ON MATHEMATICALLY TALENTED YOUTH:

A Conversation With Julian Stanley

As director of Johns Hopkins University's Study of Mathematically Precocious Youth, Julian Stanley heads a national search for those who may become tomorrow's leading scientists. In this interview with Executive Editor Ron Brandt, Stanley tells how students can qualify for his program and offers advice on educating the gifted.

Q For more than ten years you've been involved in finding and encouraging youngsters who show extraordinary talent in mathematical reasoning. Why?

Stanley: The average age of Ph.D. recipients in science or mathematics in this country is 30. Most have been attending school all that time—25 years or so. That is much too long; it prolongs the training period unnecessarily and is a tragic waste of a rare national resource. Advanced mathematical reasoning undergirds the whole scientific and technological enterprise, and it's always in short supply.

I hope that at least half the young people we identify will get Ph.D's from excellent universities by the time they're in their early twenties, or even their teens.

Julian C. Stanley is Professor of Psychology, The Johns Hopkins University, Baltimore, Maryland, and Director of the Study of Mathematically Precocious Youth (SMPY) there.

Q: How many such young people have you helped discover and what does that suggest about how many there are?

Stanley: If you're talking about the very top level, we've found 61 so far who were born in 1968 or later. We estimate there are 350 to 400 in the country in each age year.

The youngsters with whom we work have, before age 13, scored better on the mathematics reasoning part of the Scholastic Aptitude Test (SAT-M) than 95 percent of college-bound 12th grade males—in other words, at least 700.

Q: Why concentrate on students identified initially when less than 13 years old?

Stanley: We decided years ago we had to specialize in some way in order to do what we wanted, which was help youngsters go through the more abstract mathematics of the school curriculum much faster and better. Therefore, we decided to start around the first pre-algebra year. In Maryland, unlike many other states, one may take algebra as an eighth grader. Now, for those who reason extremely well in mathematics, the first year of algebra is trivially easy. In our early talent searches we found that at least one-fifth of the seventh graders we identified were scoring above the average college-bound 12th grader on math reasoning ability. That's 500 or more on SAT-M. About half of those already knew first-year algebra better —before they took it—than the average person who's had the course for a year.

Q: How is that possible?

Stanley: They pick it up through general math and through the very good analytical reasoning ability they have. They may even get an Algebra I textbook on the side and study it. They read it the way you and I might read a novel.

In our three-week summer program (see pp. 96-100) at St. Mary's College in southern Maryland, the typical student learns two years of mathematics. The ablest ones learn math through precalculus, which usually takes four and a half years in school. It's not really as though they were learning it for the first time; they already "know" a good deal of it. It's just under the skin, ready to erupt. The "slow" ones learn "only" one year in three weeks!

Q: Let's discuss sex differences for a moment. You and your colleagues have made some controversial claims about differences in mathematical aptitude between boys and girls.

Stanley: What we've done is demolish the claim that boys and girls are equally good at mathematics until the girls drop out of math courses and therefore haven't had as much background as boys. It's quite clear that at 12 years of age—when mathematics is still required—boys have higher average SAT-M scores than girls.

In our large math talent searches involving the mathematically top 3 percent, fewer girls than boys participate—43 percent girls compared to 57 percent boys. And we have found substantial differences in their scores every year—from 30 to 48 points higher for boys than girls.

The biggest differences are in the high scores. For instance, at the 500 SAT-M level males outnumber females about two to one. At 600, there are five boys to every girl. At 700, it's about 17 to one. In fact, among the 61 students found recently who scored 700 or more before age 13, there are, regrettably, no girls at all.

This is, of course, surprising. In the past we found seven girls at that level. But an interesting thing: for a girl to score extremely high on math reasoning, she seems almost to have to earn a high verbal score also, whereas we have lots of boys who are very good at math but not at verbal.

It's been suggested in the literature —not our literature, but others'—that girls appear not to be as lateralized as boys in brain hemispheral dominance. They appear to have more balance between the hemispheres and to be processing nonverbal material more in the verbal hemisphere—the left hemisphere—than boys. You might speculate that these girls—and some boys, of course—make high math reasoning scores primarily because they have high general intelligence. Some of the boys seem to have special math aptitude, localized in the right hemisphere. Many girls who score high on SAT-M appear to lack such a specific math aptitude but can learn to do math because they're brilliant verbally.

Julian Stanley and some of the mathematically precocious students.

