levels of math anxiety are related to higher levels of trait and test anxieties. Secondly, arithmetic ability scores were negatively related to math anxiety scores: the higher math anxiety the worse arithmetic performance. This relationship was found for the total score and the task and course math anxiety subscale scores (it approaches significance for the test math anxiety scores, $r = -.11$, $p = .067$). Finally, we also found the expected negative associations between math anxiety and the degree of mathematical enjoyment, self-confidence and motivation. As for the correlations between the BMAs and sMARS scores, values were very high (i.e., all ≥ .90).

Regarding the relationship between math anxiety and gender, results showed that female obtained higher scores than males in each subscale of the BMAS, resulting in statistical significant differences (i.e., *math test anxiety*: $t(672) = 5.909$, $p < .001$; *numerical task anxiety*: $t(672) = 2.889$, $p < .01$; and *math course anxiety*: $t(672) = 2.721$, $p < .01$). Similarly, BMAS total score differed between males and females ($t(672) = 4.927$, $p < .001$).

Percentile Scores of the BMAS

With the total sample (n = 1,349), we obtained BMAS percentile scores for male and female participants separately for both their subscales and overall scores (see Table 3).

Table 2

Correlation of the Brief Math Anxiety Scale Scores With the Other Measures and the Shortened Math Anxiety Rating Scale

Subscale	Mean *(SD)*	Min - Max	STAI-T (*n* = 634)	GTAI (*n* = 162)	Arithmetic ability (*n* = 190)	Enjoyment (*n* = 275)	Self-confidence (*n* = 275)	Motivation (*n* = 275)	sMARS
Math test	10.92 (2.77)	3 - 15	.29**	.45**	-.11	-.35**	-.50**	-.34**	.90**
Numerical task	5.31 (2.67)	3 - 15	.17**	.15*	-.34**	-.24**	-.36**	-.23**	.95**
Math course	5.73 (2.76)	3 - 15	.25**	.37**	-.13*	-.36**	-.40**	-.36**	.93**
Total	21.97 (6.43)	9 - 44	.30**	.41**	-.23**	-.40**	-.55**	-.40**	.94**

** $p < .01$
* $p < .05$
Note. STAI-T: Trait subscale of the State-Trait Anxiety Inventory; GTAI: Test Anxiety Inventory; sMARS: Shortened Math Anxiety Rating Scale

Table 3

Descriptive Statistics and Percentile Scores of the Brief Math Anxiety Scale for Males (n = 297) and Females (n = 1,052)

			Percentile										
Subscale	*Mean*	*SD*	5	10	20	30	40	50	60	70	80	90	95
Male													
Math test	9.82	2.87	5	6	7	8	9	10	11	12	12	13	14
Numerical task	4.87	2.29	3	3	3	3	3	4	5	6	6	8	9
Math course	5.23	2.55	3	3	3	3	4	4	5	6	7	9	10
Total	19.92	6.17	11	13	14	16	17	20	21	23	24	28	32
Female													
Math test	11.23	2.72	6	7	9	10	11	12	12	13	14	14	15
Numerical task	5.55	2.83	3	3	3	3	4	5	6	6	8	9	11
Math course	6.03	2.82	3	3	3	4	5	5	6	7	8	10	11
Total	22.81	6.58	13	15	17	19	21	22	24	26	29	32	34

Discussion

The present study was designed to develop a brief version of the sMARS –that we named *Brief Math Anxiety Scale* (BMAS)–, establish its psychometric properties, examine its relationships with other variables, and provide percentile scores in a large sample of 1,349 university students. Even if there was already a short questionnaire to measure math anxiety, namely the 9-item AMAS (Hopko et al., 2003), it was worth providing educators and researchers interested in the study of math anxiety a short test that would allow them to measure the three anxiety dimensions in the original sMARS: *math test anxiety, numerical task anxiety*, and *math course anxiety*. Notice that the AMAS provides only measurements of math anxiety in the academic context (i.e., *learning math anxiety* and *math evaluation anxiety*). In the present study, with a developmental sample, a 9-item version of the sMARS was created, of which some validity and reliability evidence were gathered in an independent validation sample. In addition, percentile scores for the BMAS were presented, for female and male participants separately, to tentatively identify easily highly math-anxious individuals in educational and research settings when assessing persons with similar characteristics that in the present study.

