Research Article

Tracking Exceptional Human Capital Over Two Decades

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ABSTRACT—*Talent-search participants (286 males, 94 females) scoring in the top 0.01% on cognitive-ability measures were identified before age 13 and tracked over 20 years. Their creative, occupational, and life accomplishments are compared with those of graduate students (299 males, 287 females) enrolled in top-ranked U.S. mathematics, engineering, and physical science programs in 1992 and tracked over 10 years. By their mid-30s, the two groups achieved comparable and exceptional success (e.g., securing top tenure-track positions) and reported high and commensurate career and life satisfaction. College entrance exams administered to intellectually precocious youth uncover extraordinary potential for careers requiring creativity and scientific and technological innovation in the information age.*

Since 1972, the SAT has been widely used to identify intellectually talented seventh and eighth graders to facilitate their movement along trajectories leading to high achievement and success in adulthood (Colangelo, Assouline, & Gross, 2004). More than 200,000 young adolescents participate annually in such talent searches in the United States.[1] Four cohorts of these adolescents identified between 1972 and 1997 (totaling more than 5,000 individuals) are being tracked by the Study of Mathematically Precocious Youth (SMPY) throughout their adult lives (Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000; Lubinski & Benbow, 1994, 2000). A 20-year follow-up of SMPY's ablest cohort has just been completed. Before age 13, these participants scored within the top 0.01% for their age on either SAT mathematical reasoning ability (SAT-M $\geq$ 700) or SAT verbal reasoning ability (SAT-V $\geq$ 630; Lubinski, Webb, Morelock, & Benbow, 2001). They were identified in talent searches conducted in the early 1980s and, with a Web-based survey, were followed up in 2003 and 2004 at the mean age of 33.6 years (286 men, 94 women; response rate > 80%).

The achievements of these talent-search (TS) participants were compared with those of a cohort of first- and second-year graduate students identified by SMPY at approximately age 24 through their enrollment in 1992 at top U.S. programs in engineering, mathematics, and the physical sciences (Gourman, 1989; National Research Council, 1987). Because the male:female ratio in these programs often exceeded 3:1, all females in each program were invited to participate, along with an equal number of randomly selected males (cf. Lubinski, Benbow, Shea, Eftekhari-Sanjani, & Halvorson, 2001). These graduate-student (GS) participants were psychologically profiled in 1992 (Lubinski, Benbow, et al., 2001) and surveyed again in 2003 and 2004, approximately 10 years later (299 men, 287 women; response rate > 80%). When initially identified, the GS participants were among the nation's ablest scientists in training, having mean quantitative and verbal Graduate Record Examination scores (GRE-Q and GRE-V, respectively) as follows: males—GRE-Q = 750, GRE-V = 627; females—GRE-Q = 736, GRE-V = 615. Never before has a sample of future scientists of this caliber, with nearly equivalent numbers of men and women, been psychologically assessed so comprehensively and tracked longitudinally. At this follow-up, their mean age was 35.4 years, 1.8 years older than the TS participants.

RESULTS

Education

Doctoral-level degrees (Ph.D., M.D., or J.D.) were earned by 51.7% and 54.3% of male and female TS participants, respec-

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[1]Modern talent searches cover essentially the entire United States. They identify seventh and eighth graders who score in the top 3% on national norms on grade-level achievement tests routinely offered in their schools. These students are given the opportunity to take college entrance exams. Those scoring at or beyond the mean for college-bound high school seniors are invited to participate in summer residential programs, in which they typically complete a full high school course (e.g., algebra, chemistry, English) in 3 weeks (Benbow & Stanley, 1996; Bleske-Rechek, Lubinski, & Benbow, 2004; Colangelo et al., 2004; Stanley, 2000).