It seems to resemble musical aptitude. Some people may or may not be particularly intelligent otherwise but learn to play the piano because of their natural talent. A person who's very bright but not directly talented musically can be taught to play the piano but is unlikely ever to be a great pianist.

Q: You're suggesting that these differences may be at least partly genetic?

Stanley: Yes, but it's a complicated issue. There isn't a gene for math ability; that's too simplistic for words. And it certainly doesn't mean girls can't do well in mathematics.

Lynn Fox, who came through our doctoral program here and helped start our talent search, has speculated for years that most early adolescent girls should be taught mathematics separately from boys by female teachers who use a socialized approach. She thinks most boys at that age should be taught math by male teachers who use a theoretical, investigative, analytical approach.

I'm pretty sure that many 12-year-old girls differ in their instructional needs in mathematics from most 12-year-old boys. Still, it's wrong to stereotype. You don't want to say, "A girl is like this and a boy is like that," because clearly there are exceptions. We need to find out more about how these differences arise, at what stages they appear, and what they mean for instructional practice.

Q: Benjamin Bloom and his students have investigated development of highly talented adults in music, athletics, and mathematics. They report that when these individuals were young they not only had natural

ability but also had a great deal of encouragement and skillful coaching. Do you find this true of the young people you've discovered?

Stanley: They vary radically in the extent of special training they've had. Most of the 61 boys who scored 700 or more on the math test before they were 13 have pretty well-educated parents, but for the majority their mathematical aptitude seems more a matter of natural talent than early training. The children exhibited striking ability so early that conscientious, caring parents did a lot to enable the youngsters to use it.

For example, the father of one of our most successful physics students ran an ice cream parlor. The boy went through Hopkins, graduated at age 18 in physics with highest honors, went on to a famed Ivy League university to take his doctorate, and is now researching theoretical plasma physics at a great university. His parents helped him to get to special classes, paid tuition, and let him become a full-time college student after the ninth grade. They did the right motivational and supportive things, but there was no hint of their being able to help him with math or physics.

Q: That seems consistent with Bloom's findings.

Stanley: Good parents don't have to be particularly bright themselves, or even well educated. Of the 14 youngsters who graduated early from Johns Hopkins in the first few years of our work not a single one had a father who was a lawyer, physician, professor, or major businessman. Some of the parents who seem to be least helpful educationally are brilliant professionals who are so busy and preoccupied with their careers they have too little time for their children.

Some well-educated parents actually oppose providing special opportunities for their children. They say, "I don't want my child to be accelerated; I just want him to be happy." They don't seem to realize that a brilliant person who is unfulfilled at age 40 or 50 is not likely to be happy. Brilliant children who don't have to put out much effort at age 12 to 14 tend to become more and more overqualified as they go through school. They may even make A's, but often they don't develop the fast-paced, high-level thinking they need to perform outstandingly at a major university.

Q: Is it a problem that some young students may have high intelligence but haven't yet developed the abstract reasoning ability needed for advanced mathematics?

Stanley: Dan Keating studied that in a doctoral dissertation here in 1973. He found that most of the upper 2 percent of both girls and boys (as judged by a nonverbal reasoning test —the Raven Progressive Matrices) had already attained formal operational status in fifth grade. It's different with students of average ability. When he compared fifth and seventh grade students, Keating found that relatively few average-ability fifth graders were formally operational in their thinking, while a large percentage of the average seventh graders were. Of course, SMPY deals mainly with at least the upper 2 percent of seventh graders, so we're safe with respect to algebra and geometry.

Children can be poorly served by being expected to learn abstract math too early. On the other hand, we've seen an eight year old who learned calculus very well on his own. He went to an excellent college at 11 and a half and was graduated *summa cum laude* in mathematics a few months after his 15th birthday. Then he entered graduate school at a famed university. So you don't want to misinterpret Piaget by saying there is a certain age at which all people reach a certain stage. That's not so. Brilliant children reach formal operational status much earlier than others, and some people never do much formal operational thinking all through their lives.

Q: How do educators treat these young students?

Stanley: Every conceivable way, of course, from truculence and rejection to complete cooperation. We think it's closely related to the parents' attitudes. Our experience has been that schools—particularly the public schools—are susceptible to good ideas from parents if parents go about it in the right way.

Q: How frequently do educators take the initiative to help find these youngsters?

Stanley: Some do, but math reasoning ability isn't as easy to spot as one might think. After all, much math in the lower grades is rote—add, subtract, multiply, divide—so talented youngsters may sit back and have no way to demonstrate their reasoning ability. They may even be bored with the processes and not do them very well.

