How to raise a genius

A long-running study of exceptional children reveals what it takes to produce the scientists who will lead the twenty-first century.

BY TOM CLYNES

On a summer day in 1968, professor Julian Stanley met a brilliant but bored 12-year-old named Joseph Bates. The Baltimore student was so far ahead of his classmates in mathematics that his parents had arranged for him to take a computer-science course at Johns Hopkins University, where Stanley taught. Even that wasn't enough. Having leapfrogged ahead of the adults in the class, the child kept himself busy by teaching the FORTRAN programming language to graduate students.

Unsure of what to do with Bates, his computer instructor introduced him to Stanley, a researcher well known for his work in psychometrics — the study of cognitive performance. To discover more about the young prodigy's talent, Stanley gave Bates a battery of tests that included the SAT college-admissions exam, normally taken by university-bound 16- to 18-year-olds in the United States.

Bates's score was well above the threshold for admission to Johns Hopkins, and prompted Stanley to search for a local high school that would let the child take advanced mathematics and science classes. When that plan failed, Stanley convinced a dean at Johns Hopkins to let Bates, then 13, enrol as an undergraduate.

Stanley would affectionately refer to Bates as "student zero" of his Study of Mathematically Precocious Youth (SMPY), which would transform how gifted children are identified and supported by the US education system. As the longest-running current longitudinal survey of intellectually talented children, SMPY has for 45 years tracked the careers and accomplishments of some 5,000 individuals, many of whom have gone on to become high-achieving scientists. The study's ever-growing data set has generated more than 400 papers and several books, and provided key insights into how to spot and develop talent in science, technology, engineering, mathematics (STEM) and beyond.

> *"Whether we like it or not, these people really do control our society."*

"What Julian wanted to know was, how do you find the kids with the highest potential for excellence in what we now call STEM, and how do you boost the chance that they'll reach that potential," says Camilla Benbow, a protégé of Stanley's who is now dean of education and human development at Vanderbilt University in Nashville, Tennessee. But Stanley wasn't interested in just studying bright children; he wanted to nurture their intellect and enhance the odds that they would change the world. His motto, he told his graduate students, was "no more dry bones methodology".

With the first SMPY recruits now at the peak of their careers[1], what has become clear is how much the precociously gifted outweigh the rest of society in their influence. Many of the innovators who are advancing science, technology and culture are those whose unique cognitive abilities were identified and supported in their early years through enrichment programmes such as Johns Hopkins University's Center for Talented Youth — which Stanley began in the 1980s as an adjunct to SMPY. At the start, both the study and the centre were open to young adolescents who scored in the top 1% on university entrance exams. Pioneering mathematicians Terence Tao and Lenhard Ng were one-percenters, as were Facebook's Mark Zuckerberg, Google co-founder Sergey Brin and musician Stefani Germanotta (Lady Gaga), who all passed through the Hopkins centre.

"Whether we like it or not, these people really do control our society," says Jonathan Wai, a psychologist at the Duke University Talent Identification Program in Durham, North Carolina, which collaborates with the Hopkins centre. Wai combined data from 11 prospective and retrospective longitudinal studies[2], including SMPY, to demonstrate the correlation between early cognitive ability and adult achievement. "The kids who test in the top 1% tend to become our eminent scientists and academics, our Fortune 500 CEOs and federal judges, senators and billionaires," he says.

Such results contradict long-established ideas suggesting that expert performance is built mainly through practice — that anyone can get to the top with enough focused effort of the right kind. SMPY, by contrast, suggests that early cognitive ability has more effect on achievement than either deliberate practice or environmental factors such as socio-economic status. The research emphasizes the importance of nurturing precocious children, at a time when the prevailing focus in the United States and other countries is on improving the performance of struggling students (see 'Nurturing a talented child'). At the same time, the work to identify and support academically talented students has raised troubling questions about the risks of labelling children, and the shortfalls of talent searches and standardized tests as a means of identifying high-potential students, especially in poor and rural districts.

"With so much emphasis on predicting who will rise to the top, we run the risk of selling short the many kids who are missed by these tests," says Dona Matthews, a developmental psychologist in Toronto, Canada, who co-founded the Center for Gifted Studies and Education at Hunter College in New York City. "For those children who are tested, it does them no favours to call them 'gifted' or 'ungifted'. Either way, it can really undermine a child's motivation to learn."

START OF A STUDY

On a muggy August day, Benbow and her husband, psychologist David Lubinski, describe the origins of SMPY as they walk across the quadrangle at Vanderbilt University. Benbow was a graduate student at Johns Hopkins when she met Stanley in a class he taught in 1976. Benbow and Lubinski, who have co-directed the study since Stanley's retirement, brought it to Vanderbilt in 1998.