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tively, and 79.7% and 77.1% of male and female GS participants. Because the latter were identified as graduate students, their higher rates of doctoral degrees would be expected; in fact, it is remarkable that the GS-TS difference is not more marked. Selection before age 13 on the basis of one high SAT score resulted in the identification of a population that, 20 years later, earned doctorates at 50 times the base-rate expectation of 1% for the general population and at two thirds the rate of enrollees in prestigious doctoral programs.[2] Moreover, the institutions at which these TS participants earned their doctorates were highly ranked; for example, 51.8% of these degrees were taken at U.S. institutions ranked within the top 10.[3] Interestingly, of the 5.3% of TS participants who earned M.B.A. degrees (16 men, 4 women), all but one did so in programs ranked within the top 10 (America's Best Colleges, 2004)[4]; such M.B.A.s are highly sought in corporate settings.

Occupations

The occupations for both groups are displayed in Figure 1. Not surprisingly, given their selection criteria, many GS participants (69.3%) were postsecondary teachers, engineers, and scientists; yet nearly half of TS participants (45.8%) reported careers in these areas as well. Although there were clear differences between the percentages of GS and TS participants in these occupational fields, $\chi^2(1, N = 907) = 49.8$, $p < .001$, the gap between the samples closed by more than half when careers in medicine[5] and law[6] were added (GS: 70.9%; TS: 59.4%), $\chi^2(1, N = 907) = 12.8$, $p < .001$. Executive and administrative positions were frequently reported occupations for both groups.

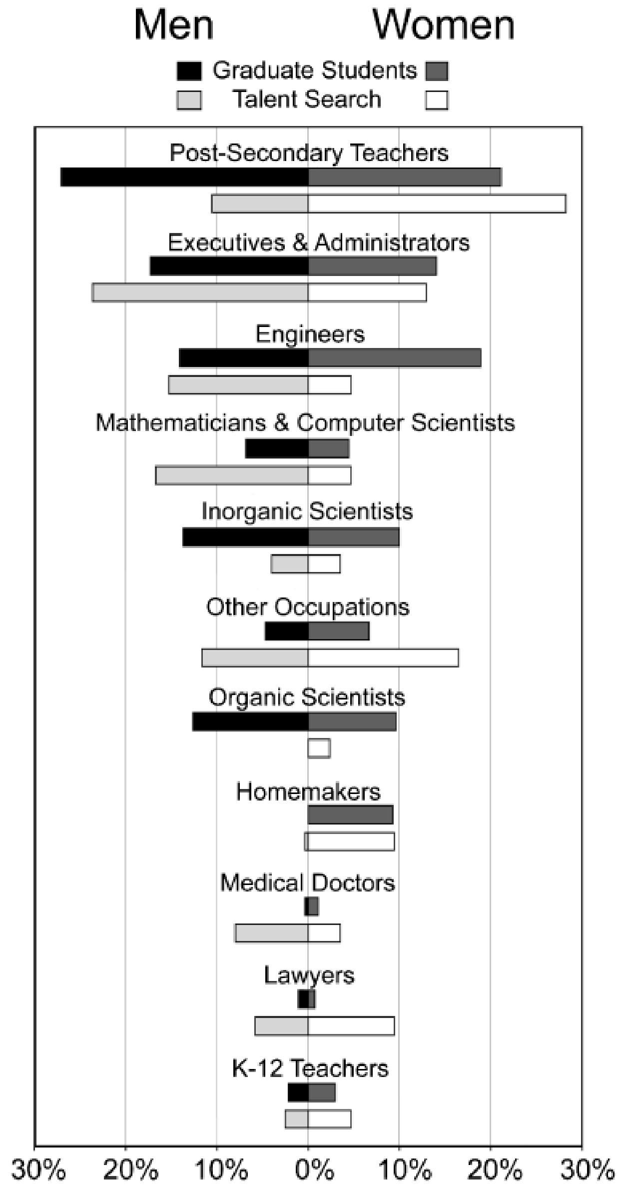

Fig. 1. Occupations of the graduate-student (GS) and talent-search (TS) participants. The data shown here are based on *ns* of 277 and 270 for male and female GS participants, respectively, and 275 and 85 for male and female TS participants, respectively.