Some educators are wise enough to look at the test scores they get, spot students with high scores in math, and give them special attention. We had an excellent illustration of that recently. A principal from an elementary school near Akron, Ohio, wrote me saying, "You're not going to believe this." He had a boy in sixth grade math who took the SAT-M and scored 540, which is better than 63 percent of college-bound 12th grade males. And the boy was only seven years old! The fact that he was already in sixth grade math shows that his special needs were being attended to; he was probably about where he belonged. The principal had heard about our encouraging brilliant youths to try the SAT, so he had the boy take it—even though he was only seven. But for every educator like that, there are cases of unperceptive, even obtuse, principals and teachers who, when parents try to get special help, say, "You're just a pushy parent." One of the great things we do with our talent search is to document for some parents that they're not being pushy; their children really are mathematically and/or verbally highly talented.

We don't expect restructuring of the whole school system. The right courses are usually available at different levels. If the youngster's too good for Algebra I, put him or her into Algebra II. If he or she is too advanced for Algebra II, try plane geometry or college algebra, or get a mentor. Unfortunately, most schools just don't know where and how to start.

Q: Some school systems have developed individually paced continuous progress mathematics programs, which they assume will take care of students who need to move faster. You apparently disagree.

Stanley: It depends, of course, on how well taught and monitored such programs are. But individually programmed instruction often does not work well, even for brilliant youngsters, because of the lack of stimulation and challenge. If you go jogging with someone, you're going to try to keep up. And if you play tennis, you should play against good competitors or your tennis runs down; you get worse and worse. So we don't usually find purely individually paced instruction nearly as helpful as a special fast-paced class.

Q: How do you feel about special curriculums such as CEMREL's Elements of Mathematics or the Unified Math program developed by Columbia University Teachers College?

Stanley: Those programs do a nice job of rearranging mathematics topics in a more integrated fashion. They can be excellent for able youngsters (they're not usually suitable for slower students because they're more abstract than the typical course might be), but they're still paced far too slowly for really brilliant youths.

Q: Aside from accelerating students through the regular program, what else do you recommend for mathematically talented students?

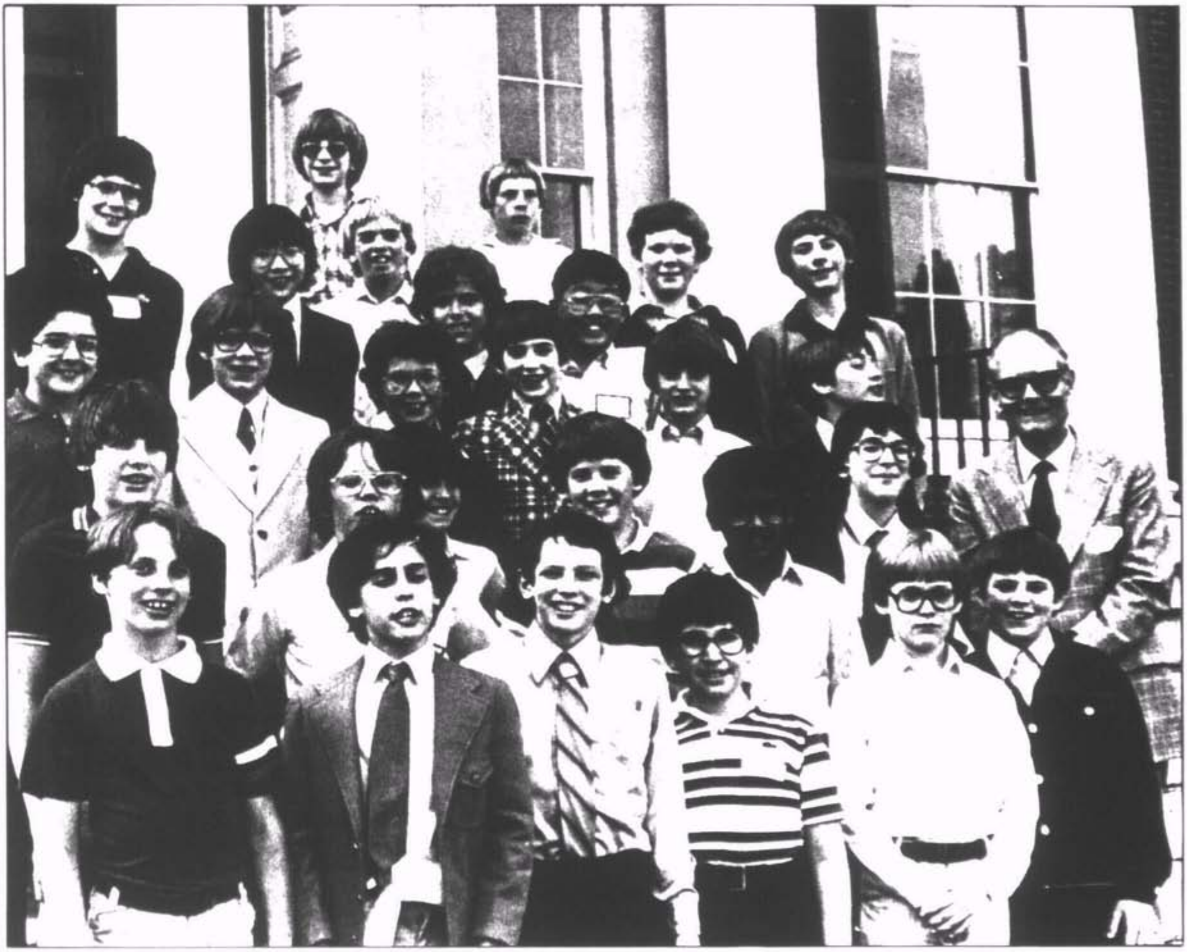
"But individually programmed instruction often does not work well. . . ."

