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Measurement of Mathematics Anxiety in an Israeli Adult Population

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Supplementary Materials: Data, Materials [see Index of Supplementary Materials]

Abstract

Maths anxiety is common and refers to feelings of anxiety, fear and other negative emotions and thoughts in individuals when confronted with mathematical tasks or numerical information. Self-report measures of maths anxiety have been created, but the majority are in English and are not culturally relevant to all countries. This study aimed to translate and validate existing measures for future use in Hebrew-speaking adult populations. The Mathematics Anxiety Scale – UK (MAS-UK) was translated to Hebrew and adult participants completed it alongside the Mathematics Anxiety Rating Scale – Revised (MARS-R) and a general anxiety measure. Factor structures were explored for both the translated MAS-UK and a Hebrew version of the MARS-R, as well as being checked for reliability and convergent and discriminant validity. Results from a final sample of 213 participants, indicated the shortened, Hebrew version of the MAS-UK and the MARS-R are internally consistent and suitable for use in future maths anxiety research in adult Israeli populations. Findings regarding sex differences in maths anxiety are also discussed.

Keywords

maths anxiety, psychometric, translation, measurement, Hebrew

Maths anxiety can be described as the feelings of tension and apprehension when manipulating numbers or completing maths-based tasks (Ashcraft, 2002; Cipora et al., 2022). There is neurophysiological evidence that self-reported maths anxiety is associated with brain activity in anticipation of doing maths (Lyons & Beilock, 2012), during mathematical problem solving (Young et al., 2012), and even when presented with basic numerical information (Batashvili et al., 2020). Furthermore, maths anxiety has been linked to physiological reactivity in response to maths problems of increasing difficulty (Hunt et al., 2017). It is related to, but distinct from, general anxiety and test anxiety (Dowker et al., 2016), with maths anxiety typically moderately, positively related to general anxiety (Hembree, 1990; Xie et al., 2019). There is consistent evidence that maths anxiety is negatively related to maths performance (Barroso et al., 2021; Caviola et al., 2021; Hembree, 1990; Namkung et al., 2019; Zhang et al., 2019) and willingness to pursue maths based study or careers (Ahmed, 2018; Chipman et al., 1992; Hembree, 1990). Maths anxiety is typically measured using psychometric scales and the majority of existing scales have been developed and validated on North American and U.K. populations, however maths anxiety is not limited to these populations, and so translations of scales and validations in other populations are needed. This study aims to fill the gap in the literature by exploring the factor structure of maths anxiety scales translated into Hebrew, and testing their suitability within an Israeli adult population.

Maths Anxiety Measurement

The Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972) was one of the earliest instruments designed to measure maths anxiety in adults. The MARS uses brief descriptions of maths related situations and respondents are required to specify, on a 5-point scale (1 = *Not at all*, 2 = *Slightly*, 3 = *A fair amount*, 4 = *Much*, 5 = *Very much*) how anxious they would feel in each situation. The scale has been widely used in empirical studies of maths anxiety. However, due to its size (98 items), administration time can be lengthy and there is an increased risk of participant drop-out. Shortened versions of the scale have been created to address these concerns, e.g. sMARS (Alexander & Martray, 1989), MARS-R (Plake & Parker, 1982), Revised MARS-R (Hopko, 2003; henceforth referred to as the MARS-R[1]), and AMAS (Hopko et al., 2003). More recent measures include the general maths anxiety subscale of the Math Anxiety Scale for Teachers (Ganley et al., 2019), the Single-Item Math Anxiety Scale (SIMA, Núñez-Peña et al., 2014), and the Mathematics Calculation Anxiety Scale (Hunt et al., 2019). For a wider overview of maths anxiety measurement instruments including measurement scales designed for children see Cipora et al. (2019).

There is much evidence to suggest that maths anxiety is a multidimensional construct (Cipora et al., 2019). Early work on the MARS indicated a two-factor structure (Rounds & Hendel, 1980). The first was labelled 'Mathematics Test Anxiety', which represents items relating to maths tests and exams. The second factor was termed 'Numerical anxiety' and consisted of items pertaining to numerical calculations. Subsequent factor analyses on prominent maths anxiety scales have demonstrated support for a two-factor structure (Alexander & Cobb, 1987; Plake & Parker, 1982). However, others have presented evidence for a three-factor (Ferguson, 1986; Hunt et al., 2011; Resnick et al., 1982) and even a six-factor structure (Bessant, 1995; Pletzer et al., 2016). Whilst labelling of factors has varied, studies have consistently reported a factor pertaining to maths evaluation or testing. Remaining factors generally relate to maths learning and calculations/problem-solving. There is some evidence for specific factors, e.g. relating to passive experience of maths (Bessant, 1995; Hunt et al., 2011), anxiety associated with maths in everyday contexts, i.e. outside of school or academic settings (Hunt et al., 2011), and maths anxiety associated with abstract maths (Ferguson, 1986). Whilst scores on very brief scales, such as the SIMA (Núñez-Peña et al., 2014), have been shown to have strong validity and reliability, they do not capture the complexity of maths anxiety across individuals and do not enable researchers to take nuanced measures of maths anxiety that may apply to certain contexts more than others. For example, other scales have also assessed the dimensions of maths anxiety that include items on the manifestation of math anxiety, rather than just situations, such as cognitive and affective subscales of math anxiety (Ho et al., 2000).

