Math Anxiety: An Update

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As reported in Overcoming Math Anxiety ***(1978, 1980), in 600 interviews with college-age and older returning students, Tobias found three significant variables in her subjects' inability to do college-level mathematics: fear of mathematics, the conviction that mathematics is a white male domain, and the conviction that one is either good in mathematics or in language arts but never both. The students' absence of coping skills in dealing with mathematics classes and with their own anxieties appeared to be the main barrier to their attempting mathematics one more time. Subsequently, Tobias focused her research on entering college students. Her second book,*** Succeed With Math: Every Student's Guide to Conquering Math Anxiety ***(1987), was commissioned by The College Board. What follows is a selection of excerpts from that book, reconfigured for the use of counselors and advisors.***

Two myths about mathematics need to be put to rest. One is that college-level mathematics is too difficult for otherwise intelligent students to master. Another is that without mathematics anyone can live a productive intellectual and professional life.

Mathematics is no longer just an entry-level prerequisite for engineering, the physical sciences, and statistics. Its principles and techniques, along with computers, have become part of almost all areas of work, and its logic is used in thinking about almost everything. This is a big change from the days when a number of professions were virtually math-free. Today, many occupations that do not require college-level calculus or statistical skills at the outset do demand them later on for anyone aiming toward promotion into management or work in more interesting technical areas.

Mathematical expressions such as "the slope of the curve," "zero sum," "normalized distribution," and "asymptotic" are no longer just the mutterings of bearded thinkers who cannot remember to wear socks of the same color. They have become part of the basic vocabulary of business, politics, library science, health care, and even social work. One important reason is that mathematical expressions give us a way of thinking about relationships that would otherwise be unavailable to us. Just as college students' ability to think more complex thoughts is enhanced every time they learn a new word or phrase, so their ability to understand abstract concepts will be enriched when they master such mathematical constructs as "limits," "nonlinear," and "exponential growth."

Where Does Math Anxiety Come From?

I have interviewed hundreds of college students who have math anxiety. They can all remember the moment when they began to doubt that they had what it takes to learn math. In some cases, it was because someone had told them "girls don't do math" or "blacks don't become engineers." Others came to the conclusion that they would either be good with numbers ***or*** with words but that they could not be good with both. Because our American culture is ambivalent about mathematicians as role models, some students decided they did not want to enter the field. Besides, math seemed dreary, never any fun.

None of these widespread assumptions are true. First, if there are still few females and blacks in the top tiers of working mathematicians and scientists, it is not because they are genetically inferior; it is because social and institutional barriers exist that are only now slowly disappearing. Second, while some writers do not like math and some mathematicians do not like to write, no evidence exists, whatsoever, that writing ability and mathematics ability are mutually exclusive. On the contrary, college admissions counselors know that the student who shows high capability on ***both*** the mathematical and verbal sections of the SAT is more likely to succeed in math than the student who has a severely skewed score, strong only in quantitative skills. And, finally, while elementary mathematics may indeed be repetitive, it is a skill that must be practiced to get to the creative part later on.

Another source of trauma for many young people is the style of the mathematics classroom. Students complain that math offers little opportunity for debate or discussion. Many say they like English and social studies better than math because they can participate more in class and because they do not experience the pressure to

find the one right answer. Mathematics does depend on right answers, but it can also be experienced as a series of discoveries that we all make for ourselves. More often than not, however, math is presented as a fixed set of rules to be digested whole and without dispute, which may discourage students from learning.

Few people can think clearly and well with a clock ticking away. It is hard to perform at the blackboard with thirty sets of eyes watching you. No one likes a subject that is presented rigidly and uncompromisingly. And most people do not do well when they are scared. Some years ago, my colleagues and I came to suspect that math inability may not be the result of a failure of intellect but rather of nerve.

How Does Math Anxiety Work?

We think of math anxiety as causing an emotional "static" in the brain. It might be best to begin by thinking about the brain (entirely hypothetically) as consisting of three parts: an input area, a memory bank, and some kind of understanding and recall pathways connecting the two. If the system is working well, upon looking at a math problem or trying to fathom a new piece of mathematical information, the math-healthy student will call up from memory the right formula and the right approach. He or she will move back and forth effortlessly along the recall and understanding pathways of the brain until the problem is solved or the new mathematical idea is understood. Any time the student gets stuck, he or she can return to the memory bank or get some more information from the problem. Perhaps the student will draw a diagram or will put some hypothetical numbers into the problem to make it more concrete. But whatever he or she chooses to do, the student will be busy — moving along the pathways of the brain, activating memory, using analytic skills, learning, and doing.

