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Cross-cultural adaptation and validation of the elementary school mathematics anxiety scale - elementary form - MARS-E into portuguese/Brazil

Traducción y validación de la escala de ansiedad matemática de la escuela primaria - formulario elemental - MARS-E al portugués/Brasil

Traduction et validation de l'échelle d'anxiété mathématique à l'école primaire - forme élémentaire - MARS-E vers le portugais/Brésil

Tradução e validação da escala de ansiedade matemática do ensino fundamental- forma elementar- MARS-E para o português/brasil

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Abstract

In this study, we translated and validated the Mathematical Anxiety Scale for Elementary School - Elementary Form - MARS-E into Brazilian Portuguese. We assessed its validity evidence based on the structure, internal consistency and individual parameters of the instrument's items, based on the Item Response Theory (IRT) paradigm. The psychometric data considered a sample of 214 students aged between 9 and 12 years. The results of the Confirmatory Factor Analysis indicated that the bifactorial model, similar to the original instrument, presented satisfactory adjustment indicators, indicating that mathematical anxiety can be explained by the factors "Mathematical Performance Anxiety (MPA)" and "Mathematical Tests (MT)", with all factor loadings presenting sufficient magnitudes and different from zero. In addition, the internal consistency indicators demonstrated high precision of the instrument (αF1 = 0.875 and ωF1 = 0.857; αTM = 0.850 and ωTM = 0.866). Therefore, it can be inferred that the MARS-E presented adequate psychometric parameters of validity, based on the internal structure, good individual parameters of the items, both in the APM factor and in the TM factor, indicating that they are items that adequately measure their respective latent factors. It is considered that the instrument is psychometrically appropriate for large-scale use in the Brazilian context.

Keywords: Math anxiety, Confirmatory factor analysis, MARS-E, Cross-cultural adaptation.

Resumen

En este estudio, tradujimos y validamos la escala de ansiedad matemática para la Escuela Primaria - Forma Elemental - MARS-E al portugués brasileño. Se evaluó su evidencia de validez con base en la estructura, consistencia interna y parámetros individuales de los ítems del instrumento, con base en el paradigma de la Teoría de Respuesta al Ítem (TRI). Los datos psicométricos consideraron una muestra de 214 estudiantes con edades entre 9 y 12 años. Los resultados del Análisis Factorial Confirmatorio mostraron que el modelo bifactor, similar al

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instrumento original, presentó indicadores de ajuste satisfactorios, indicando que la ansiedad matemática puede explicarse a través de los factores “Ansiedad por el Desempeño Matemático (APM)” y “Pruebas Matemáticas (TM)”, con todas las cargas factoriales presentando magnitudes suficientes y distintas de cero. Además, los indicadores de consistencia interna demostraron alta precisión del instrumento (αF1= 0,875 y ωF1= 0,857; αTM= 0,850 y ωTM= 0,866). Por lo tanto, se puede inferir que el MARS-E presentó adecuados parámetros de validez psicométrica, basados en la estructura interna, buenos parámetros individuales de los ítems, tanto en el factor APM como en el factor TM, indicando que son ítems que miden adecuadamente sus respectivos factores latentes. Se considera que el instrumento es psicométricamente apropiado para uso a gran escala en el contexto brasileño.

Palabras clave: Ansiedad matemática, Análisis factorial confirmatorio, MARS-E, Adaptación transcultural.

Résumé

Dans cette étude, nous avons traduit et validé l'échelle d'anxiété mathématique pour l'école primaire - Forme élémentaire - MARS-E en portugais brésilien. Nous avons évalué ses preuves de validité sur la base de la structure, de la cohérence interne et des paramètres individuels des items de l'instrument, sur la base du paradigme de la théorie de la réponse aux items (IRT). Les données psychométriques ont porté sur un échantillon de 214 étudiants âgés de 9 à 12 ans. Les résultats de l'analyse factorielle de confirmation ont montré que le modèle bifactoriel, similaire à l'instrument original, présentait des indicateurs d'ajustement satisfaisants, indiquant que l'anxiété mathématique peut être expliquée par les facteurs « Anxiété liée à la performance mathématique (APM) » et « Tests mathématiques (TM) ». , avec toutes les saturations factorielles présentant des ampleurs suffisantes et non nulles. De plus, les indicateurs de cohérence interne ont démontré une grande précision de l'instrument (αF1= 0,875 et ωF1= 0,857 ; αTM= 0,850 et ωTM= 0,866). Par conséquent, on peut en déduire que le MARS-E a présenté des paramètres de validité psychométrique adéquats, basés sur la structure interne, de bons paramètres individuels des items, tant dans le facteur APM que dans le facteur TM, indiquant qu'il s'agit d'items qui mesurent de manière adéquate leurs facteurs latents respectifs. On considère que l'instrument est psychométriquement approprié pour une utilisation à grande échelle dans le contexte brésilien.

Mots-clés : Anxiété mathématique, Analyse factorielle de confirmation, MARS-E, Adaptation transculturelle.

