Letters

Cholesterol Study

The recent article "Lowered cholesterol decreases heart disease" by Gina Kolata (Research News, 27 Jan., p. 381) reports a study carried out on a group of male volunteers, carefully selected so as to include only subjects exhibiting an abnormally high level of blood cholesterol. The results of the study clearly demonstrated that, at least for this atypical group, a combination of diet and cholestyramine therapy was associated not only with a sharp reduction in heart attacks but also with a similar drop in cholesterol levels. The study's conclusion, however, that the decrease in heart attacks was a direct result of the lowered cholesterol level, would seem to have little basis in scientific logic, particularly in view of the extraordinary complexity of the cholesterol deposition mechanism (Research News, 16 Sept., p. 1164). The additional conclusion regarding the benefits to the general population of cholesterol reduction by a markedly different procedure (that is, by diet alone) rests on even more tenuous grounds, particularly since, from a practical point of view, the effect of diet on the incidence of heart attacks has been shown to be indetectably small.

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Achievement in Mathematics

The results presented by Camilla P. Benbow and Julian C. Stanley (Reports, 2 Dec., p. 1029) on the difference in performance of mathematically precocious boys and girls on the mathematical part of the Scholastic Aptitude Test (SAT-M) test are startling. But what is perhaps more startling is that the authors do not investigate the reasons for these differences. Their results could stimulate new research areas in an attempt to understand the phenomenon. However, instead of suggesting which questions might be pursued, they provide weak rationales for why they think socialization explanations are unlikely.

It appears to us that these findings pose questions that might be grouped into two classes. First, what is the significance of scores on the SAT-M tests? It is conceivable that there is very little significance. For instance, the difference between a 600 and an 800 on the test may have no predictive value for how students will fare in college or in subsequent professional life. The score may say nothing about whether a student will enter a mathematically based career and do well in it. A curious fact, which is perhaps relevant to these questions, is mentioned in an earlier paper by Benbow and Stanley. They report that the girls in this same study did better than the boys in math courses and in an advanced placement math test while in high school (*1*). Clearly, it is assumed that performance in such courses or tests is not a measure of ability while the SAT-M score is. What is the basis of this assumption?

Related to these questions is the nature of the test and the test-taking experience itself. The tests are not just a measure of the capacity to do the problems. They are also a measure of the ability to do the problems in a certain period of time. Could there be differences in attitudes on the part of boys and girls toward this kind of test-taking experience?

Second, despite the hints of Benbow and Stanley, they have not begun to plumb the myriad socialization factors that might provide at least partial explanation for the boy-girl difference. They write, "But it is not obvious how social conditioning could affect mathematical reasoning ability so adversely and significantly, yet have little detectable effect on stated interest in mathematics, the taking of mathematics courses during the high school years before the SAT's are normally taken, and mathematics-course grades." Contradicting the thrust of this statement are the earlier findings of the authors that, in fact, the boys in the study "enjoyed mathematics more than girls ($P = 0.001$)," (*2*) and that boys tended to take math courses at an earlier time than girls in high school (*1*). Although there was not a high overall correlation of liking of mathematics with SAT-M scores, a more detailed analysis might determine the significance of this difference. Their evaluation of students' interest itself is rather cursory, as they merely report whether students stated a "very strong liking," a "fairly strong liking," and so forth for mathematics.

There is a whole body of literature that describes possible ways in which "social conditioning" could affect performance in mathematics (*3*). Studies have shown that, from very early on, teachers pay more attention to boys than to girls in math classes (*4*). This raises questions about whether the students have taken the same courses. They may have sat in the same classrooms, but their learning experiences may have been very different. Other studies suggest that boys perform better in certain mathematics tests because they have had more experiences outside the classroom which involve developing mathematical skills (*5*). Further, Fox *et al.* (*6*), who studied the same children as Benbow and Stanley, report several ways in which the backgrounds of the boys and girls differ, including out-of-class math experience. Benbow and Stanley, themselves, have reported that nearly twice as many boys as girls in their study had participated in special math programs (*2*). Wouldn't it be important, then, to continue to analyze in great detail the history of classroom experiences, family attitudes, and childhood experiences, to determine whether any of these might be responsible for girls' scoring lower?

Finally, the interpretation which Benbow and Stanley have attached to their studies and the publicity they have received are not harmless. Public media reports of a "math gene" (*7*) have already had their influence on students in math classes (*3, 8*). It would be tragic if the attention drawn to this study were to contribute to a reversal of the increased participation of women in mathematics seen in recent years, including a dramatic rise in the number of Ph.D.'s.

