by Julian C. Stanley, Jia-fen Huang, and Xue-min Zu

SAT-M Scores of Highly Selected Students in Shanghai Tested When Less than 13 Years Old

China's Search for Mathematically Talented Youths

Although China's culture dates back thousands of years, its major technological development is much more recent. The need for young students with great aptitude for science first became obvious during the 1950s. In those days the People's Republic of China paid so much attention to science education as to deem social science less important. There was, however, a period of "book knowledge is not useful" during 1966–76. It was not until the downfall of the "gang of four" in 1976 that this need again became urgent. Upon the reinstatement of trade with many parts of the world, including the United States, the need for young students with great aptitude for mathematics, science, computer science, and engineering quickly became apparent. Large numbers of Chinese who have earned Ph.D. degrees from the world's greatest universities will be required if Chinese industries and research centers are to flourish.

As educational psychologists, we believe that, besides general intelligence, excellent mathematical *reasoning* ability is probably the most important single cognitive aptitude associated with success in learning pure and applied mathematics, physics, computer science, electrical engineering, chemical engineering, chemistry and related subjects.[1] Although it is quite likely that teachers of mathematics can estimate this ability in their students at appreciably better than the chance level, they often confound such assessments with the diligence, cooperativeness, and chronological maturity of the pupil.[2] More direct and less subjective measures of mathematical reasoning ability should improve the identification of young students who could benefit from the opportunity to move ahead in mathematics and related subjects faster and better than their less mathematically apt age-mates.

Fortunately, in the United States a highly relevant test of mathematical reasoning ability is administered each year under the auspices of the College Board, a nonprofit private organization of schools and colleges, to more than a million 16- to 18-year-old applicants. It is called the Scholastic Aptitude Test (SAT). Stanley and his associates have used it since 1972 to find exceptionally talented youths as young as seven years old, and help them educationally.[3]

The Scholastic Aptitude Test

In the United States, some 70,000 bright students aged 13 years old or less take the SAT each year. It is a three-part multiple-choice test of developed ability, not primarily learned subject matter, designed for approximately the abler half of twelfth-grade students throughout the United States, most of whom are 17 or 18 years old.[4]

One part of the SAT, called SAT-V, is verbal. It consists of reading passages, antonyms, verbal analogies, and incomplete sentences. The chief purpose of SAT-V is to test the type of reading and verbal reasoning ability needed for success in a United States college or university. Strongly culture-bound, it could not effectively be translated literally into Chinese and administered to students in the People's Republic of China. It would have to be greatly revised, and restandardized.

The Test of Standard Written English (TSWE), which always accompanies the SAT, deals with the mechanics of English composition and tests the skills considered necessary for writing well.

The remaining part, SAT-M, tests mathematical reasoning ability. To take it effectively, the examinee needs some grasp of elementary algebra and geometry.

The SAT is little used outside the United States, even

Even in China, SAT-Math is a simple, quick way to look for gifted students in order to help them educationally.

in English-speaking countries such as Canada, England, and Australia, except to test applicants for admission as undergraduates to colleges and universities in the United States. A special, revised, and restandardized Spanish-language edition has been available from the College Board for about 20 years, chiefly for use in Puerto Rico and the countries of Latin America. A German version is administered in a talent search conducted by the University of Hamburg, in West Germany, in cooperation with the Center for the Advancement of Academically Talented Youth (CTY) at Johns Hopkins University. Educational officials in most countries, however, prefer to use their own examinations to certify or evaluate high-school graduates.

Comparing Mathematical Abilities

The children of immigrants to the United States from Taiwan, South Korea, India, Pakistan, Bangladesh, and the Philippine Islands tend to reason mathematically considerably better than persons whose American ancestry dates back many generations.[5,6] More recent arrivals, from Vietnam, Laos, and Cambodia, seem likely to perform well in mathematics, also.[7,8] Until recently, much of this superiority may have occurred because only the best-educated, most employable Asians were permitted to settle in the United States. It may be that certain groups have a better basic aptitude for learning mathematics. Temperamental factors and parental-control factors may also be involved. Of course, the initial mathematical edge could decline in succeeding generations if westernization affects those factors appreciably.

Since 1969, Stanley has studied many thousands of mathematically precocious youths. He has found that among his 292 highest scorers on the SAT-M (a score of 700 or more), tested before the thirteenth birthday, 65, or 22 percent, are of Asian origin.[9] This 22 percent contrasts with the 1.6 percent of the United States population whose ancestors came from Asia[10]; it is 14 times as many as one would expect. All 292 test subjects had volunteered to take SAT-M, so this large percentage may be partly a result of parental and child alertness to the special educational opportunities that scoring extremely highly on SAT-M might bring. Although it is by no means clear what the causal factors are, Asian-Americans are forging well ahead in the educational system of the United States at all levels, especially in mathematics.