Now, suppose the student's memory bank is intact and understanding and recall skills are well developed, but every time he or she looks at some new mathematical material, negative emotions come into play. There is panic. "This is just the kind of problem I can never solve." Tension develops that comes from time pressure and uncertainty, as well as from lack of confidence. At this point, the understanding and recall pathways will have become cluttered by emotions. This is what we mean by "static." There is an inability to think but not because the hardware is inadequate. The input, memory, and understanding and recall systems are as good as they were before. But, because the pathways have been blocked, the student cannot remember. Soon the pencil stops moving; the brain seems to stop functioning altogether. The student thinks, "I cannot work because I cannot think." In fact, it is just the reverse. The student cannot think because she or he has stopped working.

Self-Monitoring

To reduce and eventually overcome math anxiety, we recommend that students learn first to recognize when panic starts, then to identify the static as precisely as possible, and finally, to clear it up without ceasing to work on the mathematical problem. How can we expect students to do all this at once? The essence of math-anxiety therapy is self-monitoring. We have students practice while doing homework and even while in class. They are taught to draw a line down the center of the page they are working on. On one side they record their feelings and thoughts, however random and seemingly disconnected they may be. On the other side, they keep their notes, calculations, and problem-solving steps. Elusive feelings and thoughts are not easy to capture, especially the first time students try. But, in time, they learn to observe the messages they give themselves under stress. This is the way they discover the obstacles they are creating when they work at math.

For example, if a student writes on the left side of the page, "This is just the kind of problem I can never solve," we teach him or her, instead of quitting, to ask, "What is making this problem difficult for me, and what can 1 do to make it easier for myself?"

Self-Permission

The point of the divided-page exercise is to teach math-anxious students to give themselves permission to explore their own confusions (instead of giving in to them) and to find out what is making the problem or the new material seem difficult. We find that, as they become more and more familiar with their own learning styles, students become more adept at discovering flaws in their thinking. Most important, doing the exercise permits them to keep on working.

One purpose of the divided-page exercise is this: When students are stuck and not able to

put anything down on the right-hand side of the page, they can still be writing their thoughts and feelings on the left. That means they can continue working, even if they are not doing math calculations. So long as they are ***writing,*** they are ***thinking,*** and so long as they are ***thinking,*** they do not give up. And because ***thinking*** in mathematics involves ***doing,*** writing down random feelings and thoughts breaks the tension and their sense of isolation. Students are at least talking to themselves. Soon their ability to analyze their own problems becomes a source of insight into the math problem itself. In time the two mental processes become so entwined that no one can say with certainty whether the insights that finally crack a problem come from the problem itself or from the students' self-assessments.

Best of all, the tuning-in process teaches students about their idiosyncracies. In talking with students who are successful in math, I have found that they are not necessarily smarter than the rest of us but that they seem to know themselves better. They can anticipate the difficulties they are going to have. They know what kinds of questions and actions will give them the power and confidence to continue. They know when to skim and when to focus in on a paragraph, sometimes for hours at a time. They are never bored because they are busy. They never quit because they recognized long ago that progress in mathematics very often involves making just a little headway, one step at a time. They do not judge themselves as harshly as we judge ourselves when answers do not come out right. They are patient, tenacious, and rarely very fast.

The goal of all of this training is not to turn out mathematical geniuses but to offer students mathematical mental health, which involves the willingness to learn the math they need when they need it. This mental health translates into better career choices, decisions made from strength and certainty instead of from weakness and avoidance, more risk-taking in college, and more persistence on the job.

Math-anxiety workshops can easily be arranged by academic advisors with the assistance of willing math instructors. There is no blueprint, but it is advisable to include at least some of the following:

1) the solicitation of a student's "math autobiography" in a one-on-one interview
2) the creation of six or more sessions of math-anxiety reduction, including relaxation training, group discussion of difficulties in confronting mathematics, and training in keeping a journal and divided-page work
3) the development of transitional slow-paced math sessions where no more than twenty minutes of new material is introduced by a math instructor and this instruction is followed by at least as many minutes for processing led by a counselor (Each student should be assessed in an exit interview before being encouraged to enroll in a mainstream math class.)
4) a return to mainstream mathematics with a weekly group session to discuss feelings and "left-hand side of the page" comments, and
5) assertiveness training to transform the passive student into an active and demanding one.

