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AN EXPLORATORY FACTOR ANALYSIS OF MATH ANXIETY QUESTIONNAIRE IN A 5TH-GRADE ROMANIAN SAMPLE – A PRELIMINARY STUDY

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Abstract
The current study examines the factorial structure of a modified version of the Math Anxiety Questionnaire (Wigfield & Meece, 1988). We conducted an exploratory factor analysis on a 5th-grade Romanian sample and found support for a three-factor structure. A Math test and evaluation factor added to the original two-factor structure of worry and negative affect. Results are discussed in the light of possible implications for Math anxiety assessment and intervention in Romanian students.

***Keywords*:** Math anxiety, exploratory factor analysis

Introduction

Given the complexity of its expression and the complexity of Mathematics, one can understand the lack of consensus on one definition of Math anxiety. There are various definitions that describe the construct, of which the one of Richardson and Suinn is mostly employed in research. Richardson & Suinn (1972) define math anxiety as *"a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in ... ordinary life and academic situations"* (p.551). There is a significant association between math anxiety and math performance (Ashcraft & Ridley, 2005). Studies show that math

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anxiety is negatively related to math performance, thus representing a threat in the long run for professional success, Math course enrollment. Individuals with math anxiety will enroll in only few classes that involve math and may develop a negative attitude towards math (Ashcraft, 2002; Hembree, 1990; Meece, Wigfield, & Eccles, 1990) and avoid situations that require Math. The results of the Pisa Study (Organisation for Economic Co-operation and Development [OECD], 2012) show that with regard to Romania, 75% of the students who took the tests reported that they feel worried in relation to Math and that the math classes are difficult.

The preoccupation for studying more systematically math anxiety started six decades ago (Dowker, Sarkar, & Looi, 2016). Much research has been carried on since 1972 on the dimensionality of the construct. Research that addresses the multidimensionality of Math anxiety takes one of the two dominating conceptualizations (Vukovic, Kieffer, Bailey, & Harari, 2013): dimensions given by a particular math context, such as operating with numbers or being evaluated on Math knowledge and skills; another conceptualization which draws on existing cognitive models of anxiety, considers the cognitive and the affective features of Math anxiety. First of them views math anxiety through two related aspects: *numerical anxiety* (involved in math use in everyday situations) and *math test anxiety* (math evaluation in school).

Mathematics Anxiety Rating Scale -MARS (Richardson & Suinn, 1972), a 98 items scale using daily situations in which math is needed, is constructed in this conceptualization. This instrument was created initially for adults use but it was adapted for teenagers from 7th to 12th grade (Suinn & Edwards, 1982), for children in elementary school 4^{th} to 6^{th} grade (Suinn, Taylor, & Edwards, 1988) and most recently for children before 4^{th} grade (Gierl & Bisanz, 1995; Ramirez, Gunderson, Levine, & Beilock, 2013; Young, Wu, & Menon, 2012).

Rounds and Hendel (1980) analyzed the factorial structure of MARS and brought evidence for the two factor model of numerical and Math test anxiety. Using MARS – A, Suinn and Edwards (1982) showed that it is possible to distinguish between emotional reactions from using math in testing and no testing situations, but not between cognitive and affective components of math anxiety.

The second model is based on the generalized anxiety model. The common feature for most anxiety disorders is worry. Based on this model, math anxiety comprises: *worry* (cognitive behavior regarding the preoccupation for the performance and weighing the consequences in case of failure) and *negative reactions* (emotional component – tension and nervousness that appear in testing situations and its physiological reactions. Wigfield and Meece (1988) obtained that the emotional component is more strongly related to Math performance, as compared to the worry component (see Morris, Davis, & Hutchings, 1981, for a review of the work on worry and emotionality, (Sarason, Sarason, Keefe, Hayes, & Shearin, 1986; Wine, 1971; Wine, 1980).

Conceptualization on two components served as a base for the development by Wigfield and Meece (1988) of Math Anxiety Questionnaire (MAQ; developed initially by Meece, 1981), but also Fennema–Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976) and Mathematics Anxiety Scale (Betz, 1978).