Maths Anxiety Scale Translation

Organisation for Economic Co-operation and Development (OECD, 2015) data and maths anxiety review papers (e.g., Dowker et al., 2016) highlight maths anxiety as a global phenomenon (Lau et al., 2022). Lee (2009) conducted factor analyses on data from 41 PISA 2003 participating countries, which demonstrated that maths anxiety, maths self-efficacy and maths self-concept are universally related yet distinguishable from each other. Therefore, researchers have translated and modified English measures of maths anxiety into a range of other languages (Artemenko et al., 2021; Baloglu & Balgalmis, 2010; Brown et al., 2020; Cipora et al., 2015; Krinzinger et al., 2009; Kyttälä & Björn, 2010; Núñez-Peña et al., 2013; Rubinsten et al., 2015; Szczygiel, 2020; Vahedi & Farrokhi, 2011; Wood et al., 2012; Xie et al., 2019). The similar factor structures, good reliability and similar patterns of correlations with other forms of anxiety, has highlighted the robustness and validity of these translated and modified instruments.

It is important that educators and researchers adopt valid measurement tools for assessing maths anxiety in students and participants. To the best of the current authors' knowledge, there have been few attempts to assess the validity of existing maths anxiety scales in Hebrew. Macmull and Ashkenazi (2019) used a Hebrew version of the shortened Mathematics Anxiety Rating Scale (Suinn & Winston, 2003) to test the relationship between maths anxiety, maths self-efficacy, and parenting style. Whilst they provided some evidence for the validity of the translated scale, they did not incorporate additional measures of anxiety to assess discriminant and convergent validity.

1) The MARS-R (Plake & Parker) and its revision by Hopko, are two different instruments, which are often mixed up in the literature due to naming proposed by Hopko, who used the term "Revised MARS-R".

Current Study Scales

Following inclusion of alternative terms and items pertaining to maths situations that would be more familiar to individuals in the U.K., Hunt et al. (2011) developed the 23-item MAS-UK. The MAS-UK scores were shown to be reliable, valid and appropriate for assessing maths anxiety in British and European populations. An exploratory factor analysis on the MAS-UK generated a 3-factor solution. Of the 3 factors, the first related to evaluation of maths ability and accounted for 42.5% of the variance. As the items reflect testing and calculation in front of others it was named 'Maths Evaluation Anxiety'. The second factor (accounting for 4.7% of the variance) included items that relate to everyday social occurrences, such as adding up a pile of change, and was labelled 'Everyday/Social Maths Anxiety'. The final factor (accounting for 4.5% of the variance) was named 'Maths Observation Anxiety' as the items represent passive observation of maths, e.g., watching a teacher/lecturer writing an equation on the board. Hunt et al. reported the MAS-UK to have high internal consistency (Cronbach's α = .96) and excellent test-retest reliability (r = .89). Further studies have supported these findings (Firouzian et al., 2015; Vallée-Tourangeau et al., 2016).

The MAS-UK has been translated and modified for use with University students in Iran (Firouzian et al., 2015). The scale was reported to have very good internal consistency (Cronbach's α = .87) and convergent validity was demonstrated through significant relationships between scores on the Maths Evaluation Anxiety and Social/Everyday Maths Anxiety subscales and maths confidence. A modified version of the MAS-UK was also deemed to be suitable for a Hungarian student population (Bernáth & Krisztián, 2017), again demonstrating high internal consistency and test-retest reliability. The researchers further confirmed the existence of a three-factor structure, consistent with that observed by Hunt et al. (2011) and suggested the removal of a small number of items. Thus, the MAS-UK has been shown to be a suitable measure of maths anxiety in countries where English is not the dominant language. The MAS-UK was chosen for this reason, as well as to add further maths anxiety scales to the limited pool of Hebrew measures.

Another measure of maths anxiety, the MARS-R (Hopko, 2003), has also been translated into Hebrew. The 12-item MARS-R was developed by Hopko (2003) after assessing the validity of an earlier version of the scale, containing 24 items (Plake & Parker, 1982), using confirmatory factor analysis. Hopko identified that the original model fitted the data poorly, therefore 12 items were removed, which was shown to fit a two-factor solution with improved goodness-of-fit indices. The two factors identified were 'Learning Math Anxiety' (concerning items associated with thinking about maths or using maths materials) and 'Math Evaluation Anxiety' (much like the MAS-UK factor of a similar name, it concerns being tested and evaluated by others). This was translated to Hebrew and published by the The National Center for Mathematics Teachers in Upper Secondary Education (Hershkovitz & Rotenberg, 2013) to measure and track maths anxiety in adolescents. However, when translated, this scale was not tested for any form of validity or reliability.

Study Aims

The aim of this study was to validate a Hebrew version of the MAS-UK (Hunt et al., 2011) and MARS-R (Hopko, 2003) for use with an Israeli adult population, with the inclusion of a further, general anxiety measure. We anticipated the scales to maintain high internal consistency in a new population. Given the modification in language, exploratory factor analysis was used to explore the factor structure of the scales, with the expectation that this would be similar to previous factor structures. Furthermore, it was assumed that maths anxiety scores, measured using the modified MAS-UK and MARS-R, would be related (convergent validity) whilst also being related, but to a lesser extent, to general anxiety (discriminant validity). Finally, consistent with previous findings based on an Israeli population (Macmull & Ashkenazi, 2019; OECD, 2013), it was expected that women would report higher maths anxiety than men.

Method

Participants

Participants were 239 adults in Israel. Twenty-six participants were removed as they had missing data on scale items. Of the remaining 213 participants, 1 non-student did not report their sex. Participants comprised 155 students enrolled at the Reichman University in central Israel (123 [79.35%] Women, Mean age = 23.92, SD = 2.36). Note that due to mandatory national service / military service in Israel, students are older when they enrol at the university compared to countries which do not require such a service. The remaining 58 participants were non-student Israeli adults (42 Women [72.41%], Mean age = 31.84, *SD* = 9.09). All had Hebrew as their first language. Students received research credits for their participation, whilst non-students received no reward for participating.

Student participants were recruited via the university's online research participation system and non-students were recruited via social media (online completion of the scales was not anticipated to influence participants' maths anxiety scores nor the factorial structure of maths anxiety; c.f. Cipora et al., 2018). The survey was administered using Qualtrics online software and the presentation order of the measures was randomised.