Success

Vocational success can be defined in multiple ways. Two indicators are illustrated in Figure 2: positions in academe and compensation. First, we report the proportion of GS and TS participants in tenure-track or tenured faculty positions (the most coveted positions in academe), with the institutions of employment partitioned by their overall school ranking (America's Best Colleges, 2004). Overall, as expected, GS participants were found more frequently in academic positions than

[2]The percentages of doctorates from three large-scale studies of intellectually precocious youth (top 1%) completed during the past century are useful benchmarks for calibrating these findings. Lewis Terman's study (launched in 1920, $N = 1{,}528$) found that 27% of males and 4% of females earned doctorates (Holahan, Sears, & Cronbach, 1995). In a subset of Project Talent participants (launched in 1960, $N = 1{,}005$), 30% of males and 5% of females reported doctorates (Lubinski & Humphreys, 1990). Finally, in SMPY's first two cohorts (launched in the 1970s, $N = 1{,}975$), 28% of males and 24% of females earned doctorates (Benbow et al., 2000).

[3]The top 10 universities were ranked according to Webster and Skinner's (1996) compilation of the National Research Council's ratings of the nation's doctoral programs in 41 disciplines from 274 institutions (Goldberger, Maher, & Flattau, 1995). Webster and Skinner's analysis relied on the National Research Council's report of the "Scholarly Quality of Program Faculty" of universities with doctoral programs in at least 15 disciplines. The number of participants with doctoral degrees from each top-10 institution is as follows: Harvard, 25; Stanford, 21; University of California–Berkeley, 16; Yale, 9; University of Chicago, 8; Massachusetts Institute of Technology, 7; Princeton, 7; California Institute of Technology, 4; University of California–San Diego, 4; and Cornell, 3. Five participants earned more than one doctoral degree; 1 of these participants earned two degrees at different top-10 institutions and therefore is represented twice in these counts.

[4]The one exception earned an M.B.A. in a European university not considered in the ranking system used.

[5]These 46 physicians were impressive: More than 20% were professors of medicine at major universities. The group also included an orthopedic hand surgeon, an associate director of kidney transplantation, a medical-journal editor, a director of pediatrics, a neurosurgeon, a director of family practice, a head-and-neck radiologist, and two fellows of cardiology.

[6]More than 40% of the lawyers had secured Law Review appointments during law school.