MAQ includes items that are meant to evaluate the possible cognitive and affective components of math anxiety, starting from the work of Liebert and Morris (1967). According to Wigfield and Meece (1988, p. 211), Meece defined 6 possible dimensions of negative reactions regarding math: lack of confidence, dislike, discomfort, worry, fear and confusion/frustration). The initial items were built or adapted from other instruments of math anxiety. After the exploratory analysis, 11 items were kept in the final version of the instrument. Both exploratory and confirmatory analyses were made involving students from 6th to 12th grade and showed the existence of two factors. The first one represents the worry of how the math tasks are performed (4 items) and the second represents negative affective reactions towards math (7 items). On the original MAQ, internal consistency was adequate Alpha Cronbach was .76 for worry scale and .80 for negative affective reactions towards math scale (Wigfield & Meece, 1988). Kazelskis and Reeves-Kazelskis (1999) conducted a study with 135 men and 173 women, students in the first year at college. The results of factor analysis showed that the model with two factors (worry and negative reactions) was adequate for both men and women, not being shown any variations based on gender.

Ho et al. (2000) tested the bidimensional model in three different cultural contexts (China, Taiwan and the United States of America) in the case of 6th graders. The study reproduced the two-factor structure. Similar results were obtained by Bai, Wang, Pan, & Frey (2009) and Jenßen, Dunekacke, Eid, Blömeke (2015). By analyzing the literature, we can say that limited testing of this factor structure has been conducted, as compared to the first conceptualization. Given this lack of consensus in definitions, as a reflection of the complexity of the Math anxiety phenomenon, there is still much to explore on the dimensionality of the construct, while considering the various Math anxiety measures.

Math anxiety is nearly exclusively measured through the use of self-administered questionnaires with rating scales (Luttenberger, Winner, & Paechter, 2018), that were addressing a wide range of age groups. By analyzing the content of such measures, Math anxiety seems to be assessed more in a global way. The instruments vary on at least three characteristics (Luttenberger et al., 2018): 1. the age group addressed, which raised constraints on formulating and answering formats that are developmentally appropriate; 2. The dimensions of Math anxiety they measure; 3. The various weights given to Math anxiety vs other related variables such as Math appraisals. In order to efficiently intervene to alleviate the negative reactions as well as the negative consequences of Math anxiety, it is important to have relevant measures of the construct (Wilder, 2013) and to better understand the nature of Math anxiety.

While using Richardson and Suinn's definition to guide our study, we employed an existing MA measure that subscribes to the second conceptualization. In anxiety research literature, worry is considered as an important feature of anxiety, if not even a primary feature (see Rabner, Min, Langer, Comer, & Pincus, 2017; on Weems, 2008). On the other hand, the negative affective reactions experienced by children are also important to be assessed and addressed by the individual and by the other actors involved (teacher, parents, and psychotherapists). Based on the current knowledge and while assuming the existence of at least these two dimensions of math anxiety, we will also investigate the distinctiveness of the concept dimensions through their relationships with Math performance. Wigfield and Meece (1988) recommended further deepening the knowledge of the dimensionality of MA by assessing also the time when these two dimensions can be identified in younger children. In their sample, they included students from 6^{th} up to 12^{th} grade.

Method

Participants

A total of 146 children from three public urban schools from Cluj- Napoca, Romania participated in this study. Parental consent forms were obtained from each child participating in the study. A total of 146 signed parental consent forms were returned. All of the participants were in the fifth grade of elementary school, 88 boys and 58 girls with ages between 10 and 12 years (mean age 11 years 5 months). We chose 5th grade, as students go from primary school to secondary school and from one primary education teacher to one teacher for every subject, including Math. Schools differed in performance ranking (school B being in the top 10 of schools in the city, based on national evaluation grades, while schools A and C being somewhat equal in rank, in the first 40). The distribution of children per school was as follows: 17 children belonged to school A, 54 were enrolled in school B, while 77 were enrolled in school C. Students belonged to various socio-economic statuses. A one-way between-subjects ANOVA was conducted to compare the effect of school on Math anxiety. There was no significant effect of school on Math anxiety reports at the $p <.05$ level for the three conditions [$F(2, 143) = .296$, $p = .74$].

Measures

In this study, we measured Math anxiety using a modified version of Math Anxiety Questionnaire (Wigfield & Meece, 1988). We have translated the 11 items. The retroversion was done by an English teacher. The two versions were compared and minor revisions were made in order to better word the questionnaire. Differences emerged while adapting to the emotional vocabulary used. Also, another modification to the original 7-point Likert scale was done. Initially, the instrument was employed for students between 6^{th} to 12^{th} grades. Given that we applied it to a younger sample, we have reduced the rating scales to a 5- point one.

