Peers + performance pressure = math anxiety?

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Peers + Performance 
Pressure = Math Anxiety?
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Abstract
Math anxiety interferes with many students' ability to learn math (Richardson & Suinn, 1972). Our research indicates that students' peak math anxiety years are those immediately following puberty. Research by Costanzo and Shaw (1966) suggests that children are most powerfully influenced by their peers during the months immediately following pubescence. In this light, we theorized that the amount of time students spend working math problems in front of peers (exposure to peer performance pressure) during the months proximal to puberty will be positively correlated with measures of math anxiety. Fourth through eighth grade public and private school students completed measures of math anxiety in October, 1992 and again in April, 1993. The hypothesis was supported for females only. Results suggest that peer performance pressure actually facilitated the development of math confidence except for females during puberty.

Mathematics anxiety obstructs the learning of mathematics (Richardson & Suinn, 1972). Math anxiety has been defined as tense and nervous feelings that "interfere with the manipulation of numbers and the solving of math problems" in the classroom as well as in various situations of everyday life (Richardson & Suinn, 1972, p. 532). Factors involved in math anxiety include a student's "negative affective reactions to math" and "worries about doing well in mathematics" (Wigfield & Meece, 1988, p. 214).

Several variables have been cited as being correlated with math anxiety (or its converse, math confidence, depending upon the researcher). Math confidence is a good predictor of high mathematics achievement for students in grades 6 through 12 as shown by Fennema & Sherman (1977, 1978). This confidence in one's ability to learn mathematics also predicts future course selections for both males and females (Reyes, 1984), and even career choices (Chipman, Krantz & Silver, 1992). As expected, there is also a negative correlation between math anxiety and math achievement from the early school years, throughout school, and into adulthood; however, a cause-effect relationship has not yet been determined (Reyes, 1984).

In related research, students' current performance expectancies and perceptions of outcomes in math were found to be good predictors of math anxiety (Eccles, Meece, & Wigfield, 1990). Parents' perceptions of the importance of mathematics (especially those of the mother) seem to also be an excellent predictor of math anxiety (Eccles, Meece, & Wigfield, 1990; Eccles & Jacobs, 1986).

All of these research findings were correlational in nature. Therefore, no cause-effect relationship between the variables studied and math anxiety has yet been demonstrated. This indicates that it is not yet known whether the anxiety causes the low performance or the low performance causes the anxiety. It seems likely that these two variables are mutually causal with anxiety driving performance down and low performance driving anxiety up.

The importance of this research is highlighted by other studies which have revealed that women generally suffer more math anxiety than men (Flessati & Jamieson, 1991; Hyde, Fennema, & Lamon, 1990; Tobias, 1978). Still other studies reveal a relationship between math anxiety and academic course and career choices. Females with high levels of math anxiety and average or above average math ability are less likely to choose careers that involve mathematics than those females with lower levels of math anxiety (Eccles, Meece, & Wigfield, 1990; Chipman, Krantz, & Silver, 1992).

We begin to see the initial cause of math anxiety in Harper and Quilter's
MATH ANXIETY

(1988) self-report study which indicated that the learning environment, and whether or not it motivated the students, may influence the development of math anxiety. Mathematics classrooms routinely involve an element of pressure to perform math calculations and formula manipulations in front of peers. This is referred to as peer performance pressure.

Costanzo and Shaw (1966) reported that adolescents show an acute awareness of their peers and a peak amount of conformity at the onset of puberty. On average, in America today, the adolescent reaches puberty at 13 (12 for girls and 14 for boys) (Brodzinsky & Gormly, 1993). Given this heightened sensitivity to peer approval during this developmental epoch, board work and the individual exposure the student experiences in the math classroom are likely to generate acute peer-related anxiety. In other words, students at this stage in their development get especially nervous (self-conscious) when they must do math problems on the blackboard in front of other students. This consistent pairing of math-related activity with peer-related anxiety may form the basis for later generalized anxiety elicited by any mathematics activity, especially activities involving problem solving.