One tested way advisors can prepare themselves to lead math-anxiety reduction sessions is to enroll in a challenging math class and to keep a record of their own feelings and thoughts. Specialists in test-anxiety reduction and stress management willing to join forces with a friendly mathematics instructor are readily able to design effective clinical interventions. The last time math-anxiety clinics were surveyed, more than 100 were in operation at the college level.

Bibliographic Notes

The topics of mathematics anxiety and mathematics-anxiety reduction fall within several areas of more general research: (a) attitudes and mathematics, a subset of mathematics education; (b) anxiety and learning, including the literature on test anxiety and learned helplessness; (c) sex differences in mathematics confidence and achievement and the psychology of women and girls; and (d) attribution theory. The references listed below include the classics in the field and some newer works. Most of the interventions used to reduce math anxiety have been described in detail only in unpublished dissertations (see Suydam & Kirschner, 1980). There are two validated measuring scales of math anxiety (Fennema & Sherman, 1976; Suinn, 1970).

Bibliography: Math Anxiety

Aiken, L. R., Jr. (1978). Update on attitudes and other affective variables in learning mathematics. *Review of Educational Research, 46,* 293-311.

Betz, N. E. (1978). Prevalence, distribution, and corre-

lates of math anxiety in college students. *Journal of Counseling Psychology, 25*, 441-448.

Connolly, P., & Vilardi, T. (Eds.). (1989). *Writing lo learn mathematics and science.* New York: Teachers College Press.

Donady, B., Kogelman, S., & Tobias, S. (1980). Math anxiety and female mental health: Some unexpected links. In C. Landau (Ed.), *The evolving female: Women in psychosocial context* (pp. 325-345). New York: Human Sciences Press.

Donady, B., & Tobias. S. (1977). Counseling the math anxious. *Journal of the National Association for Women Deans, Administrators and Counselors,* 41(1), 13-16.

Eccles, J. S., &Jacobs, J. E. (1987). Social forces shape math attitudes and performance. In M. R. Walsh (Ed.), *The psychology of women* (pp. 341-354). New Haven: Yale University Press. (Reprinted from *Signs: Journal of Culture and Society,* 1986, *2*[21], 367-389)

Fennema. E., & Sherman, J. (1976). Fennema-Sherman mathematics attitude scales. *JSAS Catalogue of Selected Documents in Psychology, 6*(31), Ms. No. 1225.

Fennema, E., & Sherman, J. (1978). Sex-related differences in mathematics achievement and related factors: A further study. *Journal for Research in Mathematics Education, 9*, 189-203.

Fox, L. H., Brody, L., & Tobin, D. (1980). *Women and the mathematical mystique.* Baltimore: Johns Hopkins University Press.

Fox, L. H., Fennema, E., & Sherman, J. (Eds.). (1977). *Women and mathematics: Research perspectives for change* (NIE Papers in Education and Work No. 8). Washington, DC: U.S. Department of Health, Education, and Welfare.

Jacobs, J. (Ed.). (1978). *Perspectives on women and mathematics* Columbus, Ohio: ERIC.

Sherman, J., & Fennema, E. (1977). The study of mathematics by high school girls and boys: Related variables. *American Educational Research Journal,* 14, 159-168.

Sieber, J. E., O'Neill, H. F., Jr., & Tobias, S. (1977). *Anxiety, learning, and instruction.* Hillsdale, NJ: Erlbaum.

Skemp, R. R. (1973). *The psychology of learning mathematics.* Baltimore: Penguin Books.

Suinn, R. M. (1970). The mathematics anxiety rating scale. Unpublished manuscript, Colorado State University, Fort Collins.

Suydam, M., & Kirschner, V. (1980). *Selected references on mathematical anxiety, attitude, and sex differences in achievement and participation.* Columbus, OH: Ohio State University, ERIC Clearinghouse for Science, Mathematics, and Environmental Education Analysis Center (ERIC/SMEAC).

Tobias, S. (1978). *Overcoming math anxiety.* New York: Norton.

Tobias, S. (1980). *Overcoming math anxiety.* Boston: Houghton Mifflin.

Tobias, S. (1987). *Succeed with math: Every student's guide to conquering math anxiety.* New York: The College Board.

Tobias, S., & Weissbrod, C. (1980). Anxiety and mathematics: An update. *Harvard Educational Review, 50*(1), 63-70.

Weiner, B. (1972). Attribution theory, achievement motivation, and the educational process. *Review of Educational Research,* 42, 203-215.

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