Because the largest percentage of the Asian-Americans in Stanley's high scoring group are of Chinese origin, it seemed natural to ask whether or not youths in the home country would do as well. A simple way of finding out was to translate the SAT-M into standard Chinese and administer it to a sizable group of the ablest young mathematics students a large city in the People's Republic of China could provide. Through Professor (of physics) C. T. Feng of Shanghai Teachers University, Stanley was put in touch with its Educational Research Institute. He arranged, with permission from the College Board and Educational Testing Service, for Professor (of mechanical engineering) Dan Fan of Howard University in Washington, D.C., to make a preliminary translation of a recent form of the SAT-M.[11] It was then sent to Huang. She and Zu completed the translation and, following detailed written instructions from Stanley, arranged to administer it to students of the appropriate age and ability in Shanghai's most selective schools.

The Subjects

As indicated earlier in this paper, Stanley had studied at great length the characteristics of students who before age 13 score extremely well on SAT-M. Huang and Zu, therefore, sought out mathematically gifted youths from Shanghai's most academically demanding schools, basing their choices on teacher recommendations. Fewer than 13 years should have elapsed between the birth date and the day on which the child took the SAT-M.

They went to ten first-rate high schools and asked each school to select 12 to 18 boys and girls who were exceptionally talented mathematically and had not yet reached their thirteenth birthday. They then set up dates for practice testing and formal testing. Huang went to six schools to give students test-taking tips and to allow them to become familiar with the format and item types of the SAT-M—but not, of course, using any items of the test they would later administer. Zu went to the other four schools for the same purpose.

The date of formal testing was set for March 16, 1985. Two high-school teachers helped Huang and Zu administer SAT-M. Thirty minutes were allowed for the 25 items in the first part, and another 30 minutes for the 35 items in the second part. Thus, the one-hour examination consisted of 60 four- or five-option multiple-choice items.

After testing, Huang and Zu found that many of the examinees had reached their thirteenth birthday on or before the testing date. Also, more boys than girls had been nominated. They then selected another nine high schools and did the work of preparation over again. All testing and scoring were finally completed by April 6.

In all, 160 boys and 119 girls were tested. Eighty of the boys and 65 of the girls met the age criterion. Age-qualified boys were born as early as March 17, 1972 and as late as April 7, 1973. The age-qualified girls were born as early as March 17, 1972 and as late as January 23, 1973. Thus, the age span was about a year for the boys and somewhat less for the girls.

The oldest person in the over-age-13 groups was a girl nearly 3 months beyond her fourteenth birthday; she scored 650. Table 1 shows that the older examinees scored little better than the younger ones. The highest score, 780, was earned by a boy 13 years and 136 days old. The lowest score, 410, was earned by a girl 13 years and 131 days old.

Results: SAT-M Scores of the Under-Age-13 Groups in China vs. U.S.

Scores of the under-age-13 groups tested in Shanghai ranged from 480 to 740 for boys, with a median of 633, and from 460 to 750 for girls, with a median of 619. The respective arithmetic means of the scores were 630 and 614. The standard deviations were 60 and 57.

These are *astoundingly* high statistics, as compared with the means of the 23,985 able under-age-13 students tested at Johns Hopkins University's January 1985 annual talent search: 417 for boys (standard deviation 89) and 383 for girls (standard deviation 74). The mean of the Shanghai under-age-13 boys is 2.4 United States standard deviations greater than the mean of the male United States group, and the girls' mean is 3.1 standard deviations greater than the mean of the female United States group. Only 1.45 percent of the United States boys scored higher than the median Shanghai boy, and only 0.31 percent of the United States girls scored higher than the median Shanghai girl. The lowest-scoring Shanghai boy scored 63 points (0.71 of the United States boys' standard deviation) above the mean of the United States boys, and the lowest-scoring Shanghai girl was 77 points (1.04 standard deviation) above the mean of the United States girls.

Table 1. SAT-M Averages and Standard Deviations of the Four Groups Tested

Gender	*Age*	*N*	*Median*	*Mean*	*S.D.*
Male	≥13	80	650	645	55
	<13	80	633	630	60
Female	≥13	54	628	625	60
	<13	65	619	614	57

About the Authors

Julian C. Stanley is professor of psychology and director of the Study of Mathematically Precocious Youth at Johns Hopkins University.

Jia-fen Huang and Xue-min Zu are members of the Educational Research Institute of the Shanghai Teachers University.