From this perspective, generalized math anxiety is simply a conditional emotional response (CER). According to Lieberman (1993) and Estes & Skinner (1941), a CER is the phenomenon that occurs when a normally neutral stimulus is paired with an aversive stimulus in a classical conditioning situation. Since anxiety is the generalized result of fear, math anxiety may most appropriately be described as a CER.

The connection between math anxiety and classical conditioning may be explained further using the story of little Albert as a reference point. The theory of the CER historically is related to the widely reported story of an eleven month old infant, Albert B., commonly referred to as little Albert. In an "experiment" by John B. Watson and his research associate Rosalie Rayner, little Albert touched a rat, originally producing no fearful response. When the rat (Neutral Stimulus or NS) was paired with the loud striking of an steel bar (Unconditioned Stimulus or UCS, causing a startled fear response), the infant showed the emotional response of fear. After pairing the NS and the UCS eight times, just seeing the rat produced fear in the infant (Watson & Rayner, 1920; Blumenthal & Paul, 1989). Math classes that continually pair peer performance pressure (UCS that elicits fear or a sense of embarrassment) with math content produce fear for a student when later presented with math related stimuli, even if peer performance pressure is absent. This fear of math content then may generalize into "math anxiety" for many students.

The purpose of this research was to determine the extent of a relationship between three variables: exposure to peer performance pressure in the classroom (the extent to which the student must perform in front of peers), the age at which this exposure occurred (whether or not it takes place during the critical months before and during puberty, age 12 for girls and 14 for boys), and math anxiety. Thus, our hypothesis was that the amount of time students spend working math problems in front of peers during the months proximal to puberty is positively correlated with measures of math anxiety (or negatively correlated with math confidence). In order to assess the impact of varying amounts of peer performance pressure, we needed data indicating how much exposure to peer performance pressure students experienced during the academic year, and how much math anxiety they experienced in the beginning and near the end of that year. Therefore, a short-term cross-sequential design (Baltes & Goulet, 1970) was implemented whereby students were assessed during the fall and spring of the academic year so that the relationship between the teaching methods and math anxiety could be explored.

Method

Subjects

1001 (500 male, 501 female) children from public schools, 568 (261
male, 307 female) children from private schools in the 4th through 8th grades, and 46 math teachers from nine schools in Wisconsin participated. All schools sampled were within a ten mile radius of our institution. All students who were present during survey distribution days completed the questionnaire.

Materials

A questionnaire of 21, Likert-scaled questions was distributed to students through their respective math teachers; this type of scale had been used reliably in other studies with this age group (Cote, Pronovost, & Ross, 1990; Lefkowitz, Tesiny, & Solodow, 1989). The questionnaire, which was compiled for this study alone, contained a nine-item inquiry into the instructional style of the math teacher, a subset of items from Fennema & Sherman's (1978) instrument to assess the students' attitudinal evaluations of mathematics, three items measured the students' performance in past math classes and allowed a predictive look into the students' performance in the current class. See Appendix A for a copy of the questionnaire and the minimum, maximum, and mean scores on each scale. A second ten-item questionnaire, made up of original questions, was completed by teachers. It assessed self-perceived teaching techniques and teacher perceptions of student attitudes and emotional responses to mathematics. Open-ended questions were included in this segment to allow teachers to explain additional teaching techniques. See Appendix B for a copy of this questionnaire.

Procedure

A letter explaining the purpose of our study and sufficient copies of each questionnaire were sent to math teachers after receiving verbal approval via telephone from the Principals of the schools involved. These teachers administered the surveys in their math classes in late October, 1992. At that time, we also distributed the teacher questionnaire to assess teaching styles. In mid-March, 1993, the same students completed the same student questionnaire as a follow-up measure. The data collected via the baseline questionnaire were then compared with those collected via the follow-up questionnaire to assess changes in the constructs being measured.