Materials and Procedure

Maths Anxiety Scale – UK (MAS-UK)

The 23-item translated version of the MAS-UK (Hunt et al., 2011) was used to measure maths anxiety levels of participants. Participants are asked how anxious they would feel in a range of situations (e.g. 'Being asked to add up the number of people in a room'), with scores calculated using a five-point Likert scale (from 1 – *Not at all*, to 5 – *Very much*). Higher scores indicate higher levels of maths anxiety, up to a maximum total of 115. The translation process of the MAS-UK followed International Test Commission guidelines (ITC, 2017). The scale was translated to Hebrew by an independent, native Hebrew speaker who was fluent in English (forward translation) and then translated back to English by another independent, native Hebrew speaker who is fluent in English (back translation). Finally, the overall process was reviewed by a further independent, fluent Hebrew and English speaker. One item was edited to ensure cultural relevance with an Israeli population; the item on the MAS-UK that includes Pounds (£) as a currency was amended to Shekels (₪).

Maths Anxiety Rating Scale – Revised (MARS-R)

In addition to the translated version of the MAS-UK, a translated version of the MARS-R (Hopko, 2003) was used to assess maths anxiety. The MARS-R is a 12-item measure of maths anxiety, where participants are asked how anxious they would feel in the presented situations (e.g. 'Watching a teacher work an algebraic equation on the blackboard'), measured on a five-point Likert scale (from 0 – *I don't feel anxious at all*, to 4 – *I feel very anxious*). Higher scores indicate higher levels of maths anxiety, up to a maximum total of 48. After data collection, it was found that the original translation article (Hershkovitz & Rotenberg, 2013) had mistranslated the item, confusing the word 'text' with 'test'. This changed the item 'Looking through pages in a maths text' to 'Looking through pages in a math test'. Implications of this are noted in the results.

Beck Anxiety Inventory (BAI)

The BAI (Beck et al., 1988) was included in order to assess discriminant validity. The BAI has previously been translated to Hebrew and used in Israeli populations (Lupo & Strous, 2011). The BAI is a 21-item self-report measure of general anxiety shown to have high internal consistency (Cronbach's α = .92) and test-retest reliability (over one week: $r_{tt}[81] = .75$; Beck et al., 1988). This scale is often used for measuring anxiety levels in both clinical and non-clinical samples and has been shown to have better convergent and discriminant validity than other measures of general anxiety (Fydrich et al., 1992). Items ask how bothered individuals have been by a symptom (e.g. Unable to relax) during the past month (measured on a four-point Likert scale, from 0 – *Not at all* to 3 -*Severely – it bothered me a lot*). The total score is calculated by summing the score on each of the items with higher scores (up to a maximum of 63) indicating higher levels of anxiety.