Qualifiers for the "700–800 on SAT-M Before Age 13" Group

Even more startling was the number of *extremely* high scores in the Shanghai groups. For several years Stanley's Study of Mathematically Precocious Youth (SMPY) at Johns Hopkins University has been seeking students who, before age 13, score at least 700 on SAT-M.* For comparison, the average college-bound twelfth-grade male in the United States, who is 17 or 18 years old, scores 499 (standard deviation 121) on SAT-M. Only 6 percent score 700 or more.[12] Therefore, those in the top

* Those who have already reached the thirteenth birthday may, nevertheless, qualify by scoring 10 points above 700 for each month or fraction of a month beyond that birthday, up to the maximum possible score of 800 on the day the youth becomes 13 years 10 months old. Thus, for example, the Chinese boy who scored 780 at age 13 years 4½ months qualified; he needed only 750 to do so.

score range, 700–800, at age 12 or less are truly remarkable. The CTY finds about 50 each year out of the approximately 24,000 able persons under age 13 whom it tests. That is one in 480 of a group not lower than upper-5 percent in mathematical reasoning ability, and hence about one in 10,000 of the entire age group. To reason mathematically in the top $\frac{1}{100}$ of 1 percent of the age group is to exhibit extreme aptitude for quantitative academic subjects.

Fifteen of the Shanghai boys and six of the girls qualified for this group. That is about two-fifths as many as qualify in a given year in CTY's large talent search, which involves 19 of the 50 states in the United States of America!

Discussion

Shanghai is an extremely large city, and Huang and Zu had sought out the mathematically ablest youths. The parents of 80 percent of the students tested are college graduates. Obviously, mathematical reasoning ability in highly selected young students in Shanghai is great. China should flourish in science and technology, if the talents of such youths are applied properly to the learning of appropriate fields and to creative work within them.

The People's Republic of China has another advantage, a huge population compared with the United States, about four times as many people. Even if its talent base is only the same as the United States', the percentages will still represent larger actual numbers.

A Caution

But, of course, we do not have an appropriate comparison group. Getting one would involve similar testing in large metropolitan areas such as those of Tokyo, London, New York, or Paris. Even then, except perhaps in Tokyo, locating concentrations of superb mathematical reasoners under 13 years old would probably be more difficult than it was in Shanghai. Also, the school and student refusal rate (unwillingness to permit the testing or participate in it) would almost surely greatly exceed the zero percent in this study.

Nevertheless, we encourage replications internationally in order to help determine how much high-level mathematical talent can readily be confirmed in just an hour of testing time. That small investment could yield great educational dividends.

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Mathematics Curriculum in the People's Republic of China

This initial effort in applying the SAT-M to young Chinese students reveals that many of them reason extraordinarily well mathematically before age 13, and before having covered the bulk of the high-school mathematics curriculum. Therefore, they must have keen analytical ability. In the junior and senior high schools of Shanghai, mathematics is compartmentalized into first-year algebra for the seventh grade, second-year algebra and first-year plane geometry for the eighth grade, etc. Judging from the content of Educational Testing Service's rather difficult old (copyright 1962) Cooperative Mathematics Tests (CMT) in first-, second-, and third-year algebra (which have been used a great deal by SMPY and CTY), high-school teachers in Shanghai consider that their textbooks and examinations are probably rather different from those in the United States. Also, teaching methods seem quite different. CMT items, especially, seem easier to them than their own test items do. The content of CMT algebra I appears to them commensurate with their first- and second-year algebra. The CMT algebra II roughly parallels their second-, third-, and even fourth-year algebra. All but about 10 of the examinees in this study were seventh-graders (the rest were eighth-graders). They had studied Shanghai's first-year algebra, but not yet geometry.

From the turn of the century, when intellectuals proclaimed that "only science and technology can save China," and especially since 1949, the Chinese have taken science and technology quite seriously in order to make their country rich, strong, and prosperous.[13] Most *(continued on page 28)*

to the demands placed on the admissions professional during decision time. They also become integral parts of the recruitment process themselves.

Faculty members nationwide are becoming increasingly involved in direct-contact programs with students and parents. They are visiting high schools, conducting interviews, meeting students on campus and off, and talking with and writing letters to students and parents about their disciplines. Like us, they agonize over decisions, weighing the merits of candidates against the omnipresent institutional considerations. While recognizing that the college has overall enrollment goals, most faculty members are adept at bringing the admissions process back to its fundamental concern of attracting young people best equipped to succeed at the institution.

Given the competitiveness of student recruitment, there needs to be greater recognition of the fact that admissions officers represent the all-important marketing branch of the college. The most attractive, innovative, and exciting academic program in the country will fail if there is insufficient information abroad to attract the kinds of students who will take advantage of it. Although, in most colleges the contribution of the admissions officers to the growth of the institution usually is not recognized.