Resumo

Neste estudo, traduzimos e validamos para o português brasileiro a escala de ansiedade matemática para o Ensino Fundamental - Forma Elementar - MARS-E. Avaliamos suas evidências de validade a partir da estrutura, consistência interna e parâmetros individuais dos itens do instrumento, baseados no paradigma da Teoria de Resposta ao Item (TRI). Os dados psicométricos consideraram uma amostra de 214 alunos com idades entre 9 e 12 anos. Os resultados da Análise Fatorial Confirmatória apontaram que o modelo bifatorial semelhantes ao instrumento original, apresentou indicadores de ajuste satisfatórios, indicando que a ansiedade matemática pode ser explicada através dos fatores "Ansiedade de Performance Matemática (APM)" e "Testes matemáticos (TM)", com todas as cargas fatoriais apresentando magnitudes suficientes e diferentes de zero. Além disso, os indicadores de consistência interna demonstraram alta precisão do instrumento (α_{F1}= 0,875 e ω_{F1}= 0,857; α_{TM}= 0,850 e ω_{TM}= 0,866). Sendo assim, pode-se inferir que o MARS-E apresentou adequados parâmetros psicométricos de validade, baseada na estrutura interna, bons parâmetros individuais dos itens, tanto no fator APM quanto no fator TM, indicando serem itens que mensuram adequadamente seus respectivos fatores latentes. Considera-se que o instrumento é apropriado psicometricamente para o uso em larga escala no contexto brasileiro.

Palavras-chave: Ansiedade matemática, Análise fatorial confirmatória, MARS-E, Adaptação transcultural.

Cross-Cultural Adaptation and Validation of the Elementary School Mathematics Anxiety Scale - Elementary Form - MARS-E into Portuguese/Brazil

Mathematics anxiety (MA) is an adverse emotional reaction to numbers that can impact people from early childhood through adulthood. It is associated with low mathematical proficiency and has cognitive, physiological, and behavioral repercussions (Richardson e Suinn, 1972; Hembree, 1990; Ashcraft & Ridley, 2005; Ashcraft & Kirk, 2001; Suárez-Pellicioni, 2014; Lyons & Beilock, 2012, Moura-silva et al., 2020).

Due to the negative consequences of this emotional construct, several instruments have been developed to assess children and adults over the decades (CAMPOS, 2022). The first self-report instrument designed to measure mathematical anxiety, the Numerical Anxiety Scale, was developed by Dreger and Aiken in 1957 based on an adaptation of the Taylor Manifest Anxiety Scale (Taylor, 1953). Later, more comprehensive scales, such as the Mathematics Anxiety Rating Scale (MARS), were developed and investigated. MARS is one of the most used instruments for measuring mathematics anxiety in academic literature (SUINN et al., 1988; BESSANT, 1995; HOPKO, 2003; LUKOWSKI et al., 2016, WANG, 2018). The Elementary Mathematics Anxiety Scale (MARS-E) for children and young people consists of 26 items. It assesses the degree to which students experience mathematics anxiety in specific math-related situations (SUINN et al., 1988).

Multiple studies worldwide have proposed adaptations and validations to the MARS-E, seeking to develop its factorial structure (Brush, 1978; Rounds & Hendel , 1980; Plake & Parker, 1982; Suinn & Winston, 2003; Hopko, 2003; Daharnis et al., 2018). These instruments have similarities, such as analyzing the dimensions of anxiety, mathematical assessment, and numerical anxiety (Suinn, 1988; Alexander & Cobb, 1987; Alexander; Martray, 1989; Pletzer et al., 2016), addressing cognitive, behavioral, and affective aspects. The instruments are based on a 5-point Likert scale ranging from (1) “completely disagree” to (5) “strongly agree” to identify possible behavioral patterns based on attitudes, beliefs, values, and anxiety related to mathematics. The MARS-E presented good reliability indices and robust psychometric properties in its original and adapted versions (SUINN et al., 1988; HOPKO, 2003).

Despite the different versions of the scale developed worldwide, no MA scale, even those adapted from MARS-E, has been translated and adapted to the Brazilian context. In Brazil, 68% of the school-age population is below level 2 (two) of mathematical proficiency-considered by the Organization for Economic Cooperation and Development (OECD) to be the basic level of proficiency to allow young people to take advantage of learning opportunities and participate in a globalized world. PISA data confirm these results within and between countries of the OECD, considering its last years of application in 2018 and 2022 (OCDE, 2019a; BRASIL, 2023). Such evidence appears critical, given that low mathematical proficiency is associated with Mathematics Anxiety, indicating the need for instruments that measure this construct in the Brazilian context for decision-making by educators and political, scientific, and educational.

In this study, we translated and cross-culturally validated the Mathematics Anxiety Scale for Elementary Education - Elementary Form (MARS-E) into Brazilian Portuguese. We evaluated its validity evidence based on the structure, internal consistency, and individual parameters of the instrument's items, using the Item Response Theory (IRT) paradigm.

Method

All methodological procedures developed in this study were submitted and approved by the Research Ethics Committee (CEP) of the Federal University of Pará- Instituto de Health Sciences, according to the consolidated opinion (annex A) - CAAE: 76887417.2.0000.0018, opinion number: 2,305,203, being extended by the resolutions and regulations of the National Health Council (CNS).

The cross-cultural adaptation of the instrument followed the steps indicated by Beaton et al. (2000), namely: (l) Independent Translations, (2) Synthesis of Translations, (3) Committee of Experts, (4) Pre-test. Back translation was not performed. Briefly, the instrument was independently translated from English to Brazilian Portuguese by two Brazilian Portuguese native speakers, fluent speakers in English, synthesized by this study's authors, followed by a meeting to define the consolidated version of the instrument. The consolidated version of the scale was analyzed by an Expert Committee, composed of 04 PhD professors and researchers

in the field, and their suggestions were incorporated into the instrument. After adjustments, a Pilot study with xxx children between 9 and 12 years old) were performed. After the pilot test, no item on the scale needed to be reformulated, and the final version of the Brazilian Portuguese scale was defined.