Results

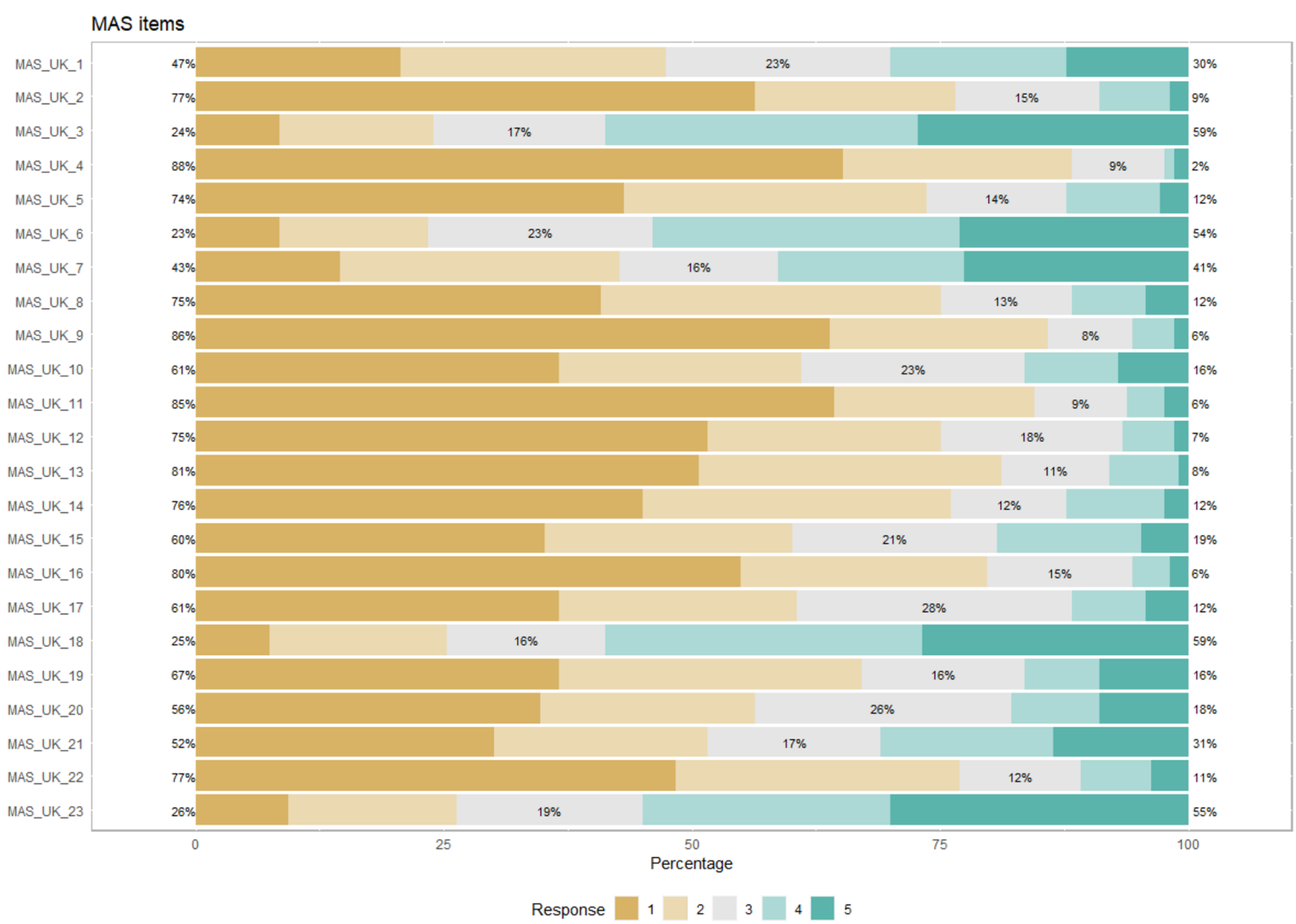
Data Screening

Internal consistency checks, initial exploratory factor analyses and scale and subscale correlations were conducted in SPSS. Bayesian analyses and between-group comparisons were obtained using JASP. Parallel analysis (used alongside initial factor analyses) was conducted using Monte Carlo PCA for Parallel Analysis (Computer Software; Watkins, 2000). Ordinal alpha was calculated using R and further factor analyses were calculated using FACTOR (Lorenzo-Seva & Ferrando, 2006). Data were plotted and, with the exception of BAI scores, deemed to be normally distributed. The positive skew observed among the BAI data is to be expected; lower scores show evidence of lower clinical anxiety, which is more likely in a non-clinical population (Magán et al., 2008). Levene's test results indicated the homogeneity of variance assumption was met for all comparisons, with the exception of BAI between men and women (p = .05). Item scores were summed to provide total scores for each of the scales and relevant items were summed to create subscale totals for the MAS-UK and MARS-R. These total scores were used for convergent and discriminant validity analyses, whereas item-level data were used in the internal consistency and factor analyses.

Responses to all the items of the MAS-UK are presented in Figure 1. To ensure there were no significant differences in maths anxiety and general anxiety between students and non-students, independent samples t-tests were conducted on scale total scores.

Figure 1

Distribution of Responses to Items of the MAS-UK



There was no significant difference in maths anxiety according to the MARS-R, $t(211) = .37$, $p = .71$, $d = 0.06$, $BF_{01} = 5.64$ and the MAS-UK, $t(211) = .18$, $p = .86$, $d = 0.03$, $BF_{01} = 5.92$. Finally, there was no significant difference in general anxiety, $t(211) = 0.72$, $p = .47$, $d = 0.11$, $BF_{01} = 4.72$ (see Table 1 for means and *SD*s). In all cases Bayesian analysis supported the null hypothesis model (i.e., no between group differences, as all $BF_{01} > 3$).

Table 1

Anxiety Totals (SDs) and Means (SDs) for Students and Non-Students

	Anxiety Measure					
	MARS-R		MAS-UK		BAI	
Participant Group	**Total**	***M***	**Total**	***M***	**Total**	***M***
Student	21.79 (11.39)	1.82 (0.95)	53.17 (18.60)	2.31 (0.81)	13.80 (10.94)	0.66 (0.52)
Non-Student	21.14 (11.31)	1.77 (0.95)	53.75 (19.92)	2.34 (0.87)	12.58 (9.14)	0.60 (0.44)
Total	21.61 (11.34)	1.80 (0.95)	53.31 (18.88)	2.32 (0.83)	13.48 (10.45)	0.64 (0.50)

Note. Range of total scores (and range of the scale for means) for each scale: MARS-R = 0-48 (0-4), MAS-UK = 23-115 (1-5), BAI = 0-63 (0-3).

Internal Consistency of the MAS-UK, MARS-R and BAI

Cronbach's alpha was used to measure the internal consistency of all scales and subscales. However, to account for the ordinal nature of Likert scale data, ordinal alpha was also reported (Cipora et al., 2015).

All MAS-UK items were correlated with the overall 23-item scale total (minimum $r = .49$). Cronbach's alpha was .95 and ordinal alpha was .97, indicating very high internal consistency. Maths Evaluation Anxiety, Everyday/Social Maths Anxiety and Maths Observation Anxiety total subscales also showed very high internal consistency (Cronbach's alpha = .93, .89 and .87, ordinal alpha = .95, .92 and .93, respectively). The MARS-R also showed very high internal consistency (Cronbach's alpha = .94, ordinal alpha = .96), as well as for the Math Learning Anxiety and Math Evaluation Anxiety subscales (Cronbach's alpha = .92, .91, ordinal alpha = .94, .94 respectively). The BAI also showed high internal consistency (Cronbach's alpha = .91, ordinal alpha = .94).

Exploratory Factor Analysis of MAS-UK

Exploratory factor analysis was conducted on the 23-item MAS-UK using principal axis factoring as the extraction method, with a direct oblimin rotation. Factors were determined using eigenvalues greater than 1. A high Kaiser-Meyer-Olkin measure (KMO = .94) indicated sampling adequacy was met (Tabachnick et al., 2018). The mean correlation between extracted factors was .43 indicating non-orthogonality, justifying the decision to apply a direct oblimin rotation. Four factors were extracted, explaining a total of 64.16% of the variance, with 48.99%, 7.31%, 4.99%, and 2.88% of the total variance being explained by Factors 1 to 4, respectively. However, the eigenvalue of the fourth factor only just exceeded unity. Parallel analysis (Watkins, 2000), based on 100 random datasets, indicated only the first three eigenvalues exceeded the criterion values.