Admissions officers often exist in a twilight state professionally with few granted the cachet of faculty rank or status, and even fewer allowed to tread the path of the tenure track. Appreciation of the role of the admissions officer and willingness to help in the recruitment process will do much to break down the barriers that many admissions officers feel exist between themselves and the rest of the institution. The usual uneasiness prevailing between many faculties and administrations is particularly odious when it impinges upon the educational goals which all in the community share.

Reading this account one may ask why anyone would stick with it. Many of my colleagues could not answer this question, and have left the field. Perhaps those of us who remain take a more positive view of the process. The life of the college admissions officer may be tiresome and full of unrelenting pressure, but there is a renewal every year. There is the challenge of perfecting the machinery of our enterprise so it can become increasingly efficient and responsive to the needs of our students. We need to pay particular attention to bringing order out of the growing anarchy of financial needs analysis and "merit" scholarships. We also like to believe that we do make a difference in the lives of people we meet on all the trips we make, replete with rush hour dashes to visit schools, lonely meals, and mind-numbing waits in airport terminals. We carry the message to the true seekers of knowledge and on our best days inspire them to realize their educational potential. After all, that is the reason for the existence of the academy. That thought does much to soothe the existential dread which drenches the long nights of late hours, file folders, and pernicious uncertainty.

SAT-M and Brilliant Chinese Students

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students, even those good in the arts, want to take science courses. The major criteria of school assessment are the mean scores in science subjects. Quite likely, mathematics courses in Shanghai tend to go more deeply into the subject than in the United States. Also, seventh-graders in China probably work much harder.[14]

Concluding Remarks

The students in this study were selected from the most outstanding schools in Shanghai. Moreover, Huang and Zu asked the teachers in those schools to choose mathematically exceptionally able youths. Thus, the examinees were the best-performing young mathematics stars in Shanghai, only 160 boys and 119 girls. If the sample had been extended to 23,985 students (the number CTY tested in 1985), undoubtedly the scores would have averaged far lower than these.

In the course of adapting the Wechsler Intelligence Scale for Children (WISC) for use in Shanghai, Huang and Zu found mean scores on the arithmetic and digit span subtests that were much higher than the American norms. Informal research at their Educational Research Institute has shown that more than half of the six-year-old children in their sample pass Piaget's Conservation Tasks. Some researchers are coming to suspect that students in Shanghai may tend to have an especially good

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"head for figures." It may be too soon, however, to put much credence in that, as contrasted with selectivity and environmental pressures.

The next step is to help the high scorers move ahead in mathematics and related subjects such as physics, computer science, chemistry, and biology at paces and levels commensurate with their mathematical and other abilities. Special, fast-paced mathematics and science classes such as those pioneered by Stanley and his associates seem imperative.[15–18] If these brilliant mathematical reasoners do not use their abilities properly, they may become bored or inattentive and lose interest in quantitative subjects. No nation can afford to waste one of its rarest, most precious natural resources, great mathematical reasoning ability. SAT-M is a simple, quick way to find such youths in order to help them educationally.

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AP Telephone Teaching

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lecture. Has everybody loaded the September 24 disc?"

Each week's lecture and example problems are contained on a magnetic disc—a "floppy disc"—and copies are loaded into the computers at the respective schools. Tucker can turn the "pages" of the lecture from the computer in his home, and the computers in the five schools follow his command.

He begins to work on one of the example problems, using his electronic pen and tablet to calculate over the equation that appears on the screen. "What should I do now? Oxford?" A student in Oxford uses the electronic pen and tablet at her desk to complete the equation. Her calculations appear on all of the computer screens in the system. Words of encouragement from the professor.

"Okay, Franklin, you take the next one." The writing is red now, appearing on Tucker's computer screen as a student at Franklin High scratches out an answer.

Later Tucker will explain, "When the system is working right, it's as though you are teaching a class where every student has access to the blackboard. As soon as one student gets onto the board by placing the pen on his tablet, he has control of the screens here and at the other schools." Though this class is taking place in six locations, it is as if teacher and students are all seated around one large table, actively participating in the solution to each problem. "It's the sort of give and take you'd like to have in a classroom," Tucker says. He is at ease. The students chatter back over the phone as though this is nothing new.

But if Tucker is at ease during the class, the challenge of his assignment emerges in conversation once the phones have been hung up. "We really have 30 class meetings to teach what would normally be taught in 140 class sessions of a typical high school Advanced Place-

About the Author

James Leach is director of communications and editor of the alumni newspaper at Colgate University in Hamilton, New York. He holds a B.S. from Utica College and a B.A. from the State University of New York at Plattsburgh.