Two hundred and fourteen children between 9 and 12 years old responded individually to the final version of the questionnaire. Children indicated the intensity of their response to each item on a five-point Likert scale: (1) Not at all nervous, (2) Not very nervous, (3) Fairly nervous, (4) Very nervous, (5) Extremely nervous. The score was the sum of all points from the 26 questions. Each raw score has percentage equivalents for interpreting the results based on the school grade (Table 1)(SUINN et. al., 1988). As an example, a 57 score on MARS-E of a sixth-year student would correspond to a 75% level of Mathematics Anxiety, as shown in Table 1 below:

Table 1.

Quantitative correlations of the Instrument, according to the school year

PERCENTILE	FOURTH GRADE	FIFTH GRADE	SIXTH GRADE	ALL SUBJECTS
10%	43	42	42	42
30%	47	46	46	46
50%	52	50	49	50
75%	63	59	57	60
95%	85	82	76	81

In the table above, it is noted correlation between percentile, school years, and raw scores in relation to the Mathematics Anxiety Scale (MARS-E). The higher the score, the higher the percentage parameter of the MA level, depending on the school year. Source: Suinn et. al., 1988.

Statistical analysis

The data were tabulated in Excel spreadsheets and analyzed using the R programming language (R CORE TEAM, 2022). To this end, the Lavaan (ROSSEEL et al., 2017), semTools

(JORGENSEN et al., 2016), and semPlot (EPSKAMP; EPSKAMP, 2017) packages were used. The Lavaan package was used to calculate the fit indicators of the measurement model, while the semPlot package was used to calculate the internal consistency of the instrument and to obtain the structural equation model figure. To test the individual parameters of the items, according to the Item Response Theory (IRT) paradigm, the mirt package was used (CHALMERS, 2012) based on the Gradual Response Model (SAMEJIMA, 1969).

As evidence of validity based on the internal structure of the instrument, Confirmatory Factor Analysis (CFA) was used, considering the factorial structure of the instrument (SUINN; TAYLOR; EDWARDS, 1988). This analysis evaluates the fit of a model (defined *a priori*) to real data based on the quality of fit indicators (HAIR et al., 2009). In this way, the presence of two latent factors was tested, being "Mathematical Performance Anxiety" (MPA)- referring to ordinary situations involving numerical manipulation, and "Mathematical Test Anxiety" (MTA)- relating to situations involving mathematical assessment, based on the Weighted Least Squares Mean and Variance Adjusted- WLSMV estimator (LI, 2016; MÚTHEN; MÚTHEN, 2017). As this is a confirmatory factor analysis, the two factors considered were chosen because they are the factors of the original scale (Suinn et.al., 1988).

The adjustment indicators used in this study to interpret the quality of the model were: a) χ^2, for which non-significant values are expected ($p > 0.05$); b) the ratio χ^2/gl, with appropriate values when ≤ 5; c) Comparative Fit Index (CFI) and d) Tucker-Lewis Index (TLI), with cut-off points reached when ≥ 0.90; e) Root Mean Square Error of Approximation (RMSEA), with appropriate values when ≤ 0.08, beyond the upper limit of the confidence interval ≤ 0.10; and f) Standardized Root Mean Square Residual (SRMR), with satisfactory values when ≤ 0.08 (BROWN, 2015; BYRNE, 2016; TABACHNICK; FIDELL, 2007).

The instrument's internal consistency was measured using Cronbach's α and McDonald's ω coefficients. These indicators assess the degree to which a latent factor presents highly correlated items, and their cutoff points adopt values ≥ 0.70 (Hayes & Coutts, 2020; Bland & Altman, 1997). Cronbach's coefficient α is calculated based on the analysis of the variance of the items and the total variance of the test ($\alpha = (k / (k - 1)) * (1 - (\Sigma\sigma^2 i / \sigma^2 t)$, where: k is the number of items, $\sigma^2 i$ is the variance of each item and $\sigma^2 t$ is the total variance of the test).

Finally, the Item Response Theory (IRT) paradigm was used to verify the latent traits of an individual about the pattern of responses to the scale items, investigating to investigate the individual parameters of the items, namely (a) Discrimination and (b) Difficulty. To this end, the mirt package (Chalmers, 2012) was used to calculate the indicators based on the Gradual Response Model (Samejima, 1969).

It is important to highlight that the discrimination parameter indicates the ability of an item to differentiate people with different levels of latent trait (HUTZ; BANDEIRA; TRENTINI, 2015), while the difficulty presents the level of latent trait that the person needs to demonstrate to obtain 50% chance of selecting one response category over another (PASQUALI; PRIMI, 2003).

As a basic interpretation of the indicators mentioned above, the cutoff points delimited by Pasquali (2020) and the power of discrimination are considered according to the following ranges of values: between 0.01 and 0.034 is very low; 0.35 and 0.64 low; 0.65 and 1.34 average; 1.35 and 1.69 high; equal to or above 1.70 are very high discrimination results. On the other hand, difficulty levels are measured in a range from -3 to +3, with values closer to -3 indicating easy items, while values closer to +3 indicate items with high difficulty (PASQUALI; PRIMI, 2003).