The analysis was re-run specifying the extraction of three factors. The pattern matrix was explored for factor loadings of .45 or more, as this is considered to be a good factor loading (Comrey & Lee, 1992). Of the 23 items, 3 did not load onto any factors (see Appendix A). Consequently, 3 items were removed and the analysis was rerun on the remaining 20 items. The KMO measure was still found to be high (.94). Three factors were extracted, based on eigenvalues above 1, which explained a total of 62.59% of variance, with 49.09%, 8.11% and 5.40% of the total variance being explained by Factors 1 to 3, respectively. All 20 items loaded onto one factor each (see Appendix B). The factor structure was broadly consistent with that observed by Hunt et al. (2011), except for one item ('Being asked to calculate three fifths as a percentage') which loaded onto Everyday/Social Maths Anxiety instead of Maths Evaluation Anxiety. Everyday/Social Maths Anxiety retained eight items, Maths Evaluation Anxiety retained seven items, and Maths Observation Anxiety retained five items. Maths Evaluation Anxiety and Maths Observation Anxiety items had negative loadings as the factors were negatively correlated to the Maths Evaluation Anxiety Factor (-.510 and -.522, respectively). These two factors were positively correlated with each other (.520).[2]

The above analysis was conducted in SPSS to enable comparison to previous factor analyses typically reported in the extant literature. However, to account for the ordinal nature of the data, a further exploratory factor analysis was carried out in FACTOR, a standalone exploratory factor analysis package that has the ability to run polychoric correlations, rather than the standard Pearson correlations that are the default in SPSS. The procedure was followed using the recommendations of Baglin (2019). When running the analysis with three factors selected and a direct oblimin rotation (to match the previous analysis), the output showed similar results. A high KMO (.89) was reported and the overall loading matrix was the same (with some slightly different item loading values). The same three items that failed to load in the SPSS analysis again did not load or cross loaded onto multiple factors (see Appendix A). The analysis was re-run, removing these items which again showed the same loading matrix to the 20-item analysis conducted in SPSS (see Appendix B).

Cronbach's Alpha of the Hebrew MAS-UK – Revised (H-MASUK-R)

Reliability analysis was conducted on the total scores for the Hebrew revised MAS-UK (H-MASUK-R), which showed that all 20 items were still found to be correlated with the overall scale (minimum $r = .50$). Cronbach's alpha was .95 and ordinal alpha was .96, suggesting high internal consistency. Maths Evaluation Anxiety, Everyday/Social Maths Anxiety and Maths Observation Anxiety subscales again showed very high internal consistency (Cronbach's alpha = .92, .90 and .92, ordinal alpha = .94, .93 and .94, respectively).

Exploratory Factor Analysis of MARS-R

The same exploratory factor analysis method was applied to the Hebrew MARS-R (KMO = .94). The correlation between extracted factors was -.74 indicating non-orthogonality, justifying the decision to apply a direct oblimin rotation. Two factors were extracted, explaining a total of 65.80% of the variance, with 58.67% and 7.12% of the total variance being explained by both factors. All 20 items loaded onto one factor each (see Appendix C). The factor structure was broadly consistent with that observed by Hopko (2003), except the first item ('Looking through pages in a math text'), loaded onto the Math Evaluation Anxiety factor instead of Math Learning Anxiety factor. This was due to the mistranslated item, noted above where the word 'text' was replaced with 'test'. All items that loaded onto Maths Evaluation Anxiety had negative loadings as this factor was negatively correlated with the Maths Learning Anxiety Factor (-.736). When run in FACTOR the same structure and similar item loadings to the SPSS analysis were also identified (see Appendix C).[3]

To justify using total scores for subsequent analyses, factor scores were obtained for each maths anxiety scale and correlated with subscale total scores. There was a strong significant correlation between H-MASUK-R Everyday/Social Maths Anxiety total and factor scores, $r(211) = .99$, $p < .001$, $BF_{10} > 10^6$, Maths Evaluation Anxiety total and factor scores, $r(211) = .98$, $p < .001$, $BF_{10} > 10^6$, and Maths Observation Anxiety total and factor scores $r(211) = .99$, $p < .001$ $BF_{10} > 10^6$. There was also a strong significant correlation between MARS-R Math Evaluation Anxiety total and factor scores, $r(211) = .99$, $p < .001$, $BF_{10} > 10^6$, and Math Learning Anxiety factor scores, $r(211) = .98$, $p < .001$, $BF_{10} > 10^6$.

Convergent and Discriminant Validity

There was a strong, positive, significant relationship between the 20-item H-MASUK-R and MARS-R totals, $r(211) = .81$, $p < .001$, $BF_{10} > 10^4$. There was also a moderate, positive, significant relationship between the H-MASUK-R and the BAI totals, $r(211) = .29$, $p < .001$, $BF_{10} = 983.1$, and MARS-R and BAI totals, $r(211) = .32$, $p < .001$ $BF_{10} = 8643$ (see Table 2). All correlations are supported by extremely strong Bayesian evidence.

2) Negative correlations between factors originate from the analytical solution implemented in SPSS, while weighting of items shows they are correlated positively. This means that for interpretation of the correlations between scores one should ignore the sign of correlation value and item loadings.

3) It should be noted that when determining the number of factors to extract, FACTOR recommended extracting one or two factors for the MAS-UK and one factor for the MARS-R. We have kept the original three and two factor solutions to enable comparisons to previous research however, we do note that using polychoric correlations to account for the ordinal nature of the data is preferable moving forward.