"In a sense, that brought Julian's research full circle, since this is where he started his career as a professor," Benbow says as she nears the university's psychology laboratory, the first US building dedicated to the study of the field. Built in 1915, it houses a small collection of antique calculators — the tools of quantitative psychology in the early 1950s, when Stanley began his academic work in psychometrics and statistics.

His interest in developing scientific talent had been piqued by one of the most famous longitudinal studies in psychology, Lewis Terman's Genetic Studies of Genius[3,4]. Beginning in 1921, Terman selected teenage subjects on the basis of high IQ scores, then tracked and encouraged their careers. But to Terman's chagrin, his cohort produced only a few esteemed scientists. Among those rejected because their IQ of 129 was too low to make the cut was William Shockley, the Nobel-prizewinning co-inventor of the transistor. Physicist Luis Alvarez, another Nobel winner, was also rejected.

Stanley suspected that Terman wouldn't have missed Shockley and Alvarez if he'd had a reliable way to test them specifically on quantitative reasoning ability. So Stanley decided to try the Scholastic Aptitude Test (now simply the SAT). Although the test is intended for older students, Stanley hypothesized that it would be well suited to measuring the analytical reasoning abilities of elite younger students.

In March 1972, Stanley rounded up 450 bright 12- to 14-year-olds from the Baltimore area and gave them the mathematics portion of the SAT. It was the first standardized academic 'talent search'. (Later, researchers included the verbal portion and other assessments.)

"The first big surprise was how many adolescents could figure out math problems that they hadn't encountered in their course work," says developmental psychologist Daniel Keating, then a PhD student at Johns Hopkins University. "The second surprise was how many of these young

ILLUSTRATION BY VASAVA

kids scored well above the admissions cut-off for many elite universities."

Stanley hadn't envisioned SMPY as a multi-decade longitudinal study. But after the first follow-up survey, five years later, Benbow proposed extending the study to track subjects through their lives, adding cohorts and including assessments of interests, preferences, and occupational and other life accomplishments. The study's first four cohorts range from the top 3% to the top 0.01% in their SAT scores. The SMPY team added a fifth cohort of the leading mathematics and science graduate students in 1992 to test the generalizability of the talent-search model for identifying scientific potential.

"I don't know of any other study in the world that has given us such a comprehensive look at exactly how and why STEM talent develops," says Christoph Perleth, a psychologist at the University of Rostock in Germany who studies intelligence and talent development.

SPATIAL SKILLS

As the data flowed in, it quickly became apparent that a one-size-fits-all approach to gifted education, and education in general, was inadequate.

"SMPY gave us the first large-sample basis for the field to move away from general intelligence toward assessments of specific cognitive abilities, interests and other factors," says Rena Subotnik, who directs the Center for Gifted Education Policy at the American Psychological Association in Washington DC.

In 1976, Stanley started to test his second cohort (a sample of 563 13-year-olds who scored in the top 0.5% on the SAT) on spatial ability — the capacity to understand and remember spatial relationships between objects[5]. Tests for spatial ability might include matching objects that are seen from different perspectives, determining which cross-section will result when an object is cut in certain ways, or estimating water levels on tilted bottles of various shapes. Stanley was curious about whether spatial ability might better predict educational and occupational outcomes than could measures of quantitative and verbal reasoning on their own.

Follow-up surveys — at ages 18, 23, 33 and 48 — backed up his hunch. A 2013 analysis[5] found a correlation between the number of patents and peer-refereed publications that people had produced and their earlier scores on SATs and spatial-ability tests. The SAT tests jointly accounted for about 11% of the variance; spatial ability accounted for an additional 7.6%.

The findings, which dovetail with those of other recent studies, suggest that spatial ability plays a major part in creativity and technical innovation. "I think it may be the largest known untapped source of human potential," says Lubinski, who adds that students who are only marginally impressive in mathematics or verbal ability but high in spatial ability often make exceptional engineers, architects and surgeons. "And yet, no admissions directors I know of are looking at this, and it's generally overlooked in school-based assessments."

Although studies such as SMPY have given educators the ability to identify and support gifted youngsters, worldwide interest in this population is uneven. In the Middle East and east Asia, high-performing STEM students have received significant attention over the past decade. South Korea, Hong Kong and Singapore screen children for giftedness and steer high performers into innovative programmes. In 2010, China launched a ten-year National Talent Development Plan to support and guide top students into science, technology and other high-demand fields.