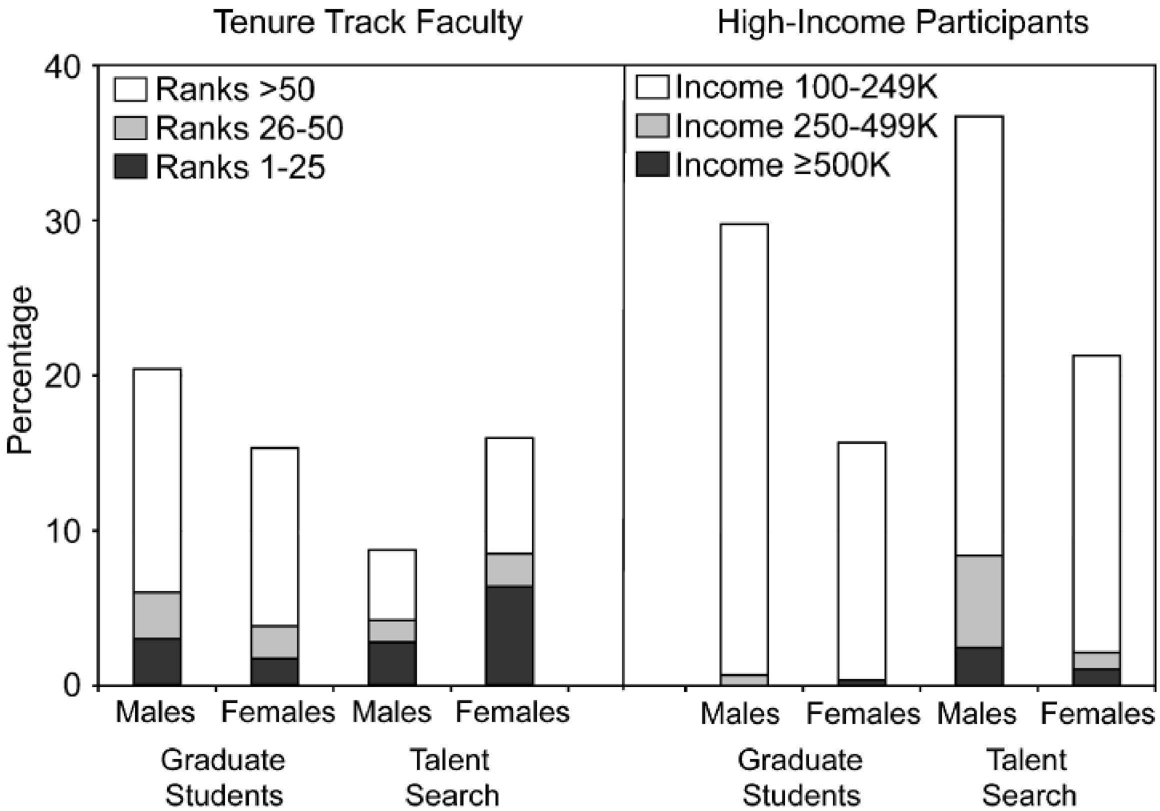

Fig. 2. Percentage of graduate-student (GS) and talent-search (TS) participants with tenure-track or tenured positions (left) and annual incomes of \$100,000 or more (right). The data shown here are based on the complete samples: 299 and 287 male and female GS participants, respectively, and 286 and 94 male and female TS participants, respectively.

TS participants were, $\chi^2(1, N = 966) = 9.2, p < .01$. In separate analyses by sex, this trend was apparent for the men, $\chi^2(1, N = 585) = 15.6, p < .001$, but not the women, $\chi^2(1, N = 381) = 0.0$, n.s. However, there were no significant differences between the GS and TS participants when academic positions at highly ranked institutions were examined separately, $\chi^2(1, N = 966) = 0.3$, n.s., for top-50 institutions and $\chi^2(1, N = 966) = 1.5$, n.s. for top-25 institutions. In fact, female TS participants secured tenure-track positions in institutions ranked within the top 25 more frequently than female GS participants, $\chi^2(1, N = 381) = 5.4, p < .05$. That the SAT can identify young adolescents who eventually achieve tenure-track positions at top universities at rates comparable to those of graduate students attending the top U.S. math, science, and engineering doctoral programs is truly remarkable. Moreover, 21.7% of the TS participants who were in tenure-track positions in the top 50 U.S. universities were already full professors, compared with "only" 6.5% of GS participants.

A second indicator of occupational success is income, especially for individuals who have entered corporate tracks. Overall, more TS than GS participants reported annual incomes of at least \$100,000, $\chi^2(1, N = 966) = 11.8, p < .001$. This trend was not statistically significant when income was examined separately by sex, $\chi^2(1, N = 585) = 3.2$, n.s., for men and $\chi^2(1, N = 381) = 1.6$, n.s., for women. Large differences, however, were observed in the proportions of GS and TS participants with exceptionally high incomes, $\chi^2(1, N = 966) = 31.7, p < .001$, for incomes of at least \$250,000 and $\chi^2(1, N = 966) = 9.3, p < .01$, for incomes of at least \$500,000. In fact, exceptionally high incomes (\$250,000+) were almost exclusively found among TS participants (mostly males). Nearly half (46.2%) of the TS participants who reported incomes of at least \$100,000 held M.B.A. degrees, and more than half (60.0%) of the TS participants with M.B.A. degrees reported incomes of at least \$100,000. High incomes were quite frequently reported by individuals who had assumed high-level executive and managerial positions (e.g., corporate vice presidents). A detailed analysis of their career descriptions revealed that, for these careers in the corporate track, income differences appeared to be, in part, a function of creativity and leadership.