Finally, Item Characteristic Curves (ICCs) and Test Information Curves (CITs) were analyzed. The ICCs indicate the amount of information measured based on the latent trait level captured by the evaluated participant, in which steeper graphs indicate items with a greater amount of information measured, while flatter graphs indicate a greater amplitude of the latent trait level measured. CITs present the amount of information the test measures (the set of items). The interpretation of the CIT is similar to the CCI. However, the meeting point between the blue (amount of information) and red (residue) lines delimits the amplitude of the latent trait level measured by the measure.

Results

The Confirmatory Factor Analysis (ACF) results showed that the bifactor model presented satisfactory adjustment indicators (Table 2), indicating that mathematical anxiety can be explained through the factors “Mathematical Performance Anxiety” (MPA) and “Mathematical Test Anxiety” (MTA) with all factor loadings presenting sufficient magnitudes ($\lambda > |0.40|$, $p < 0.05$; Table 2). Furthermore, the internal consistency indicators demonstrated high precision of the instrument (αMPA= 0.875 and ωMPA= 0.857; αMTA= 0.850 and ωMTA= 0.866). Therefore, it can be inferred that the instrument presented suitable psychometric validity parameters based on the internal structure (Figure 1).

Table 2.

Adjustment indicators for the MARS-E-Brazil model

	χ^2 (df)	χ^2/gl	CFI	TLI	SRMR	RMSEA (CI 90%)
MARS-E	416.202 (298)	1.396	0.970	0.967	0.073	0.052 (0.039 – 0.063)

χ^2 (df); χ^2/gl; CFI: Comparative Fit Index; TLI: Tucker-Lewis Index; SRMR: Standardized Root Mean Square Residual; RMSEA: Root Mean Square Error of Approximation

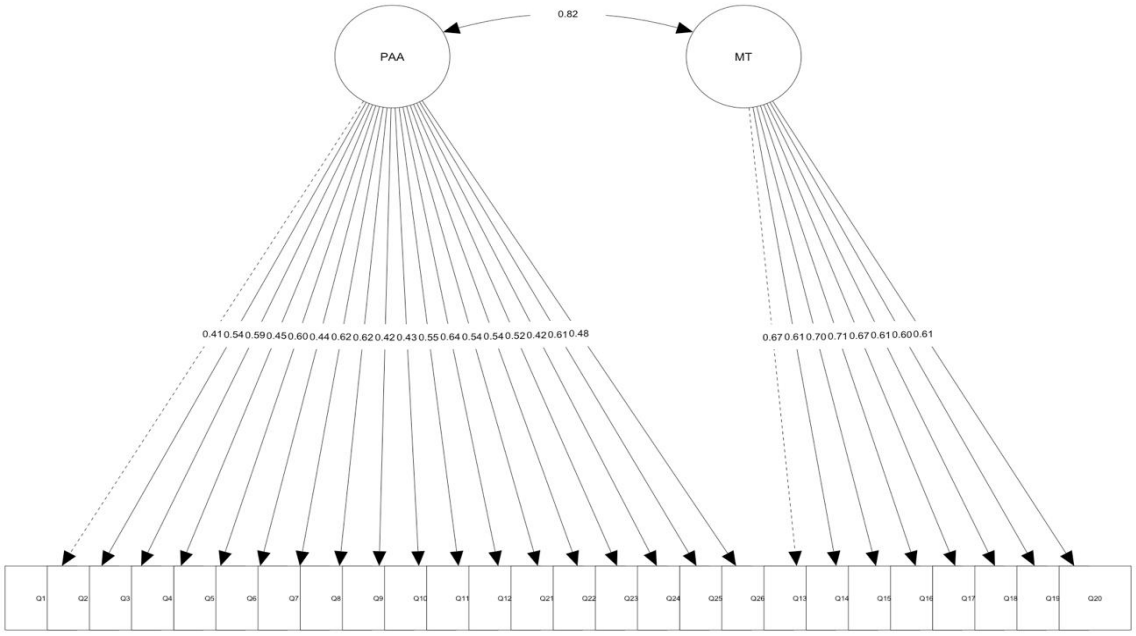

Figure 1.

Structural Equation Model of the MARS-E-Brazil instrument

Furthermore, since the factorial structure of the instrument showed satisfactory indicators (Table 3), an analysis of the items' parameters was carried out to analyze possible problem items. The results indicate that the items in the Mathematical Performance Anxiety factor showed high discrimination (aMPA= 1.225), while the Mathematical Test factor showed very high discrimination (aMTA= 1.801). Notably, the item with the lowest discrimination index for the MPA factor was Q6 (a= 1.009), while the item with the highest discrimination was Q12 (a= 1.459), both showing high discrimination. For the Mathematical Test factor, the results indicate that the item with the lowest level of discrimination was Q19 (b= 0.918; moderate), while the item with the highest discrimination was Q16 (b= 2.979; very high).

Table 3.