Stanley: We've found it's very effective to have a highly able mentor work for one two-hour period per week with perhaps three to five youngsters, giving them assignments to do on their own during the week.

Q: These mentors need not be certified teachers?

Stanley: Oh, no. For instance, we once had—this is an extreme example—a ten year old serving as a mentor for a six year old. They had lots in common and worked together very well.

That ten year old is now 15. He graduated from Johns Hopkins this May with a bachelor's degree. This fall he will study physics at Cambridge University on a Churchill scholarship. Then, in the fall of 1982 he will begin using his National Science Foundation graduate fellowship at Cal Tech for three years to earn a Ph.D. degree, probably by age 19. This summer he was a full-fledged instructor in the three-week residential summer mathematics program conducted by the Johns Hopkins Office of Talent Identification and Development, teaching mathematically apt 12- and 13-year-olds and serving implicitly as a role model for some of them. The instructors in our summer program are younger and less experienced than regular teachers in the schools. They are often former prodigies themselves. Few of these will ever be regular math teachers in schools. It's a pity; we wish more would, but most of them will go into mathematical sciences (including computer science), engineering, and physics rather than high school teach-



ing. Mentors must be able to reason extremely well mathematically. There's no substitute for that. They should be good teachers, too, of course, but you don't want slow-minded people working with fast-minded. They have the wrong approach and bore them.

Q: What other suggestions do you have for working with mathematically highly able students?

Stanley: They should be encouraged to participate in math leagues and math competitions. The Mathematical Association of America has a big high school competition every year. Two of our protégés have been among the eight top math high-school students in the country, representing the United States in the Mathematics World Olympiad.

It's not the prizes that are most important, but the competition and stimulation. It makes for better adjustment and humility, too, because always being the best without much effort can make students arrogant.

I urge talented youngsters to take the SAT every year so they can see what kind of progress they're making. We advise them to take not only the SAT, but also the College Board high-school-level achievement tests. They may take three of those for the price of one at about five different times a year.

Many schools don't make enough use of the College Board's Advanced Placement Program exams. Able youngsters can save a lot of time, boredom, and money by getting college credit in advance for courses they would otherwise have to take in college.

Suppose a student who is just entering senior high does better on the high school-level American history test than half the people who've had the course in high school. That student might go to the high school teacher and say, "Let's you and I work together so I can take the Advanced Placement Exam in May. If I score well on that exam, will you give me an A in high school history?" Some youngsters become very skillful in negotiating on their own behalf. They become good educational planners and decision makers. And that's our goal: to make them independent of us and independent of their parents as soon as feasible.

Q: Most school programs are established for students generally classified as gifted; they're not as specialized as yours.

"Using loaded words like 'gifted' may serve a bureaucratic purpose, but it doesn't serve an instructional one."

Stanley: Using loaded words like "gifted" may serve a bureaucratic purpose, but it doesn't serve an instructional one. It's all right to think about the need to provide for various types of talent, but you obviously don't handle ballet dancers the same way you handle young students who reason brilliantly mathematically.

Q: It's better to decide which talents or abilities schools can help develop and select students on that basis?