Results

The study was a short-term, cross-sequential design (Baltes & Goulet, 1970). We were therefore able to conduct both cross sectional and longitudinal comparisons. Subjects' answers to questions were converted to three main indices: math anxiety, interest, and perceived peer performance pressure. Appendix A contains these scales and item values. Our early exploratory analyses, using multivariate analyses of variance and covariance, revealed significant differences in math anxiety for age and gender. The mean male anxiety score was 1.3 while the mean for females was 1.99 ($F_{[1, 2724]} = 47.651, p < .001$). Our main hypothesis indicated that for developmental and social reasons, students were especially anxious about doing math problems in front of their peers (peer performance pressure) during the months just prior to, during, and immediately after puberty. This hypothesis was tested using an analysis of variance and focusing on the interaction between age and perceived exposure to peer performance pressure in the classroom. The first analysis yielded no significant interaction between age and perceived exposure to peer performance pressure for math anxiety. Our hypothesis was therefore disconfirmed for our population as a whole. Selecting only males for the same analysis also did not reveal a significant interaction. However, selecting only females for the analysis revealed a significant interaction between age and peer performance pressure ($F_{[25, 653]} = 1.952, p = .004$). Figure 1 and Table 1 illustrate this interaction for females at ages 10 and 14.
Consistent with our hypothesis, females around the ages of 11 through 13 scored significantly higher than males in math anxiety. The amount of exposure to peer performance pressure affected females differently at ages 10 and 14, as shown in Figure 1. At younger ages, high levels of exposure encouraged math confidence (math anxiety score = 2.47), but at age 14, the math anxiety developed (math anxiety score = 2.76). This relationship did not occur for the males in our study. It is possible that the same effect does not occur for males, or, if it does occur, not enough of the males in our sample were...
experiencing pubescence to make the effect statistically reliable. Nonetheless, the discovery of this gender biased effect among young women was important.

Our data revealed a significant increase in female math anxiety as they grew older. Males' math anxiety was more stable and always lower than that of the females. The data also reveal a parallel decline in females' interest in math, while males' interest remains significantly higher after the age of 9. These two observations suggested that as females got older, confidence and interest in math-related activities declined steadily, while males' interest and confidence in math remained relatively high and stable. It may have been that the increases in math anxiety caused females to be less interested in math, or vice versa, or the two phenomena may be co-causal in a kind of spiraling feedback loop.

The age-related correlation between math anxiety and interest may be further explained by the existence of a third causal variable that influenced both interest and anxiety, namely peer performance pressure. As was shown in Figure 1, females exposed to high levels of peer performance pressure at the early age of 10 showed declines in math anxiety. However, when high levels of peer performance pressure were used with 14 year old females, their math anxiety rose sharply. Thus, older females generally perceived themselves experiencing more peer performance pressure which led to greater math anxiety and lower interest in math related activities.

To determine which teaching methods produced the greatest and least amounts of perceived exposure to peer performance pressure, the teachers' answers to the open-ended questions were recoded and put into the following groups: non-performance-based, students working with or in front of peers (together) and students working not with nor in front of peers (independently). Those teaching methods that seemed likely to lessen perceived exposure, as when nonperformance based methods were used, were those associated with the highest perceived exposure by students \( r = -.1101, p = .01 \) Table 4 describes the methods used.

A significant main effect was found for exposure to peer performance pressure among the different groupings of teaching methods \( F [2, 1646] = 5.114, p = .006 \). Surprisingly, the non-performance-based teaching methods produced the highest perceived exposure to peer performance pressure \( M = 4.13 \). In those techniques that employed students working together \( M = 3.45 \) or individually \( M = 3.51 \), students felt they were less exposed to peer performance pressure than with the nonperformance-based methods, as indicated by the students' scores on the peer performance pressure scale.
Table 4
Math Teaching Techniques Used and Percentages of Teachers Using These Techniques

Students Working Together (32.9%):
- Contests for Review
- Games
- Oral Answering Questions
- Small Groups
- Student Experts

Students Working Individually (32.9%):
- Individual Chalk Boards
- Making Own Problems
- Calculator
- Computer
- Extra Credit
- Checking Own Papers
- Portfolios
- Journals

Non-Performance-Based (34.2%):
- Manipulatives
- Guest Presentations
- Problem Solving Strategies
- Worksheets/Activities
- Overhead
- Fun
- Related to Real Life

Other analyses suggested that overall, teachers were doing the right things with the younger students, like keeping perceived exposure to peer performance pressure high to keep confidence and interest levels high. A caution for teachers, based on this research, might be that female students between the ages of 12 and 14 may be harmed by levels of perceived exposure that are too high. These findings were based on correlational data.