Individual parameters of MARS-E Brazil items and factor loadings

	A	b1	b2	b3	b4	bx	λ

Mathematical Performance Anxiety							
Q1	1,141	0,089	2,249	3,314	4,219	2,468	0,408
Q2	1,131	-1,247	0,440	1,869	3,513	1,144	0,545
Q3	1,408	-1,268	-0,149	0,933	1,918	0,359	0,586
Q4	1,176	-0,589	0,715	1,494	2,625	1,061	0,453
Q5	1,352	-0,808	0,380	1,354	2,117	0,761	0,598
Q6	1,009	-0,216	1,512	2,480	4,139	1,979	0,438
Q7	1,319	-1,236	0,195	1,087	1,904	0,488	0,617
Q8	1,239	-1,644	-0,398	0,209	1,193	-0,160	0,616
Q9	1,063	-0,504	0,854	1,655	3,308	1,328	0,425
Q10	1,036	-0,224	1,592	2,705	3,471	1,886	0,427
Q11	1,289	-0,055	1,451	2,499	3,156	1,763	0,547
Q12	1,459	-1,385	-0,249	1,137	1,989	0,373	0,643
Q21	1,281	-0,227	1,312	2,182	3,318	1,646	0,537
Q22	1,311	-0,534	0,707	1,702	2,697	1,143	0,540
Q23	1,348	-0,107	1,120	1,871	2,405	1,322	0,520
Q24	1,064	0,061	1,392	2,268	3,165	1,722	0,424
Q25	1,340	-1,458	-0,214	0,660	1,434	0,106	0,607
Q26	1,086	-0,504	0,909	1,862	2,723	1,248	0,481
Mathematical Test Anxiety							
Q13	1,985	-1,902	-0,590	0,131	0,690	-0,418	0,675
Q14	1,067	-0,900	0,832	1,785	2,570	1,072	0,610

Q15	2,318	-1,288	-0,358	0,416	1,086	-0,036	0,699
Q16	2,979	-1,023	-0,467	0,142	0,757	-0,148	0,710
Q17	2,272	-1,328	-0,654	-0,123	0,677	-0,357	0,674
Q18	1,826	-2,351	-1,410	-0,415	0,305	-0,968	0,615
Q19	0,918	-1,122	0,403	1,514	2,846	0,910	0,603
Q20	1,040	-1,495	-0,284	0,789	1,652	0,166	0,608

When investigating the difficulty parameter of the items, the easiest MPA item was Q8 (bx= -0.160), while the most challenging item was Q1 (bx= 2.468). Most items showed difficulty between 0 and 1, indicating difficulty slightly higher than the midpoint of measurement using the Item Response Theory. The item with the least difficulty on the MTA factor was Q18 (bx= -0.968), while the most challenging item was Q14 (bx= 1.072). Furthermore, it can be inferred that most indicators had an average difficulty between -1 and 0, indicating that they were items with difficulty slightly lower than the midpoint of measurement using the Item Response Theory.

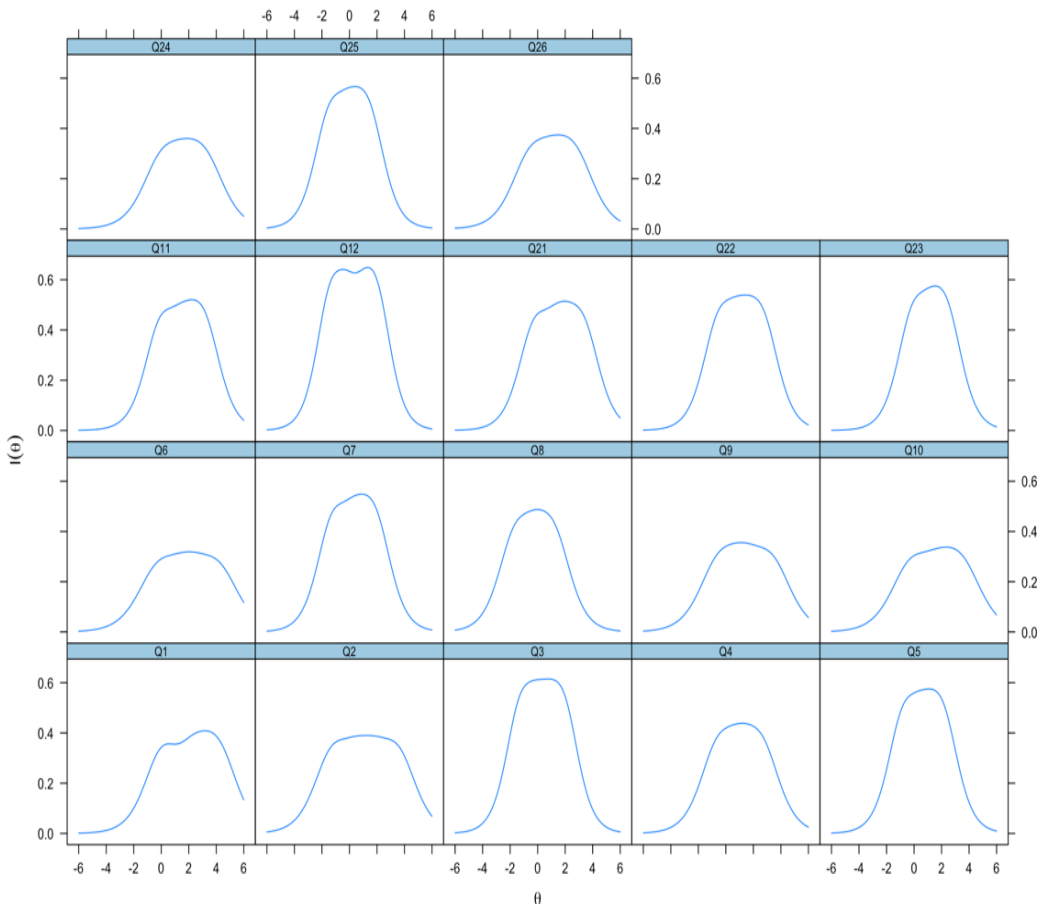

Figure 2.