Patents are another indicator of creativity, in particular, "inventive and scientific productivity" (Huber, 1999, p. 49). Discussing the process of securing documentation on intellectual property, Huber (1998) remarked, "It would be hard to find a field of study where so much effort has been expended in establishing a definition. Perhaps the definition of invention is the most solid definition in the field of creativity" (p. 61). The percentages of GS (males: 32.1%, females: 20.9%) and TS (males:

17.8%, females: 4.3%) participants who earned patents was well beyond base-rate expectations. Approximately 1% of the entire adult U.S. population holds at least one patent (J.C. Huber, personal communication, October 2004). Epidemiologists and other scientists take notice when base rates double (Lubinski & Humphreys, 1997); therefore, the percentages for these samples indicate that these individuals had an exceptional degree of creative promise for innovation in science and technology. Overall, more GS participants than TS participants earned patents (26.6% vs. 14.5%, respectively), $\chi^2(1, N = 966) = 19.9$, $p < .001$, which is not surprising given that the graduate students were selected from career tracks in which patents are commonly earned. Moreover, some TS participants were identified on the basis of their SAT-V, rather than SAT-M, scores. When analyses were restricted to TS participants who qualified on the basis of SAT-M scores, the percentages of male and female TS participants who earned patents rose to 20.1% and 9.1%, respectively; the difference in the rates for GS and TS participants was still statistically significant but diminished (26.6% vs. 19.0%, respectively), $\chi^2(1, N = 807) = 5.0, p < .05$.[7]

Each of the preceding indicators of occupational success offers a slightly different lens by which one can view professional accomplishment. The criteria examined thus far are certainly not the only manifestations of noteworthy professional achievement. For example, becoming a physician is considered by many people the height of achievement. One may also assess occupational achievement using multiple indicators simultaneously. Therefore, we created an amalgam of three divergent indicators to serve as a broad-spectrum measure of high achievement: having an M.D. degree, earning at least $100,000 annually, or securing a tenure-track position in a top-50 institution. More TS than GS participants achieved at least one of these criteria (43.2% vs. 29.6%, respectively), $\chi^2(1, N = 966) = 18.5$, $p < .001$.

Clearly, both GS and TS participants exhibited high achievement, regardless of the metric used. The criteria examined here, both independently and in conjunction, indicate that TS participants achieved levels of success at least comparable to those of their GS counterparts (and arguably higher). The TS participants truly distinguished themselves at the highest levels of achievement. Furthermore, the comparisons are likely conservative estimates of any TS advantage because of the age difference between the two samples (TS participants were 1.8 years younger than GS participants).

It is worthwhile to consider additional variables that might be relevant to career success (Lubinski, 2004; Webb, Lubinski, & Benbow, 2002). Simonton (1994), for example, has pointed out that devoting a large amount of time to work is important in achieving professional eminence. Although we did not have sufficient sample sizes within distinct careers to examine the influence of this variable in the present study, there were huge individual differences among these participants in the number of hours they worked and were willing to work under ideal circumstances (see Fig. 3). The mean numbers of hours worked per week (with standard deviations in parentheses) were 51.2 (9.6) and 47.8 (11.2) for GS and TS males, respectively, and 47.0 (12.6) and 46.3 (15.9) for GS and TS females, respectively. GS men, but not GS women, reported working more hours than their same-sex TS counterparts did, $t(493) = 3.6$, $p < .001$, for men and $t(318) = 0.2$, n.s., for women. Comparisons within cohorts revealed that GS males reported working more hours than GS females did, $t(540) = 4.4$, $p < .0001$, but no significant sex differences were found among the TS participants, $t(271) = 0.8$, n.s. The mean numbers of hours per week participants were willing to work in their ideal jobs (with standard deviations in parentheses) were 54.4 (10.4) and 53.1 (12.2) for GS and TS men, respectively, and 47.4 (12.5) and 49.8 (16.5) for GS and TS women, respectively.