Table 2

Pearson's Correlations and BF_{10} [95% Upper and Lower Credible Intervals (Bayesian)] of All Anxiety Scales' and Subscales' Total Scores

Scale/Subscale	1	2	3	4	5	6	7	8
1. H-MASUK-R	—							
2. H-MASUK-R Evaluation	.91 >10^6 [.87-.92]	—						
3. H-MASUK-R Social/Everyday	.89 >10^6 [.86-.91]	.68 >10^6 [.60-.75]	—					
4. H-MASUK-R Observation	.84 >10^6 [.79-.88]	.69 >10^6 [.61-.75]	.61 >10^6 [.52-.69]	—				
5. MARS-R	.81 >10^6 [.76-.85]	.82 >10^6 [.77-.86]	.58 >10^6 [.48-.66]	.79 >10^6 [.73-.84]	—			
6. MARS-R Evaluation	.81 >10^6 [.76-.86]	.76 >10^6 [.70-.81]	.60 >10^6 [.51-.68]	.84 >10^6 [.79-.87]	.97 >10^6[a]	—		
7. MARS-R Learning	.68 >10^6 [.60-.74]	.79 >10^6 [.73-.84]	.43 >10^6 [.32-.53]	.58 >10^6 [.48-.66]	.90 >10^6 [.87-.92]	.76 >10^6 [.69-.81]	—	
8. BAI	.29 983.1 [.16-.41]	.31 2388 [.18-.42]	.20 6.12 [.07-.32]	.28 455.6 [.15-.40]	.32 8643 [.20-.44]	.29 3499 [.18-.43]	.31 1004 [.16-.41]	—

Note. All correlations are significant at $p < .001$. H-MASUK-R = Hebrew-Maths Anxiety Scale - UK - Revised; MARS-R = Maths Anxiety Rating Scale - Revised; BAI = Beck Anxiety Inventory.

[a]Credible intervals were not estimated as BF was infinity.

Sex Differences

Sex differences in MARS-R, H-MASUK-R, and BAI total scores were explored. A significant difference in general anxiety was found, $t(210) = 3.11$, $p = .002$, $d = 0.51$, $BF_{10} = 14.26$, such that women had higher BAI scores ($M = 14.64$, $SD = 10.66$) than men ($M = 9.36$, $SD = 8.75$). A significant difference was also found in maths anxiety according to the MARS-R, $t(210) = 4.22$, $p < .001$, $d = 0.70$, $BF_{10} = 514.21$, such that women had higher maths anxiety ($M = 23.33$, $SD = 10.95$) than men ($M = 15.70$, $SD = 10.89$). Finally, a significant difference in maths anxiety was found according to the H-MASUK-R, $t(210) = 4.78$, $p < .001$, $d = 0.70$, $BF_{10} = 4530.14$, such that women reported higher maths anxiety ($M = 50.02$, $SD = 16.05$) than men ($M = 37.60$, $SD = 14.56$). All between group differences are supported by strong and very strong Bayesian evidence. This was also found for all subscales of the H-MASUK-R and MARS-R (see Table 3).

Table 3

Independent Samples t-test and BF_{10} Results for Sex Differences Across Maths Anxiety Subscales' Scores

Subscale	*t*(df)	*p*	BF_{10}	Men *M* (*SD*)	Women *M* (*SD*)
H-MASUK-R Evaluation	6.16 (210)	< .001	>10^6	15.00 (6.28)	21.18 (6.01)
H-MASUK-R Social/Everyday	3.63 (210)	< .001	67.24	13.79 (5.86)	18.02 (7.37)
H-MASUK-R Observation	2.52 (210)	.013	3.18	8.81 (4.26)	10.82 (4.98)
MARS-R Evaluation	3.52 (210)	.001	48.02	8.17 (7.00)	12.51 (7.57)
MARS-R Learning	4.72 (210)	< .001	3635.61	7.53 (4.57)	10.82 (4.10)

Discussion

This study aimed to assess the validity and factor structure of a Hebrew version of the MAS-UK (Hunt et al., 2011) and MARS-R (Hopko, 2003) in an Israeli adult population. Following factor analysis, the H-MASUK-R was reduced from 23 items to 20 as 3 items failed to load sufficiently. One item 'Being asked to calculate three fifths as a percentage', which originally loaded onto the 'maths evaluation anxiety' factor in Hunt et al.'s (2011) factor structure, now loaded onto the 'everyday/social maths anxiety' factor. This could be explained by the potential ambiguity of this item in the context of evaluation/testing as it does not entirely imply being evaluated or tested; items such as 'Taking a maths exam' or 'Being asked a maths question by a teacher in front of a class' directly infer evaluation/testing. Nevertheless, the reduction in items did not affect the internal consistency or validity of the measure. Internal consistency remained very high and the factor structure was largely consistent with that observed by Hunt et al. (2011), further supporting the proposition that maths anxiety is a multidimensional construct.

The strong positive correlation between the H-MASUK-R and the MARS-R demonstrated high convergent validity, and the moderate positive correlation between the maths anxiety scales and the BAI showed high discriminant validity. The strength of the correlations between the H-MASUK-R and the BAI (r = .29), and the MARS-R and BAI (r = .32) are typical of the relationship previously reported between maths anxiety and general anxiety (Hembree, 1990; Xie et al., 2019), although slightly lower than the relationship reported by others (O'Leary et al., 2017). This finding validates maths anxiety as a unique construct, distinct from, but related to, general anxiety.

Significant differences according to sex were observed for both maths anxiety (including subscales) and general anxiety. Whilst there are some mixed findings in the literature, it is commonly shown that women report higher levels of maths anxiety than men (Maloney et al., 2012). The findings from the current study support this and are consistent with the sex difference reported by Macmull and Ashkenazi (2019). In fact, the size of the difference, in terms of effect size, was approaching large according to Cohen's guidelines (Cohen, 1988). Macmull and Ashkenazi (2019) provide a useful explanation for the observed sex difference, in which they reported an indirect path between sex, maths self-efficacy and maths anxiety. Specifically, they observed that the negative relationship between self-efficacy and maths anxiety was stronger in women than in men. This has also been noted in past PISA data across OECD countries, where the gender gap in maths self-efficacy (for a number of mathematical tasks) has been shown to favour boys over girls, which can then affect maths performance (OECD, 2013). Future investigations should explore this sex difference in self-reported maths anxiety in relation to the broader context of sex and maths education in Israel.

