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Barbara S. Plake and Claire S. Parker

Educational and Psychological Measurement 1982 42: 551
DOI: 10.1177/001316448204200218

EDUCATIONAL AND PSYCHOLOGICAL MEASUREMENT
1982, 42

THE DEVELOPMENT AND VALIDATION OF A REVISED VERSION OF THE MATHEMATICS ANXIETY RATING SCALE

BARBARA S. PLAKE AND CLAIRE S. PARKER
University of Nebraska-Lincoln

A 24-item shortened version of the 98-item Mathematics Anxiety Rating Scale (MARS) was developed to provide a more efficient index of statistics or mathematics course-related anxiety. The revised scale, which yielded a coefficient alpha reliability estimated at .98, was correlated .97 with a full scale MARS. It shows a pattern of relationships with state, trait, and test anxiety parallel to that of full scale MARS. Further, the relationship with mathematics achievement was consistent for both the revised and full scale MARS. A principal axes factor analysis of revised MARS identified two clear factors, labeled "Learning Mathematics Anxiety" and "Mathematics Evaluation Anxiety." Revised MARS appears to be an attractive substitute for full scale MARS for statistical or mathematical course-related uses.

THE 98-item Mathematics Anxiety Rating Scale (MARS) (Richardson and Suinn, 1972) was developed to be a diagnostic tool as well as an instrument for use in the treatment of mathematics anxiety. Subjects respond to each possible anxiety-producing situation by using a one to five scale where '1' means low anxiety and '5' corresponds to high anxiety. Test-retest reliability for the MARS has been reported as .85 (Tryon, 1980), and coefficient alpha reliability has been estimated to be .97 (Rounds and Hendel, 1980).

The MARS has been used actively by practitioners and researchers either in the identification of mathematically anxious students for treatment (Suinn and Richardson, 1971) or as a categorical variable in research (Tryon, 1980).

A factor analysis of MARS (Rounds and Hendel, 1980) revealed

two dominant factors. Labeled Mathematics Test Anxiety, Factor I contained MARS items which pertained to learning, studying, or being tested over mathematics from a classwork perspective. Identified as Numerical Anxiety, the second factor contained items that dealt more with the day-to-day use of mathematical and computational concepts.

The purpose of this paper was to report on the development and validation of the 98-item MARS, which contains items for use in the diagnosis of mathematics-type anxiety in a statistics class. Specifically, the two objectives of this report were: (1) to identify the items from MARS which measured class-related anxiety in statistics courses, and (2) to evaluate the quality and usefulness of this shortened, statistics-specific subset of MARS with respect to (a) internal consistency, (b) relationship to scores on the total MARS scale, (c) association with other measures of state, trait, and test anxiety, and (d) correlation with performance on a statistically-based mathematics test. In addition, a factor analysis of the revised MARS was performed to evaluate the factorial complexity, or factorial validity, of the shortened version of MARS.

Methodology

Instruments

Items from the 98-item MARS were considered and selected by employing the following criteria:

1. The item was designed to measure anxiety in a statistically related situation—a circumstance involving inclusion of mainly items from the Mathematics Test Anxiety factor of the original MARS as well as selection of items about reading tables and graphs or about statistical-type calculations from the Numerical Anxiety factor.
2. The total number of items was to be kept at one/fourth of the original length (for efficiency).

As shown in Table 1, the resulting subset consists of 24 items.

Instruments were selected to measure situation-specific (or state) anxiety, general (or trait) anxiety, and test specific anxiety. For the first two hypothesized types of the anxiety, the instruments selected were the STATE and TRAIT subscales of the State Trait Anxiety Inventory (STAI) (Spielberger, Gorsuch, and Lushene, 1970) and Achievement Anxiety Test (AAT) (Alpert and Haber, 1960), respectively. The AAT consists of two hypothetically independent subscales, Facilitating and Debilitating.