Information Curve of the MPA factor item

In addition, the Item Characteristic Curves (ICC) and the Test Characteristic Curves (CIT) were observed. For the MPA factor, the items showed a good amount of measured information (Figure 2), indicating that they are items that can accurately capture the levels of the construct investigated. Furthermore, the CIT indicated that the MPA factor can measure the amplitude of approximately -3.3 to +4.5 levels of θ, with a peak accuracy of approximately +1.2 (Figure 3).

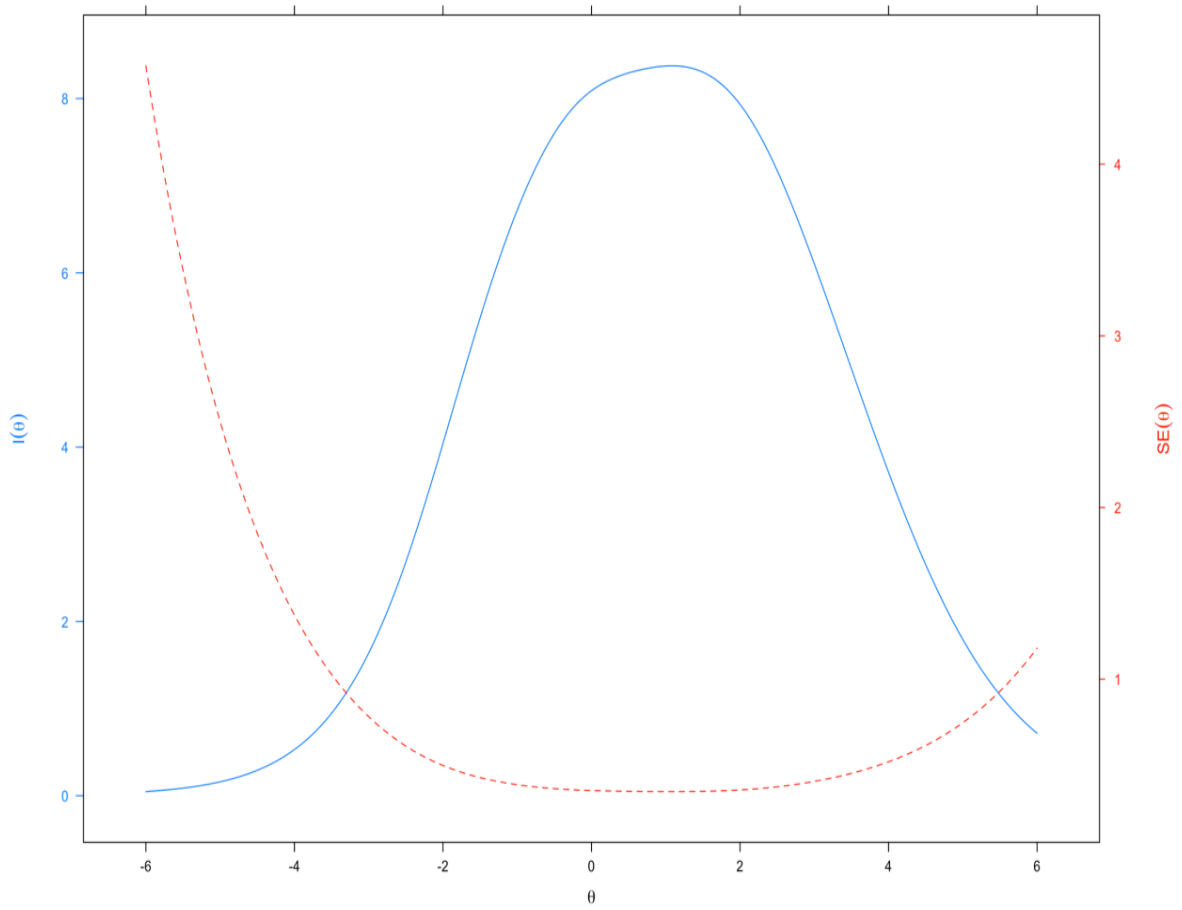

Figure 3.

Characteristic curve of the MPA factor test

When investigating the MTA factor, the CCI indicated the presence of items with a low amount of measurement of the construct, namely Q14, Q19, and Q20 (Figure 4), i.e., items that showed less discrimination and greater difficulty. On the other hand, the easier items of the MTA factor presented a greater amount of measured information, indicating greater precision of these indicators. Finally, the CIT results indicated a measurement range between -3.3 and +2.9, with a peak precision close to 0 (Figure 5).