Career and Life Satisfaction

For a more comprehensive portrait of these participants, we examined their personal satisfaction with careers, close relationships, and life in general. TS and GS males and females reported high and comparable job satisfaction, satisfaction with the direction of their careers, and perceived success in their careers (means ranged from 5.3 to 5.8 on 7-point bipolar scales). Respondents rated their relationship satisfaction with their significant others highly (means of 6.5 to 6.6 on a 7-point scale) and reported that their relationships with significant others contributed positively to their life satisfaction (6.5 to 6.7 on a 7-point scale). Finally, regardless of sex, GS and TS participants reported similar overall life satisfaction (5.0 to 5.3 on a 7-point composite scale), comparable to that reported by normative populations (Pavot & Diener, 1993).

[7]The predictive validity of the SAT-M has been supported recently in an independent study of 1,975 mathematically precocious youth identified throughout the 1970s and tracked for 20 years (Wai, Lubinski, & Benbow, 2005). This investigation compared the top and bottom quartiles of the top 1% in quantitative reasoning ability assessed before age 13 and showed that 20 years later (by age 33), the top quartile secured significantly more math-science doctorates, patents, and tenured positions at U.S. universities ranked within the top 50 than the bottom quartile did. These findings, coupled with the findings reported here, directly contradict the pervasive supposition that "there is little evidence that those scoring at the very top of the range in standardized tests are likely to have more successful careers in the sciences" (Muller et al., 2005, p. 1043).

The present investigation, along with that of Wai et al. (2005), illustrates that large score differences within the top 1% of ability reflect genuine psychological differences in capability and eventuate in marked differences in real-world outcomes. Collectively, these two investigations align well with Galton's (1869/1961) analysis of the Cambridge wranglers, the students with the top 40 scores on Cambridge University's Annual Examination in Mathematics (an examination that lasted 5.5 hr per day for 8 days). It was not infrequent to find that there was as much difference in overall scores between the 1st- and 2nd-ranked wranglers as there was between the 2nd and the 40th! Moreover, in the words of Galton: "I have discussed with practiced examiners the question of how far the numbers of marks may be considered proportionate to the mathematical power of the candidate, and I am assured that they are strictly proportionate as regards to the lower places, but do not afford full justice to the highest" (p. 5). More recent empirical investigations have revealed that the relation between ability and performance throughout the ability range is not only monotonic, but also linear (Coward & Sackett, 1990; Schmidt, Hunter, McKenzie, & Muldrow, 1979).