We based this decision on several reasons: firstly, children of this age, at least in Romania, have very little experience with the Likert response format; secondly, having more than five points does not add extra- utility (Lissitz & Green, 1975), while having more than 5- points affects response rate and increases demands on the judgment tasks for children that are in the beginning of formal operations stage (some of them still in the concrete operational stage). Therefore, responses were on a Likert- type scale, ranging from 1 which was "never true about me" to 5- "always true about me" (for the Negative affect scale). For the worry response scale, we used different wording, in accordance with the content of the items. All items were measured using a 5- point scale anchored with 1- not at all, to 5- every time. All response formats used numeric values and word-based anchors, which add to the accuracy of response in order to better reflect their judgment (Mellor & Moore, 2014).

We decided on dropping out original item 8, as it addressed worry related to school, in general. The original item was: "In general, how much do you worry about how well you are doing in school? (not at all, very much)". By looking at its content, we considered that the question addressed more aspects of academic anxiety, in general. The independence of math anxiety from academic anxiety is not enough clarified, with data suggesting that, at least in older children, Math anxiety being specific, rather than going across academic domains (apud Punaro & Reeve, 2012). We remained with a 10- item questionnaire, with a Likert- type scale of 5.

Procedure

Math Anxiety Questionnaire was administered collectively by a trained psychologist during Counseling hours (from February until March 2015). The questionnaire was presented to the students and the procedure was explained in front of the class. Afterward, the questionnaires were given to the students to be scanned. They could ask the operator for further explanations. Students could re-nounce to complete the measures at any time. However, all completed the measure. Mathematics teachers were not present during questionnaire administration.

Upon request and with parents' agreement, we have received the semester grades in Mathematics.

Statistical analysis

Several preliminary analyses were conducted. We analyzed the data for factorability. An EFA with a Principal Component Analysis with varimax rotation was conducted in order to examine the structure of the modified MAQ. We tested a two and a three-factor solution. Cut off criteria for the eigenvalues was 1. We considered the cross-loadings as situations in which variables had a second loading of at least .3. We employed the following criteria in order to make interpretation easier: load onto the primary factor to be above.4, load onto the second factor to be below .3 (Costello & Osborne, 2005); 3. the difference between the primary loading and the secondary loading to be of more than .2. In order to address the significance of the factor loadings we used the Guidelines for identifying significant factor loadings on sample size (Hair, Black, Babin, & Anderson, 2014). Accordingly, values of loadings between.45 and .5 for our sample size (at a significance level of .5, a power level of 80%, and standard error assessment twice those of conventional correlation coefficients) were considered adequate.

An internal consistency analysis for the three components was run. Lastly, since worry and negative affect seem to have a different effect on Math performance, we conducted a correlation analysis between the components and Math performance, as measured by the final semester grades.

Results

Factor analysis

Sample adequacy for factorization

Nine out of the ten items correlated at least .3 with at least one other item (see the correlation matrix). Sampling adequacy was tested using the Kaiser-Meyer- Olkin test. We obtained a KMO= .72, which is above the recommended value of .6. Bartlett's test of sphericity was significant (χ^2 (45) = 290.238, p< . 000), indicating an adequate correlation structure. Communalities were above .3. Overall, these indicators supported the appropriateness of factor analysis for our data. An EFA with a Principal Component Analysis with varimax rotation was conducted in order to examine the structure of the modified MAQ.

Method of factor number extraction

Secondly, we established a method for factor number selection. Initial eigenvalues indicated that the first three factors explained 31,87%, 13.10% and respectively 10.22% of the variance. The other factors had eigenvalues less than one. We optioned for a three-factor solution which explained 55.20% of the variance because: 1. the Kaiser criterion (three factors had eigenvalues above 1); 2. scree plot criterion (because of the small drop in eigenvalues between factor 3 and factor 4); 3. The need not to under specify, given that the last two factors explain an equal amount of variance. We have examined the loading pattern for the unrotated solution. Given that the pattern presented a high number of cross-loadings, we proceeded to rotating the factor matrix.

We decided to begin with an oblimin solution. However, the resulting component correlation matrix indicates orthogonal factors (see table 1).

Table 1. Component Correlation Matrix.

Component	1	2	3
1	1	.19	.36
2		1	.16
3			1

Note. Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Consequently, we re-run the analysis using Varimax rotation. The rotated component matrix is displayed in table 2.

Table 2. Rotated Component Matrix[a].