Stanley: I think a little of both is necessary. Rather than using an IQ test—the Stanford-Binet and the Wechsler scales are excellent for certain purposes but take too much time and are rather subjective—I would use something like the Differential Aptitude Test (DAT) published by The Psychological Corporation of New York City. Schools might look at any of the latest achievement-test-battery scores in their files to find youngsters who scored in the top 10 percent overall. They might give those students the DAT early enough, maybe in the seventh grade, and define as needing special facilitation every youngster who scored in the upper 5 percent on one or more of the eight DAT subtests: abstract reasoning, clerical speed and accuracy, language usage, mechanical reasoning, numerical ability, space relations, spelling, and verbal reasoning. That would still not provide for such abilities as fine manual skills or musical aptitude, but it would give a firmer and probably more democratic base for talking about some specific talents.

Q: It's often recommended that identification of gifted students be based on multiple criteria, including teacher judgment. You seem to be questioning that.

Stanley: Teacher judgment may be especially useful if one is looking for hard-to-measure qualities such as sociability and leadership. If you're talking about cognitive ability, tests are essential. I probably know more about math reasoning ability of 12-year-olds than almost anyone else, but I wouldn't dare try to judge the ability of an individual student without seeing test scores.

Q: Some people say using a test like the SAT is too restrictive; that it doesn't measure important qualities such as creativity, for example.

Stanley: Sure. A yardstick doesn't measure temperature and a thermometer isn't very good for telling how tall you are. They have different uses. What we're looking for is ability to learn mathematics faster and better than the typical school curriculum provides for. We want the content to be handled so that the youngster is encouraged to generate problems, to find better solutions, but we don't worry much about testing the youngsters for creativity or setting up special courses on the side in which they brainstorm uses for bricks and so on. We've talked with lots of pure mathematicians, who uniformly agree that the best way to become creative in mathematics is to learn mathematics rigorously from mathematically creative people. You can't be a creative mathematician if you are ignorant of math.

Q: What should teachers and administrators tell students who might like to participate in your program?

Stanley: Students who think they can qualify for our talent search should go to the senior high school nearest them and get the SAT application and information material along with a practice booklet. After studying the practice booklet they should take the practice test to see how good they are. If they score 400 or more on any part of the practice test, they're able enough to take the exam. It's wise to take it for information, even if they're not going to get a score of 700. Then, before age 13, they should arrange to take the SAT—not just the math part, but the entire test—trying hard on all three parts. When and if they do get a 700 on the math reasoning part before age 13, they should photocopy their score report and send it to me, Professor Julian Stanley, Department of Psychology, The Johns Hopkins University, Baltimore, MD 21218. They'll be sent much pertinent material, offered opportunities and perhaps scholarships for fast-paced summer programs, and so on.

To help students who turn 13 before taking the SAT—because it is not offered in most states from June until November—we will accept a score ten points above 700 for each month or fraction of a month beyond the youth's 13th birthday. For example, if not yet a month beyond 13 at the time the SAT is taken, the examinee needs 710. If almost ten months beyond, he or she needs 800, which is the highest possible score.

Let me emphasize again how important it is to discover and help these youths who reason extremely well mathematically. Truly, they are one of our nation's most precious resources. With a generous new three-year grant from The Spencer Foundation of Chicago, Camilla Benbow of SMPY and I intend to intensify our efforts on behalf of the mathematically most promising young students in the nation. ■

References

Arnold, A. P. "Sexual Differences in the Brain." *American Scientist* 68, 2 (March-April 1980): 165-173.

Benbow, C. P., and Stanley, J. C. "Sex Differences in Mathematical Ability: Fact or Artifact?" *Science* 210 (12 December 1980): 1262-1264.

Benbow, C. P., and Stanley, J. C. "Mathematical Ability: Is Sex a Factor?" *Science* 212, 4491 (10 April 1981): 118, 121.

Keating, D. P. "A Piagetian Approach to Intellectual Precocity." In *Intellectual Talent: Research and Development.* Edited by D. P. Keating. Baltimore: Johns Hopkins University Press, 1976, pp. 90-99.

Levy, J. "Sex and the Brain." *The Sciences* 21, 3 (March 1981): 20-23, 28. Essay review of R. W. Goy and B. S. McEwen, *Sexual Differentiation of the Brain.* Cambridge, Mass.: MIT Press, 1980.

Stanley, J. C. "On Educating the Gifted." *Educational Researcher* 9, 3 (March 1980): 8-12.