The BMAS was developed under the IRT selecting nine free-DIF (i.e., based on gender), high discriminative and most informative items from the sMARS. Three items per factor were selected to ensure content coverage in the BMAS scores and to obtain a version as short as possible. The scale showed a three-factor dimensional structure (*math test anxiety, numerical task anxiety* and *math course anxiety*), and evidence of good internal consistency and temporal stability of the BMAS scores. Correlations between the BMAS and the sMARS were shown to be very high, suggesting that the new short scale performs barely equal to the sMARS. Furthermore, our predictions as for the relationship between math anxiety and other measures were confirmed. First, a moderate negative association was found between arithmetic ability and BMAS scores, as has been previously reported in several meta-analyses where studies using other math anxiety questionnaires were reviewed (e.g., Hembree, 1990; Namkung et al., 2019; Zhang et al., 2019). Note, also, that recently Barroso et al. (2021) found an overall average correlation of –.28 between math anxiety and math ability scores across all samples included in their meta-analysis, a value very similar to ours (r = –.23 for the relationship between math ability and BMAS total scores), and that this association was also reported in the 2012 Programme for International Student Assessment (PISA), where higher math-anxious students showed lower levels of math performance compared to their lower-math-anxious peers (Organization for Economic Co-operation and Development [OECD], 2013). Second, we found positive associations between the complete BMAS scores (as well as their three subscales' scores) and the trait and test anxiety scores. The relationships between these variables have been previously demonstrated, e.g., the mean correlations reported in Hembree's meta-analysis (1990) were .38 between math anxiety and trait anxiety, and .52 between math anxiety and test anxiety. These relationships have been also found recently in other studies (e.g., Núñez-Peña & Bono, 2019). Third, the degree of enjoyment, self-confidence, and motivation in mathematics negatively correlated with the BMAS total scores (–.40, –.55 and –.40, respectively, in our study), which also agreed with correlations between these variables previously reported. For example, Núñez-Peña et al. (2013) found correlations of –.52, –.54 and –.48 for the relationships between math anxiety and math enjoyment, self-confidence and motivation, respectively (see also Hembree, 1990). These negative correlations were also found when the BMAS scores were separated in its three subscales. Finally, females obtained higher BMAS scores than their male counterparts, what is in accordance to previous studies showing that females are more likely to experience math anxiety than males (e.g. Else-Quest et al., 2010; Goetz et al., 2013; Núñez-Peña et al., 2013). Gender differences were also found for math test, numerical task and math course anxiety scores.

Finally, in the present study we provide the percentile scores for the BMAS, available for men and women, which allow to tentatively interpret the scores obtained by the individuals and to establish their level of mathematical anxiety. This information will be useful for researchers and educators interested in math anxiety who want to identify highly math-anxious students in their assessments. However, we acknowledged as a limitation that we used a non-probabilistic sampling technique. As with any convenience sample, there are limits to the generalizability of results, and special caution should be taken when utilizing the percentile scores since its use is appropriate only when the sample of participants presents characteristics similar to those of the sample of the present study. Future studies should explore the invariance of the BMAS in relation to other relevant variables beyond gender and the usefulness of the BMAS in clinical contexts, analyzing its ability to detect severe math anxiety problems (e.g., establishing a cut-off point from a study with ROC curves).

In conclusion, results support the notion that the BMAS may be a suitable alternative tool for measuring math anxiety in university students, as compared with the original instrument, especially in assessment settings where time resources are considerably constrained because, for example, the BMAS is part of a larger battery of tests.

Funding

This study was supported by the Spanish Ministry of Science and Innovation [grant number PID2020-117140GB-I00 / AEI /10.13039/501100011033]; the Spanish Ministry of Economy and Competitiveness and the European Regional Development Fund (MINECO / FEDER) [grant number PSI2015-69915-R]; and the University of Barcelona [grant number REDICE18-2222].

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