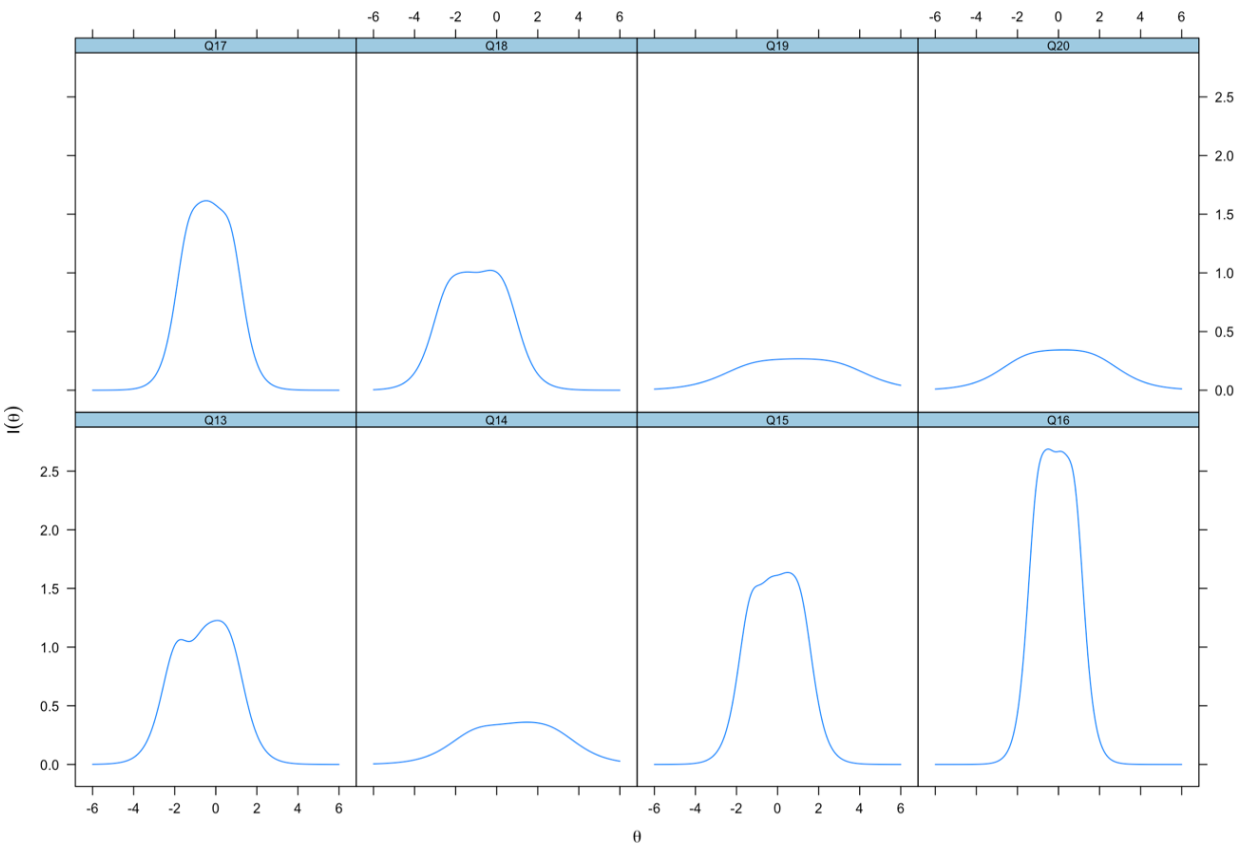

Figure 4.

Information Curve of the MTA factor item

Therefore, the MARS-E Brazil scale presented good individual item parameters in the MPA and MTA factors, indicating that the items adequately measure their respective latent

factors. Based on this information, the instrument is psychometrically suitable for large-scale use in the Brazilian context.

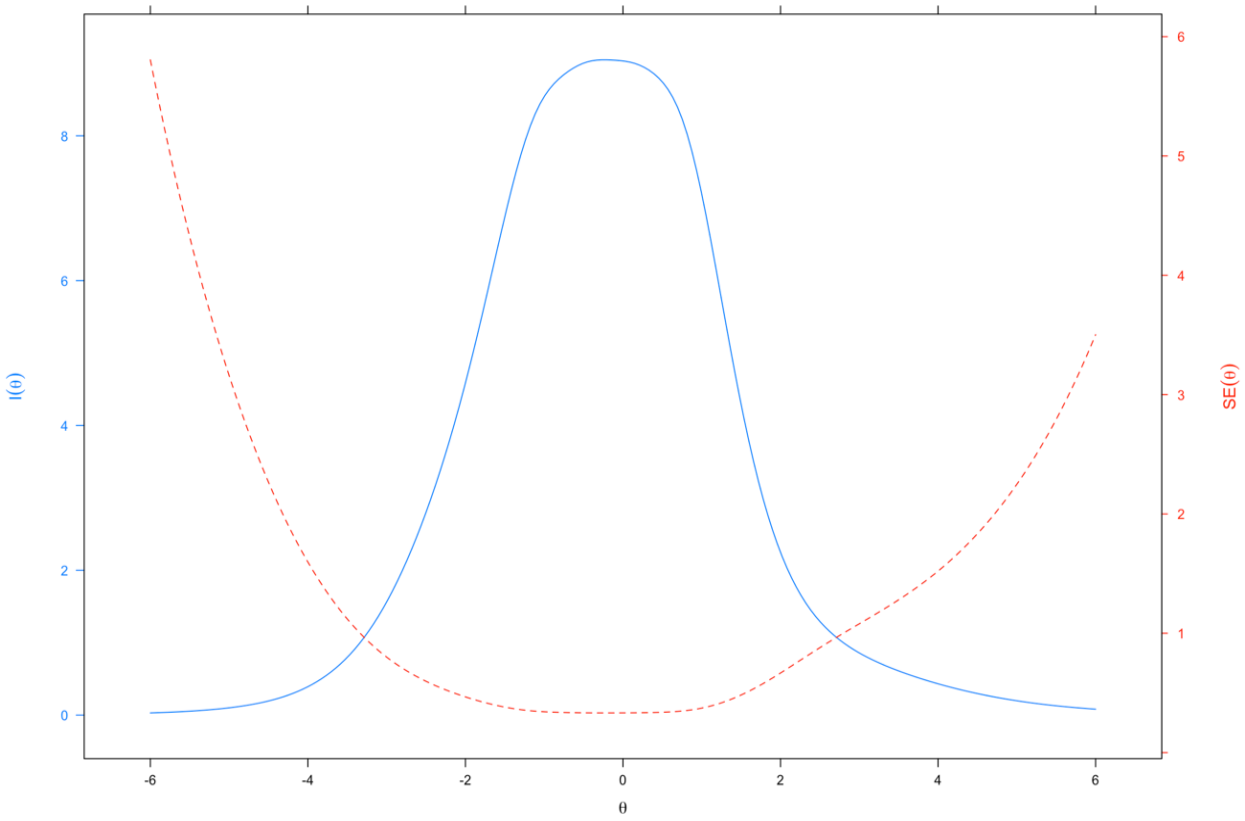

Figure 5.