	Component		
	1	2	3
Item3	.77		
Item6	.70		
Item7	.57		
Item2	.51		
Item4		.81	
Item1		.74	
Item5	.45	.62	
Item8			.77
Item10			.65
Item9			.57

Note. Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

In the VARIMAX-rotated factor solution, the first factor accounted for 21.08% of the variance, as compared to 31.87 percent in the unrotated solution. The second factor accounted for 17.60 percent of the variance, as compared to 13. 10 percent in the unrotated condition. The third factor accounted for 16. 52% of the variance in the VARIMAX- rotated factor solution, as compared to 10. 22 in the unrotated solution.

Interpretation and labeling

After rotation with Varimax, variable 3 loaded significantly on the first factor (. 77). A factor load of .31 appeared for factor 3. The difference in loadings for factor 1 and 3 was more than .20. Variable 6 loaded significantly on the first factor (.70), while under the significance level for the other two factors (.15 and .22). Variable 7 loaded significantly on factor 1, also, while loadings did not make a significant criterion for factors 2 and 3 (loadings of .16, respectively of . 20). Variable 2 loaded significantly onto the first factor, while under significance level for factors 2 and 3 (.21 and .25). Variable 4 loaded under significance level on factor 1 and factor 3 (.21 and .02), while its loading was significant for factor 2

(.81). Variable 1 had low loadings on factors one and three (.01 and .22), while its loading onto the second factor was of ,74 (considered significant). Variable 5 loaded significantly onto factors 1 and 2. It has a cross-loading of .4, meanwhile, it has a strong loading of .62 on the second factor. The .2 difference criterion between primary and secondary loadings is not fulfilled. However, by looking at the loadings, variable 5 loaded more strongly on the second factor. Variable 8 does not load significantly on either factor 1 or factor 2, however, it loads significantly and strongly on factor 3. Variable 10 has no significant loadings for factors one and two, while it loads above the established significance criterion for factor 3. Variable 9 loads under significance level for factors one and two, while above it for factor three. In summary, variables 2, 3, 6, and 7 loaded onto the first factor. Factor 2 has three variables that load on it, such as variables 1, 4 and 5. We chose to keep variable 5 (even if identified with cross-loading), as the difference in primary and secondary loadings was close to .2, and because its primary loading was .65.

Given the explained variance, as well as the loading pattern, we consider this factor solution through Component analysis with VARIMAX- rotation to be satisfactory.

The factor labels proposed by Wigfield and Meece (1988) were kept, as they were representative of negative affect in relation to Math in general (factor 2) and worry (factor 3). We named the first factor Math test and evaluation anxiety, as out of the four items, two address negative affect in relation directly to test, while the other two tap on negative affect in relation to an evaluative context. Internal consistency for each of the scales was performed.

On the Math test and evaluation anxiety subscale, we obtained an alpha Cronbach of .65. For the worry scale, we have obtained an alpha Cronbach of .53. In the case of the negative affect in relation to Math in general, the alpha Cronbach coefficient was initially .64. By dropping out item 1, alpha Cronbach would increase to .67, which would not represent a substantial modification. Consequently, we decided to retain item 1 on the scale.

Descriptive statistics for the three modified MAQ scale factors (N= 146) are presented in Table 3.

Table 3. Descriptive statistics for MAQ factors.

	N	Mean (SD)	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Math test and evaluation anxiety	146	2.57 (.98)	.44	.20	-.61	.39
Negative affect in relation to Math in general	146	2.26 (.96)	1.009	.20	.82	.39
Worry	146	2.81 (.94)	-.17	.20	-.84	.39
Valid N	146					

Note. MAQ - Math Anxiety Questionnaire

Correlation analyses

After computing composite scores based on the means of the items that loaded primarily on each factor, we conducted a bivariate correlation with Math performance, as measured through semester final grades. The correlation matrix is presented in table 4.

Table 4. Correlation Matrix.

	grades	Math test and evaluation of anxiety	Negative affect in relation to Math in general	worry1
Grades	1	-.49**	-.34**	-.28**
Math test and evaluation of anxiety		1	.47**	.36**
Negative affect in relation to Math in general			1	.27**
worry1				1

Note. **. Correlation is significant at the 0.01 level (2-tailed).
r - Pearson Correlation

Each of the scales is significantly and negatively correlated with Math performance. However, of the three factors, the Math test and evaluation anxiety correlate moderately, while the other two present low correlations.