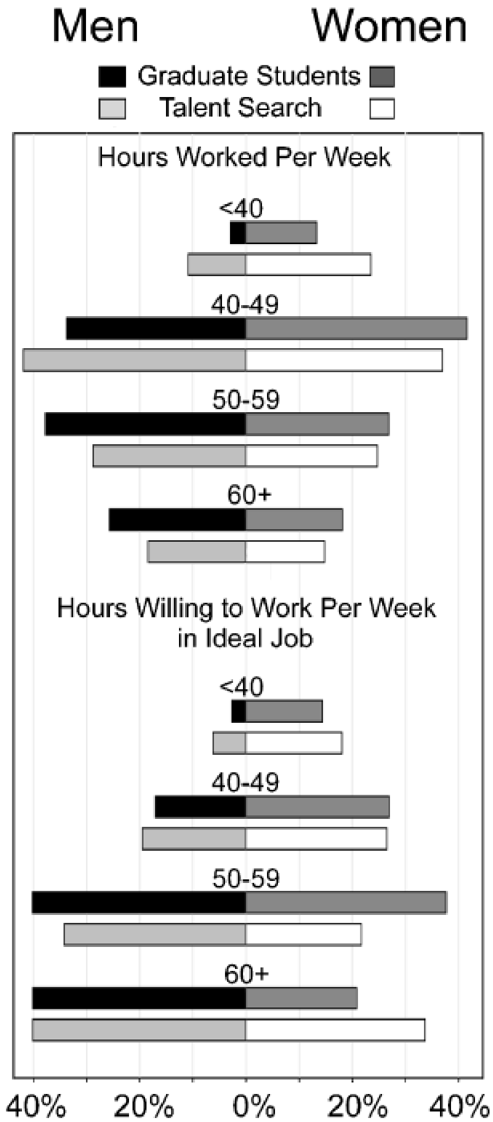

Fig. 3. Number of hours graduate-student (GS) and talent-search (TS) participants worked per week and were willing to work per week in the ideal job. The data for hours worked are based on *n*s of 276 and 264 for male and female GS participants, respectively, and 217 and 54 for male and female TS participants, respectively. The data for hours participants were willing to work are based on *n*s of 269 and 263 for male and female GS participants, respectively, and 206 and 57 for male and female TS participants, respectively.

Reproduction

Participants' reproductive rates also merit reporting. The majority of GS and TS participants, regardless of sex, had not yet had children (GS males: 62.2%, TS males: 64.9%; GS females: 64.2%, TS females: 69.0%). The majority of participants with children reported having only one child. The percentages of both GS and TS women without children were markedly above the norm for women of their age in general (26.4% for ages 30–34, 19.6% for ages 35–39; National Center for Health Statistics, 1997), but more aligned with the percentages for women who have earned graduate or professional degrees (62.2% for ages 25–34, 32.4% for ages 35–44; Bachu & O'Connell, 2001). Moreover, the mean number of biological children for male and female GS participants was 0.57 and 0.54, respectively; corresponding means for their same-sex TS counterparts were also low: 0.61 and 0.44 (no significant differences by sex or sample). These reproduction rates are well below the norm for women in general (1.59 for ages 30–34, 1.86 for ages 35–39; National Center for Health Statistics, 1997), but again aligned with rates for women who have earned graduate or professional degrees (0.61 for ages 25–34, 1.43 for ages 35–44; Bachu & O'Connell, 2001).[8]

Parental Origins

Approximately 21% of GS and 30% of TS participants came from homes in which at least one parent was foreign born; this percentage was somewhat greater (GS: 28%, TS: 41%) for highly successful participants (those earning at least $100,000, in top-50 tenure-track positions, or having an M.D.). With immigration policies attracting intense attention in the United States recently (Anderson, 2004; also see the special issue of *Science* titled "Science Careers: Brains and Borders," Mervis, 2004), these data are worth factoring into contemporary discourse.

DISCUSSION

Individuals identified solely on the basis of one very high SAT score before the age of 13 achieved occupational success comparable to that of individuals attending world-class mathematics, science, and engineering graduate training programs. Instruments such as the SAT assess much more than book-learning potential; they capture important individual differences in human capital critical for advancing and maintaining society in the information age through a variety of demanding professions, including medicine, finance, and the professoriate. Assessing exceptional cognitive abilities early uncovers a population with remarkable potential for occupational roles requiring complex information processing and creativity.

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Our Web-based survey used for both samples profited immensely from feedback by a number of colleagues: John A. Achter;

[8]To control for the mean age difference of nearly 2 years between the GS and TS samples, for GS participants we included in these analyses only children at least 2 years old. Without this adjustment, the childbearing patterns of the samples diverged (e.g., 50.7% and 51.3% of male and female GS participants were childless, and the mean number of biological children for male and female GS participants was 0.83 and 0.82, respectively).

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