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Benbow and Stanley present some persuasive data that important sex differences in mathematics achievement are evident by grade seven, especially when scores exceeding 700 on the SAT-M are used as the criterion. They also argue that these and later sex-related performance differences cannot be accounted for by differences in enrollments in math courses or school grades in math. The latter finding agrees with our own data (*1*) and a recomputation of data by Fennema and Sherman (*2*) showing that less than 2 percent of variation in enrollments is accounted for by sex as a variable. In our paper (*1*), we offer an alternative hypothesis and some data to support it.

Our hypothesis derives from cognitive learning theory (*3*) and empirical studies that indicate females more than males are socialized into rote mode learning patterns, which predominate in school classrooms, and that such learning patterns become progressively more debilitating in course work or careers where complex problem-solving or creativity is required. Of course, many males also succumb to school pressures toward rote mode learning, and hence the potential talent pool of persons skilled at complex problem-solving is reduced for both sexes.

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Beckwith and Woodruff imply that Julian Stanley and I have been remiss in failing to suggest new areas in which to search for reasons for the sex differences in mathematical reasoning ability in our data (*1, 2*). In fact, their first "new" question (What is the significance of scores on the SAT-M?) is a central question the Study of Mathematically Precocious Youth (SMPY) was established to investigate. For 10 years SMPY has studied the predictive validity of the SAT-M for our population. Moreover, SMPY is a long-term (approximately 50 years) study designed to determine to what extent high SAT-M scores predict adult achievement. In seven books and numerous articles we have shown that scores on SAT-M do relate closely to success in high-level, fast-paced mathematics and science courses, to educational acceleration, and (especially) to the choosing of careers requiring excellent quantitative ability (*3*). We must wait, however, another few decades to study their long-term predictive validity for vocational achievement. Our earliest SMPY'ers are only in their mid-20's. It seems, therefore, that we have not only been asking the first question posed by Beckwith and Woodruff, but we found the sex differences by asking it.

Beckwith and Woodruff state that we have reported that girls in our study "did better than the boys in math courses and in an advanced placement math test while in high school." The second part of this statement is incorrect. We showed (*4*) that the boys scored significantly *better* on the College Board mathematics achievement tests. Moreover, even though a larger percentage of the boys than the girls took the Advanced Placement calculus tests, boys scored *better* in five to six comparisons and girls in one. It is difficult to image how such numbers indicate that girls do better.

Their statement about better grades is true. It has been, however, attributed to the better conduct of girls in school (*5*). Moreover, course grades are hardly a measure of mathematical reasoning ability, the ability that we study.

Beckwith and Woodruff quote us out of context as saying that "the boys in the study 'enjoyed mathematics more than girls ($P = 0.001$)' " (*6*). The remainder of the quotation is crucial: "As evidenced from the effect size (small, $d = .33$), the difference was not large. The four r's between liking of mathematics and SAT scores were also small, $-.04$ to $.17$ (Table 3). Thus, at this stage, ability and sex do not relate to degree of liking for mathematics" (*6*). In addition, we simply did *not* report that "nearly twice as many boys as girls . . . had participated in special math programs."

We did report that "boys tended to take math courses at an earlier time than girls in high school." This, however, occurred *after* the students had been tested, and so could not possibly have influenced the SAT-M scores we measured.

We have never said that our boys and girls had identical learning experiences. Nevertheless, it is difficult to reconcile how differences in learning experiences in the classroom can affect mathematical reasoning ability but not computational ability, where girls are superior, nor the ability to apply learned concepts, where there are no differences.

Beckwith and Woodruff also misrepresent the conclusion of Fox *et al.* (*7*) that "the backgrounds of the boys and girls differ, including out-of-class math experience." In fact Fox *et al.* conclude that "On the basis of this study of five samples of very mathematically able girls and boys, there appear to be only a few differences in the attitudes and experiences of these students and the attitudes or behaviors of their parents or teachers that suggest some of the social processes that may influence the development of interest in pursuing scientific careers or accelerating the learning of mathematics at home or school" (*7*, p. 168).

Finally, Beckwith and Woodruff raise the valid issue of the hazards of inaccurate or sensational publicity. Although the media have used the term "math gene," SMPY has always carefully avoided the words "gene" or "genetic." Our view is still as follows. It "seems likely that putting one's faith in boy-versus-girl socialization processes as the *only* permissible explanation of the sex difference in mathematic[al reasoning ability] is *premature*" (*1*) [emphasis added].

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Erratum: A line was inadvertantly omitted from the last sentence of George S. Mumford's letter of 20 January (p. 238). It should have read, "If, at an early stage, we could foster in this manner a feeling among our graduates of their indebtedness to the general public for directly or indirectly supporting their research and the right of that public to know the results, it might become traditional for them to proceed in such a way throughout a career."