In Europe, support for research and educational programmes for gifted children has ebbed, as the focus has moved more towards inclusion. England decided in 2010 to scrap the National Academy for Gifted and Talented Youth, and redirected funds towards an effort to get more poor students into leading universities.

ON THE FAST TRACK

When Stanley began his work, the choices for bright children in the United States were limited, so he sought out environments in which early talent could blossom. "It was clear to Julian that it's not enough to identify potential; it has to be developed in appropriate ways if you're going to keep that flame well lit," says Linda Brody, who studied with Stanley and now runs a programme at Johns Hopkins focused on counselling profoundly gifted children.

At first, the efforts were on a case-by-case basis. Parents of other bright children began to approach Stanley after hearing about his work with Bates, who thrived after entering university. By 17, he had earned bachelor's and master's degrees in computer science and was pursuing a doctorate at Cornell University in Ithaca, New York. Later, as a professor at Carnegie Mellon University in Pittsburgh, Pennsylvania, he would become a pioneer in artificial intelligence.

"I was shy and the social pressures of high school wouldn't have made it a good fit for me," says Bates, now 60. "But at college, with the other science and math nerds, I fit right in, even though I was much younger. I could grow up on the social side at my own rate and also on the intellectual side, because the faster pace kept me interested in the content."

The SMPY data supported the idea of accelerating fast learners by allowing them to skip school grades. In a comparison of children who bypassed a grade with a control group of similarly smart children who didn't, the grade-skippers were 60% more likely to earn doctorates or patents and more than twice as likely to get a PhD in a STEM field[6]. Acceleration is common in SMPY's elite 1-in-10,000 cohort, whose intellectual diversity and rapid pace of learning make them among the most challenging to educate. Advancing these students costs little or nothing, and in some cases may save schools money, says Lubinski. "These kids often don't need anything innovative or novel," he says, "they just need earlier access to what's already available to older kids."

Many educators and parents continue to believe that acceleration is bad for children — that it will hurt them socially, push them out of childhood or create knowledge gaps. But education researchers generally agree that acceleration benefits the vast majority of gifted children socially and emotionally, as well as academically and professionally[7].

Skipping grades is not the only option. SMPY researchers say that even modest interventions — for example, access to challenging material such as college-level Advanced Placement courses — have a demonstrable effect. Among students with high ability, those who were given a richer density of advanced precollegiate educational opportunities in STEM went on to publish more academic papers, earn more patents and

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BRIGHT START

Nurturing a talented child

"Setting out to raise a genius is the last thing we'd advise any parent to do," says Camilla Benbow, dean of education and human development at Vanderbilt University in Nashville, Tennessee. That goal, she says, "can lead to all sorts of social and emotional problems".

Benbow and other talent-development researchers offer the following tips to encourage both achievement and happiness for smart children.

- Expose children to diverse experiences.
- When a child exhibits strong interests or talents, provide opportunities to develop them.
- Support both intellectual and emotional needs.
- Help children to develop a 'growth mindset' by praising effort, not ability.
- Encourage children to take intellectual risks and to be open to failures that help them learn.
- Beware of labels: being identified as gifted can be an emotional burden.
- Work with teachers to meet your child's needs. Smart students often need more-challenging material, extra support or the freedom to learn at their own pace.
- Have your child's abilities tested. This can support a parent's arguments for more-advanced work, and can reveal issues such as dyslexia, attention-deficit/hyperactivity disorder, or social and emotional challenges. **T.C.**

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pursue higher-level careers than their equally smart peers who didn't have these opportunities[8].

Despite SMPY's many insights, researchers still have an incomplete picture of giftedness and achievement. "We don't know why, even at the high end, some people will do well and others won't," says Douglas Detterman, a psychologist who studies cognitive ability at Case Western Reserve University in Cleveland, Ohio. "Intelligence won't account for all the differences between people; motivation, personality factors, how hard you work and other things are important."

Some insights have come from German studies[9–11] that have a methodology similar to SMPY's. The Munich Longitudinal Study of Giftedness, which started tracking 26,000 gifted students in the mid-1980s, found that cognitive factors were the most predictive, but that some personal traits — such as motivation, curiosity and ability to cope with stress — had a limited influence on performance. Environmental factors, such as family, school and peers, also had an impact.

The data from such intellectual-talent searches also contribute to knowledge of how people develop expertise in subjects. Some researchers and writers, notably psychologist Anders Ericsson at Florida State University in Tallahassee and author Malcolm Gladwell, have popularized the idea of an ability threshold. This holds that for individuals beyond a certain IQ barrier (120 is often cited), concentrated practice time is much more important than additional intellectual abilities in acquiring expertise. But data from SMPY and the Duke talent programme dispute that hypothesis (see 'Top of the charts'). A study published this year[12] compared the outcomes of students in the top 1% of childhood intellectual ability with those in the top 0.01%. Whereas the first group gain advanced degrees at about 25 times the rate of the general population, the more elite students earn PhDs at about 50 times the base rate.