Characteristic curve of the MTA factor test

Discussion

Our study translated and analyzed the psychometric properties of the MARS-E for the Brazilian Portuguese (MARS-E Brazil) context. We present evidence of the validity of the MARS-E scale for use with children and adolescents in the Brazilian context. We demonstrated from Confirmatory Factor Analysis that the bifactor model, like the original instrument and other translations (Bessant, 1995; Lukowski et al., 2016, Wang, 2018, Suinn et al., 1988), presented satisfactory adjustment indicators, indicating that mathematical anxiety can be explained through two factors: “Mathematical Performance Anxiety (MPA)” and “Mathematical Test Anxiety (MTA)” with all factor loadings presenting good magnitude parameters. In this context, our study provides insights into the factorial structure of

mathematics anxiety, contributing to the debate in the area based on a sample of Brazilian students.

The four most common factors found in screening studies regarding the dimensions of Mathematics Anxiety were those associated with anxiety about mathematics tests, anxiety when solving operations, anxiety in dealing with mathematics in social/ordinary situations and anxiety in observing and interacting with mathematics materials, therefore encompassing the factors validated in the structure considered (Suinn et. al., 1988; Hopko, 2003; Gierl e Bisanz,1995; Lukowski et.al., 2016; Chiu e Henry, 1990; Bessant, 1995).

Due to the transient nature of anxiety states, specifically math anxiety, Spielberger et al. (1983) indicated that test-retest reliability techniques may not be appropriate. Therefore, the MARS-E Brazil was analyzed only through internal consistency of the results.

The coefficients for internal consistency, both Cronbach's alpha and McDonald's omega, were high for the two factors considered, Mathematical Performance Anxiety and Mathematical Test, and consistent with the original instrument (Suinn et al., 1988) and with different versions adapted worldwide. For example, in the Turkish version (Baloÿlu and Balgalmiÿ, 2010), the coefficients on its subscales ranged between 0.77 and 0.86. In the Spanish version (Brown and Sifuentes, 2016) validated in two factors, the reliability index varied between 0.85 and 0.88. In the Japanese version (Satake and Amato, 1995), which was validated in four factors, the internal consistency based on Cronbach's alpha was estimated at 0.96. Therefore, our result aligns with previous studies' parameters and supports the widely discussed proposition that math anxiety is a multidimensional construct.

Our internal consistency indicators demonstrated the high precision of the instrument. When evaluating the individual parameters of the items, it was found that those associated with the MPA factor presented high discrimination. In contrast, the MTA factor presented very high discrimination, indicating that they are items that adequately assess their respective latent factors. Despite the promising findings, the study has some limitations. The first refers to the data constitution through the cluster sampling method, meaning the results may not be fully generalizable. Although the participating schools were distinct and random, and the resulting sample group was representative of the research, Brazil's geographic dimension justifies further

studies with larger samples from different sociodemographic contexts to assess the factorial structure's invariance better.

Conclusion

In this study, we present evidence of the validity of the MARS-E scale for use with children and adolescents in the Brazilian context. Using confirmatory factor analysis, we demonstrated that the bifactor model, similar to the original instrument, presented satisfactory adjustment indicators, indicating that mathematical anxiety can be explained by two factors: "Mathematical Performance Anxiety (MPA)" and "Mathematical Test (MT)", with all factor loadings presenting good magnitude parameters. This finding contributes to the discussion on the factorial structure of mathematical anxiety, providing new insights from a sample of Brazilian students.

Our internal consistency indicators, obtained by Cronbach's ω McDonald coefficients, showed high precision of the instrument. When evaluating the individual parameters of the items, we observed that those associated with the MPA factor presented high discrimination, while the items of the MT factor presented very high discrimination, indicating that the items adequately measure their respective latent factors.

Despite the promising results, the study has some limitations. Cluster sampling, although representative, means that the results are not completely generalizable. Although the participating schools were distinct and random, the geographic size of Brazil justifies further studies with larger samples from different sociodemographic contexts in order to assess the invariance of the factorial structure.

Within the limits of the study, the 26-item version of the MARS-E, translated, adapted and validated for Brazilian Portuguese, can be used by educators or researchers as an objective and psychometrically sound instrument to measure and monitor the levels of mathematical anxiety of elementary school students in Brazilian schools. Its application will allow the identification and monitoring of potential students with ML, enabling the implementation of appropriate strategies and methodologies to minimize the negative effects of this emotional

construct associated with the teaching of mathematics. This is especially relevant given the high rate of Brazilian students with low proficiency in this subject.

As a next step, we encourage studies that use the instrument in different educational contexts, both to monitor mathematical anxiety in short periods and in longitudinal research. Furthermore, research that associates the instrument with teaching strategies may be particularly useful for evaluating the effectiveness of pedagogical approaches on the emotional aspect of students.

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