TABLE 1
Salient Items for Factor 1 and Factor 2 Revised Mathematics Anxiety Rating Scale

Factor 1. Learning Mathematics Anxiety
1. Watching a teacher work an algebraic equation on the blackboard.
2. Buying a math textbook.
3. Reading and interpreting graphs or charts.
4. Signing up for a course in Statistics.
5. Listening to another student explain a math formula.
6. Walking into a math class.
7. Looking through the pages on a math text.
8. Starting a new chapter in a math book.
9. Walking on campus and thinking about a math course.
10. Picking up a math textbook to begin working on a homework assignment.
11. Reading the word "Statistics."
12. Working on an abstract mathematical problem, such as: "if x = outstanding bills, and y = total income, calculate how much you have left for recreational expenditures.
13. Reading a formula in chemistry.
14. Listening to a lecture in a math class.
15. Having to use the tables in the back of a math book.
16. Being told how to interpret probability statements.

Factor 2. Mathematics Evaluation Anxiety
1. Being given a homework assignment of many difficult problems which is due the next class meeting.
2. Thinking about an upcoming math test one day before.
3. Solving square root problem.
4. Taking an examination (quiz) in a math course.
5. Getting ready to study for a math test.
6. Being given a "pop" quiz in a math class.
7. Waiting to get a math test returned in which you expected to do well.
8. Taking an examination (final) in a math course.

The 48-item Mathematics Achievement Test (MAT) was derived from an item pool associated with the College Mathematics Placement Program of the American College Testing Program (American College Testing Program, 1976). The items were selected in terms of the following criteria:

1. They had to measure mathematics concepts related to performance in introductory statistics (Baggaley, 1969).
2. A high school level of mathematics was required.
3. The items comprised a test with satisfactory reliability (the Kuder-Richardson formula 20 estimate of reliability for the MAT being equal to .91).

Procedure

The study consisted of two stages. In Stage 1, Full Scale MARS was administered to 50 upper level undergraduate and beginning

graduate students in an educational statistics class at a large midwestern university. The instrument was given along with several preliminary tests on the first day of class. Based on these data, a shortened version of MARS was developed which met the criteria specified earlier. In Stage 2, the revised MARS was investigated to evaluate its quality and usefulness. For this stage 170 students enrolled in three introductory statistics classes at a large urban midwestern university participated. The class population consisted of upper-level graduates and beginning graduate students, mostly in education but also from colleges university-wide. The course has no college level mathematics prerequisite. Both the mathematics background and age of the students varied substantially. The students participated in the study as part of their statistics class requirements. Students were informed that the examination was to be used to identify which students might benefit from a mathematics remediation laboratory. The laboratory, which was scheduled for the following week, was available to all students who took the examination.

The test materials were administered to each class separately within the time period assigned to each class (75 minutes). After being assembled into packets, the instruments were distributed in a random fashion to the students as they arrived for class. Each packet contained the four anxiety measures (AAT, Revised MARS, STAI-TRAIT, STAI-STATE) arranged in balanced order followed by the MAT.

Data Analysis

Means, standard deviations, and intercorrelations of all measures were found in addition to coefficient alpha reliability estimates for the Revised MARS.

The factorial complexity of the Revised MARS instrument was investigated by means of a factor analysis. The 24-revised MARS items were intercorrelated, and the resulting correlation matrix was factored by the principal factor technique, involving use of squared multiple correlations as initial communality estimates with iterations to a satisfactory solution. The initial factors were rotated to approximate orthogonal simple structure by employing the normalized varimax algorithm (Kaiser, 1958). The following multiple criteria were used to select the best factor solution: (a) Cattell's "scree" test of residual eigenvalue (Cattell, 1966), (b) factor interpretability, (c) number of factors with eigenvalue greater than one (Kaiser, 1958). Based on the use of these multiple criteria, a two-factor solution was

TABLE 2
Means and Standard Deviations on Selected Measures: Revised MARS, AAT-Facilitating, AAT-Debilitating, STAI-State, STAI-Trait, Mathematics Achievement Test

	$\bar{X}$	*sd*
RMARS	59.84	20.55
AAT+	28.83	2.65
AAT−	29.90	2.62
STAI-State	40.98	8.26
STAI-Trait	36.96	7.49
MAT	25.35	9.67

identified, which accounted for 60% of the total variance. The two factors were rotated to an orthogonal varimax solution to facilitate interpretation. Salient factor loadings were identified as those at least equal to .50. Every item in the subscale had a salient loading on one and only one of the two rotated factors.