The mean H-MASUK-R score was 2.36, which represents 'slightly' to 'a fair amount' of maths anxiety according to the corresponding response labels. This compares to a mean of 3.43 reported by Hunt et al. (2011) when measuring maths anxiety in a population of British undergraduates, representing 'a fair amount' to 'much' maths anxiety. An explanation for the lower level of reported maths anxiety in Israel could be due to the further exposure of university/college students (which made up the majority of the H-MASUK-R sample) to maths learning before entering higher education. Typical entry to Israeli universities and colleges requires a high score on a psychometric entrance test, which covers quantitative reasoning, verbal reasoning and English language. Thus, maths proficiency may be higher in Israeli university/college students. Whilst 27% of the sample were not current students in higher education, 95% of the sample reported having received one or more years of higher education, reflecting a highly educated sample; this may explain the non-significant difference in maths anxiety that was observed between students and non-students[4]. However, PISA data (OECD, 2013) demonstrated overall higher self-reported maths anxiety among 15 year-olds in Israel compared to those in the U.K. This demonstrates the need to consider education level when investigating cross-cultural differences.

To further validate the scale, future work should investigate the extent to which scores on the H-MASUK-R and MARS-R predict behavioural outcomes in an Israeli population, such as maths performance. Reasons for the observed sex difference should be explored and testing should occur within the wider adult population. In addition, further research should assess the validity of Hebrew versions of existing self-report measures of maths anxiety in a younger population. This study has provided evidence that the H-MASUK-R and MARS-R are suitable measures of maths anxiety in an Israeli adult population. It is recommended that the scales are implemented in empirical work with this population. Furthermore, educators may find the tools useful to identify students who may require support in overcoming maths anxiety.

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Data Availability: For this article, a data set is freely available (Batashvili, Cipora, & Hunt, 2021).

Supplementary Materials

Supplementary materials include the SPSS data and syntax files used for primary analyses, JASP outputs for Bayesian analyses, R scripts for figure creation and ordinal alpha calculation and a guide for using FACTOR factor analysis software (for access see Index of Supplementary Materials below).

Index of Supplementary Materials

Batashvili, M., Cipora, K., & Hunt, T. E. (2021). *Supplementary materials to "Measurement of mathematics anxiety in an Israeli adult population"* [Research data, code, and additional information]. OSF. https://osf.io/aqrvu/

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4) This is further supported by the lower mean MARS-R maths anxiety score in our non-student sample (1.76) compared to non-student adults MARS-R scores (2.30) in more Western countries (Hart & Ganley, 2019).

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Appendices

Appendix A

SPSS (and FACTOR) Factor Loadings of Items on the Hebrew – Mathematics Anxiety Scale UK – Revised Including Removed Items[a]

Item	Factor/Loading		
	Everyday/ Social Maths Anxiety	Maths Evaluation Anxiety	Maths Observation Anxiety
Adding up a pile of change	**.627 (.721)**	-.104 (.128)	.066 (-.079)
Being asked to add up the number of people in a room	**.606 (.799)**	-.001 (-.081)	.078 (-.070)
Calculating how many days until a person's birthday	**.762 (.835)**	-.064 (.082)	.060 (-.077)
Being given a telephone number and having to remember it	**.592 (.680)**	-.062 (.038)	.038 (-.036)
Working out how much time you have left before you set off to work or place of study	**.542 (-.118)**	.080 (.673)	-.188 (.185)
Working out how much change a cashier should have given you in a shop after buying several items	**.807 (.802)**	-.013 (.081)	-.079 (.105)
Deciding how much each person should give you after you buy an object that you are all sharing the cost of	**.743 (.746)**	.160 (.020)	-.166 (.159)
Being asked to calculate three fifths as a percentage	**.509 (.531)**	-.126 (.295)	-.297 (.163)
Working out how much your shopping bill comes to	**.783 (.791)**	.031 (.039)	-.117 (.120)
Having someone watch you multiply 12 x 23 on paper	.438 (.454)	**-.535 (.612)**	.049 (-.067)
Being asked to write an answer on the board at the front of a maths class	.128 (.214)	**-.842 (.787)**	.049 (.008)
Taking a maths exam	-.038 (-.011)	**-.658 (.586)**	-.237 (.359)
Being asked to calculate £9.36 divided by four in front of several people	.385 (.465)	**-.517 (.525)**	.019 (-.016)
Being given a surprise maths test in a class	-.093 (-.089)	**-.771 (.729)**	.210 (.350)
Being asked a maths question by a teacher in front of a class	.120 (.195)	**-.711 (.604)**	-.157 (.291)
Listening to someone talk about maths	.112 (.133)	-.019 (-.004)	**-.711 (.772)**
Reading a maths textbook	.125 (.138)	-.103 (.043)	**-.746 (.806)**
Watching someone work out an algebra problem	.042 (.066)	.016 (-.078)	**-.802 (.907)**
Sitting in a maths class	-.099 (-.085)	-.288 (.237)	**-.772 (.843)**
Watching a teacher/lecturer write equations on the board	.028 (.-.018)	-.315 (.289)	**-.611 (.727)**
Removed Items			
Calculating a series of multiplication problems on paper	.390 (.381)	-.291 (.352)	-.296 (.306)
Being asked to memorize a multiplication table	.429 (.396)	-.240 (.350)	-.196 (.189)
Reading the word "algebra"	.379 (.469)	.117 (-.307)	-.344 (.548)

Note. Bold highlighting indicates the item's loading on to the corresponding factor.

[a]As noted in the results section, negative correlations between factors originate from the analytical solution implemented in SPSS, while weighting of items shows they are correlated positively. Negative signs should be ignored for interpreting item loadings in this and following tables.