Future research needs to explore the causal agents of math anxiety further for more pieces of the puzzle to fit together. Such research might utilize a within-subjects cross-lagged design to clearly establish causality of math anxiety. This study would be a short-term longitudinal study that would allow comparisons between math performance and math anxiety at two different points in time. In the study, if early math anxiety predicts later math performance and early performance does not predict later anxiety, a strong causal connection would be suggested between teaching methods that create math anxiety and later performance deficits in mathematics. Research might also require a set of experimental conditions to test causality. Another avenue for future research would be a long-term cross-sequential study, possibly spanning four to six years of schooling.

One study might include 3rd through 9th grade students in public and private schools. Students in such a study would be followed for four years to determine their math anxiety scores in each of the subsequent tests. This would provide valuable data regarding how math anxiety "grows" in youth and adolescence.

This research revealed a more detailed picture of math anxiety which is an important step in understanding this phenomenon. Future research will help us to determine what the causal factors of math anxiety are and how best to prevent and treat the symptoms over all age groups.

References


**Appendix A**

For each question, Always=1, Often=2, Seldom=3, Never=4

Scales: Math Anxiety=A, Interest=I, Peer Performance Pressure Exposure=E

Subtracted score if "-"; added score otherwise.

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>* I am sure that I can learn math.</td>
<td>-A</td>
</tr>
<tr>
<td>* My math book uses practice problems.</td>
<td></td>
</tr>
<tr>
<td>* My math book uses word problems.</td>
<td></td>
</tr>
<tr>
<td>* In math, I use a calculator.</td>
<td></td>
</tr>
<tr>
<td>* In math, I use a computer.</td>
<td></td>
</tr>
<tr>
<td>* My math teacher gives me time in class to do homework.</td>
<td>-E</td>
</tr>
<tr>
<td>* My math teacher comes around and helps in class.</td>
<td>-E</td>
</tr>
<tr>
<td>* I get nervous when I have to take a math quiz or test.</td>
<td>A</td>
</tr>
<tr>
<td>* My math teacher shows happiness when I do well on tests.</td>
<td></td>
</tr>
<tr>
<td>* My math teacher calls on me to work problems in class.</td>
<td>-E</td>
</tr>
<tr>
<td>* In math class we grade each others’ homework.</td>
<td>-E</td>
</tr>
<tr>
<td>* We work our math problems in small groups.</td>
<td>-E</td>
</tr>
<tr>
<td>* My math teacher explains things clearly.</td>
<td></td>
</tr>
<tr>
<td>* In math class, I work problems on the blackboard.</td>
<td>-E</td>
</tr>
<tr>
<td>* I get nervous when I think my teacher might call on me.</td>
<td>A</td>
</tr>
</tbody>
</table>

62 MODERN PSYCHOLOGICAL STUDIES
Appendix A
(continued)

* My parents seem to enjoy helping me with my math homework.
* My parents don't seem to understand my math homework.
* I am interested in learning more about math.
* I think when I get older I will use math in my work.
* Math scares me.
* I can get good grades in mathematics.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Minimum Score</th>
<th>Maximum Score</th>
<th>Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Anxiety</td>
<td>-10</td>
<td>6</td>
<td>3.32</td>
</tr>
<tr>
<td>Interest</td>
<td>-8</td>
<td>-2</td>
<td>-3.965</td>
</tr>
<tr>
<td>Peer Performance Pressure</td>
<td>-5</td>
<td>10</td>
<td>-2.575</td>
</tr>
</tbody>
</table>

Appendix B

For each question, Always = 1, Often = 2, Seldom = 3, Never = 4

* I require all students to work problems on the blackboard.
* I ask for volunteers to work problems on the blackboard.
* I show excitement when my students do well.
* I show disappointment when my students do poorly.
* I require students to work in small groups.
* Math anxiety is a problem for my students.
* When I was a student, I suffered from math anxiety.
* I suffer from math anxiety.

Open ended-questions:

* Please list other methods you use, not listed here, in teaching mathematics.
* Please explain briefly your theory of mathematics.