Results

The 24-item revised version of the MARS showed an internal consistency (coefficient alpha) reliability of .98. The correlation between the 24-item MARS and the total scale was .97.

Means and standard deviations for the Revised MARS, AAT+ (Facilitating Anxiety), AAT− (Debilitating Anxiety), STAI—State Anxiety, and MAT are shown in Table 2. Table 3 displays the correlation matrix of the scores on the instruments used in the study. This pattern of relationships is similar to that reported for a full-scale MARS (Richardson and Suinn, 1972). Specifically, the most noteworthy relationships were as follows:

1. The Revised MARS exhibited statistically non-significant correlations of −.15 and .00 with AAT+ and AAT− Measures (*p*

TABLE 3
Correlation Matrix of Variables Identified in Table 2 (N = 170)

	RMARS	AAT+	AAT−	STAI-State	STAI-Trait	MAT
RMARS	—	−15	00	52	51	−45
AAT+	−15	—	03	−13	−22	17
AAT−	−00	03	—	−14	−12	00
STAI-State	52	−13	−14	—	60	−21
STAI-Trait	51	−22	−12	60	—	−13
MAT	−45	17	−00	−21	−13	—

Note.—Decimal points omitted from the correlation matrix.

> .05), but statistically significant coefficients of .52 and .51, respectively with STAI-State and STAI-Trait Measures ($p <$ .05).

2. Relative to the external criterion of mathematics achievement as measured by the MAT, the validity coefficient of $-.45$ ($p <$ .01) was found with Revised MARS.

Factor 1 was identified by 16 of the Revised MARS items. Items forming Factor 1 seemed to be related to the activity or process of studying statistics. They involved class related activities such as watching a teacher work an algebraic equation on the board, listening to a lecture in a mathematics class, walking into a mathematics class, and signing up for a course in statistics. They also pertained to the process of studying statistics or mathematics, such as looking through the pages of a mathematics book, buying a mathematics textbook, reading a formula in chemistry, having to use the tables in the back of a mathematics book, and starting a new chapter in a mathematics book. Appearing to be a measure of mathematics learning anxiety, Factor 1 was labeled as Learning Mathematics Anxiety.

Eight items had salient factor loading on Factor 2. These items were concerned with the evaluation of mathematics or statistical learning, such as being given a "pop" quiz in a mathematics class, taking an examination in a mathematics course, waiting to have a mathematics test returned in which one expected to do well, and thinking about an upcoming mathematics test one day before. Only one salient item—solving a square root problem—referred to a nontest situation. Appearing to measure anxiety in the context of being evaluated in mathematics, Factor 2 was identified as Mathematics Evaluation Anxiety. Table 1 shows the division of the 24-item Revised MARS into a 16-item Learning Mathematic Anxiety and an 8-item Mathematics Evaluation Anxiety subscales.

Conclusions

The following conclusions were evident from the data analyses:

1. The Revised Mathematics Anxiety Rating Scale (MARS) shows a pattern of relationships with measures of state, trait, and test anxiety and mathematics test achievement similar to that for the full-scale MARS. Having demonstrated an estimate of coefficient alpha reliability of .98, the Revised MARS is highly related to the full-scale MARS (the correlation having been estimated to be .97).
2. Those items within the 24-item Revised MARS that pertain to

statistical class-related anxiety present a clear two-factor pattern identified as Learning Mathematics Anxiety and Mathematics Evaluation Anxiety.

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