Appendix B

SPSS (and FACTOR) Factor Loadings of Retained Items on the Hebrew Revised Mathematics Anxiety Scale-UK

	Factor/Loading		
Item	**Everyday/ Social Maths Anxiety**	**Maths Evaluation Anxiety**	**Maths Observation Anxiety**
Adding up a pile of change	**.626 (.703)**		
Being asked to add up the number of people in a room	**.601 (.786)**		
Calculating how many days until a person's birthday	**.742 (.785)**		
Being given a telephone number and having to remember it	**.590 (.672)**		
Working out how much time you have left before you set off to work or place of study	**.555 (.685)**		
Working out how much change a cashier should have given you in a shop after buying several items	**.805 (.788)**		
Deciding how much each person should give you after you buy an object that you are all sharing the cost of	**.760 (.752)**		
Being asked to calculate three fifths as a percentage	**.499 (.506)**		
Working out how much your shopping bill comes to	**.777 (.793)**		
Having someone watch you multiply 12 x 23 on paper		**-.519 (.628)**	
Being asked to write an answer on the board at the front of a maths class		**-.870 (.903)**	
Taking a maths exam		**-.626 (.580)**	
Being asked to calculate £9.36 divided by four in front of several people		**-.505 (.541)**	
Being given a surprise maths test in a class		**-.743 (.736)**	
Being asked a maths question by a teacher in front of a class		**-.708 (.659)**	
Listening to someone talk about maths			**-.718 (.754)**
Reading a maths textbook			**-.743 (.801)**
Watching someone work out an algebra problem			**-.793 (.905)**
Sitting in a maths class			**-.804 (.855)**
Watching a teacher/lecturer write equations on the board			**-.620 (.686)**

Note. Bold highlighting indicates the item's loading on to the corresponding factor.

Appendix C

SPSS (and FACTOR) Factor Loadings of Items on the Maths Anxiety Rating Scale-Revised

	Factor/Loading	
Item	**Maths Learning Anxiety**	**Maths Evaluation Anxiety**
Looking through the pages in a math text	.217 (.162)	**-.646 (.732)**
Having to use the tables in the back of a math book	**.696 (.662)**	-.116 (.214)
Thinking about an upcoming math test one day before	-.095 (-.099)	**-.952 (.981)**
Watching a teacher work an algebraic equation on the blackboard	**.794 (.847)**	.023 (.005)
Being told how to interpret probability statements	**.873 (1.009)**	.074 (-.122)
Picking up a math textbook to begin working on a homework assignment	**.956 (.875)**	.099 (.040)
Taking an examination (quiz) in a math course	.028 (.065)	**-.904 (.904)**
Reading and interpreting graphs or charts	**.513 (507)**	-.282 (.355)
Signing up for a course in statistics	**.481 (.511)**	-.279 (.296)
Waiting to get a math test returned in which you expected to do well	.036 (-.016)	**-.721 (.833)**
Being given a "pop" quiz in math class	.044 (.076)	**-.823 (.843)**
Walking on campus and thinking about a math course	**.638 (.582)**	-.139 (.269)

Note. Bold highlighting indicates the item's loading on to the corresponding factor.

Appendix D

Hebrew – Mathematics Anxiety Scale UK – Revised (H-MASUK-R)

עברית - שאלון חרדות מתמטיקה UK - מעודכן

		עד כמה את/ה מרגיש חרד/ה במצבים המתוארים מטה? אנא סמן/ני את התשובה הנכונה ביותר:				
		כלל לא	מעט	במידה קלה	במידה רבה	במידה רבה מאוד
1	מישהו מסתכל עלייך בשאת/ה מכפיל/ה X12 23עם נייר ועפרון	1	2	3	4	5
2	.כשאת/ה סופר/ת חופן מטבעות	1	2	3	4	5
3	אם תתבקש/י לכתוב את התשובה לשאלה במתמטיקה .על הלוח מול כל הכיתה	1	2	3	4	5
4	.אם תתבקש/י לספור את מספר האנשים בחדר	1	2	3	4	5
5	אם תתבקש/י לחשב כמה ימים נותרו עד ליום ההולדת .של מישהו	1	2	3	4	5
6	.במהלך מבחן במתמטיקה	1	2	3	4	5
7	אם תתבקש/י לחלק 9.36 ₪ ל-4, כשאת/ה מול כמה אנשים	1	2	3	4	5
8	.אם יתנו לך מספר טלפון ותתבקש/י לזכור אותו	1	2	3	4	5
9	אם את/ה צריך/כה לחשב כמה זמן נותר לך עד .שתצטרך/כי לצאת לעבודה או ללימודים	1	2	3	4	5
10	.כשאת/ה מקשיב/ה למישהו מדבר על מתמטיקה	1	2	3	4	5
11	כשאת/ה צריך/כה לחשב כמה עודף הקופאי/ת היה/יתה .צריכה להחזיר לך בחנות אחרי שקנית כמה פריטים	1	2	3	4	5
12	כשאת/ה צריך/כה לחשב כמה כל אדם צריך לשלם לאחר .קניה משותפת של פריט מסוים	1	2	3	4	5
13	.כשאת/ה קורא ספר לימוד במתמטיקה	1	2	3	4	5
14	.כשאת/ה צופה במישהו פותר תרגיל באלגברה	1	2	3	4	5
15	.כשאת/ה נמצא/ת בשיעור מתמטיקה	1	2	3	4	5
16	.כשנותנים לך בוחן פתע במתמטיקה	1	2	3	4	5
17	.כשהמורה / המרצה כותב משוואות מתמטיות על הלוח	1	2	3	4	5
18	כשאת/ה מתבקש/ת לחשב מהו שלוש חמישיות באחוזים	1	2	3	4	5
19	.כשאת/ה צריך/כה לחשב כמה יצא חשבון הקניות שלך	1	2	3	4	5
20	.כשהמורה שואל אותך שאלה מתמטית מול כל הכיתה	1	2	3	4	5

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