Discussions

A three-factor structure emerged for the 10 item Math Anxiety Questionnaire, based on a principal components exploratory factor analysis with VARIMAX-rotation. Originally, we bore in mind the two-factor model that was confirmed by Wigfield and Meece (1988). Due to the fact that we made several modifications to the existing measure, we conducted an exploratory factor analysis that would account also for possible cultural differences or age-related differences between our sample and the original sample. Our analysis yielded a three-factor structure in our data and on the modified measure. The factors resulted overlapped partially with the worry and negative affect found by Wigfield and Meece (1988). However, a third factor was evident, and it was comprised of items that originally loaded on the negative affect. The Math test and evaluation anxiety factor explained an important amount of variance. This factor comes in addition to the factors that were originally derived and confirmed by Wigfield and Meece (1988). Moreover, this factor correlates more strongly to Math performance than do the other two. Though low, these correlations are significant, indicating that worry and negative affect impacts negatively on Math performance. These results bring evidence for a multidimensional structure of Math anxiety that comprises not only worry and negative affect but also Math anxiety related to test and evaluation. The three-factor did not fit the proposed two-factor structure, comprising Math test and evaluation anxiety (4 items; .67), negative affect related to math in general (3 items; .64), and worry (3 items, 0.53). These values indicate an acceptable internal consistency level of the two summated scales, of negative affect related to Math in general and Math test and evaluation anxiety. However, the internal consistency of the worry scale is low. These values in the low- acceptable range could be explained, partially, by the low number of variables, at least in the case of Worry scale and Negative affect scale. Future research should be done on constructing more items for these scales. Moreover, internal reliability could have been affected by the age and the capacity of 5th graders to make judgments on an abstract topic such as emotions and worries in relation to Mathematics. In the future, a more developmentally appropriate measure should be developed either by simplifying even further the wording and the response- scale format or by adding on the concreteness of the stimuli, via the use of scenarios. By corroborating the EFA results with the correlation analysis, and the internal consistency of the scales, we can say that a more reliable and relevant measure of Math anxiety would be via its emotional manifestations in evaluative contexts. It may be that this scale is more reliable because it draws on more specific anxiogenic situations than the negative affect related to Math in general does. One explanation may be that students better remember failure in Math assessment and report its emotional consequences, than estimate a degree of negative affect towards doing Math, in general, especially given that Math is a complex subject that requires many abilities. The Math test and evaluation factor seems more relevant at this point to be taken separately from other negative emotions related to Math. This finding is supported by previous work (Suinn & Edwards, 1982).

Results inform the selection of adequate instruments that measure anxiety. There is a great need to develop such instruments for the Romanian population. Also, these instruments should take into consideration the complexity of factors related to Math anxiety and to propose developmentally appropriate items.

The dimensionality of Math anxiety construct has implications for intervention. It may be that at a different age, Math anxiety has a different structure, and certain components are more relevant to its relationship with Math performance. In our data, negative affect in relation to Math test and evaluation explained a significant amount of variance, indicating that this factor should be approached not only in clinical or therapeutic setting but also in an educational context. One method, already mentioned in the literature, is to reduce the tension of the Math assessment by including humorous items (Luttenberger, et al., 2018). Another educational method would be to offer appropriate feedback on Math tests and Math assessments, with the possibility to operate modifications on the errors made at the test. In clinical settings, cognitive reappraisal methods (Luttenberger, et al., 2018) could address all three dimensions, provided that a stronger emphasis is given to the emotionality in relation to Math, rather than worry, in young children.

Limitations

The current study, while attempting to deepen our understanding of the dimensionality of Math anxiety, has several drawbacks that need to be mentioned. A first issue is related to a small sample size that can determine important errors of analysis. We addressed this issue by considering the conjunction of sample size, overdetermination, and good level of communality (MacCallum, Widaman, Zhang, & Hong, 1999). Our data shows a high overdetermination, as the ratio is 10: 3, and a wide communality level (60% of the commonalities are over .5, 30% in the range of .4, and only 10% were .3). Under such conditions, the effects of the sample size on the solution are only little (MacCallum et al., 1999), which makes the sample size adequate for the analysis. Secondly, a low internal consistency was obtained on the worry scale. Results, however, are to be seen with prudence and to be used in the direction of emphasizing the need to develop more items that can address a certain component, such as worry. Thirdly, although promising, the current scale might benefit from further psychometric work with a variety of groups and with added items to each of the factors.

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