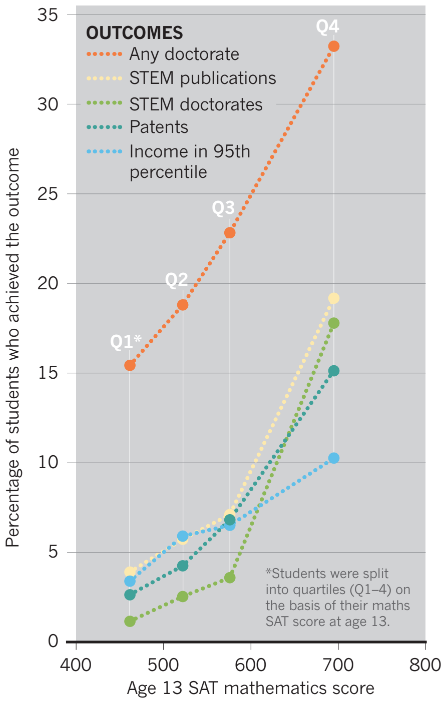
But some of the work is controversial. In North America and Europe, some child-development experts lament that much of the research on talent development is driven by the urge to predict who will rise to the top, and educators have expressed considerable unease about the concept of identifying and labelling a group of pupils as gifted or talented[13].

"A high test score tells you only that a person has high ability and is a good match for that particular test at that point in time," says Matthews. "A low test score tells you practically nothing," she says, because many factors can depress students' performance, including their cultural backgrounds and how comfortable they are with taking high-stakes tests. Matthews contends that when children who are near the high and low extremes of early achievement feel assessed in terms of future success, it can damage their motivation to learn and can contribute to what Stanford University psychologist Carol Dweck calls a fixed mindset. It's far better, Dweck says, to encourage a growth mindset, in which children believe that brains and talent are merely a starting point, and that abilities can be developed through hard work and continued intellectual risk-taking.

"Students focus on improvement instead of worrying about how smart they are and hungering for approval," says Dweck. "They work hard to learn more and get smarter." Research by Dweck and her colleagues shows that students who learn with this mindset show greater motivation at school, get better marks and have higher test scores[14].

Top of the charts

Long-term studies of gifted students — those who scored in the top 1% as adolescents on the mathematics section of the SAT — reveal that people at the very top of the range went on to outperform the others.



SOURCE: K. FERRIMAN ROBERTSON *ET AL.* *CURR. DIR. PSYCHOL. SCI.* **19,** 346–351 (2010).

Benbow agrees that standardized tests should not be used to limit students' options, but rather to develop learning and teaching strategies appropriate to children's abilities, which allow students at every level to reach their potential.

Next year, Benbow and Lubinski plan to launch a mid-life survey of the profoundly gifted cohort (the 1 in 10,000), with an emphasis on career achievements and life satisfaction, and to re-survey their 1992 sample of graduate students at leading US universities. The forthcoming studies may further erode the enduring misperception that gifted children are bright enough to succeed on their own, without much help.

"The education community is still resistant to this message," says David Geary, a cognitive developmental psychologist at the University of Missouri in Columbia, who specializes in mathematical learning. "There's a general belief that kids who have advantages, cognitive or otherwise, shouldn't be given extra encouragement; that we should focus more on lower-performing kids."

Although gifted-education specialists herald the expansion of talent-development options in the United States, the benefits have mostly been limited so far to students who are at the top of both the talent and socio-economic curves.

"We know how to identify these kids, and we know how to help them," says Lubinski. "And yet we're missing a lot of the smartest kids in the country."

As Lubinski and Benbow walk through the quadrangle, the clock strikes noon, releasing packs of enthusiastic adolescents racing towards the dining hall. Many are participants in the Vanderbilt Programs for Talented Youth, summer enrichment courses in which gifted students spend three weeks gorging themselves on a year's worth of mathematics, science or literature. Others are participants in Vanderbilt's sports camps.

"They're just developing different talents," says Lubinski, a former high-school and college wrestler. "But our society has been much more encouraging of athletic talents than we are of intellectual talents."

And yet these gifted students, the 'mathletes' of the world, can shape the future. "When you look at the issues facing society now — whether it's health care, climate change, terrorism, energy — these are the kids who have the most potential to solve these problems," says Lubinski. "These are the kids we'd do well to bet on." ■

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