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SEX DIFFERENCES IN PERSONAL ATTRIBUTES FOR THE DEVELOPMENT OF SCIENTIFIC EXPERTISE

DAVID S. LUBINSKI AND CAMILLA PERSSON BENBOW

Society is becoming increasingly scientific, technological, and knowledge-based, depending on the utilization and maximization of human talent and potential (Friedman, 2005). A nation's strength, both economically and civically, is now linked to what it can call forth from the minds of its citizens. Consequently, much attention is being focused on strategies for increasing the number of science, technology, engineering, and mathematics (STEM) professionals produced in the United States and possible untapped pools of talent. For policies to be effective, they need to build on knowledge about what it takes to become excellent in STEM areas. Here, we review a series of known antecedents to achieving excellence in and commitment to math and science domains. Particular focus is on the well-documented sex differences on these attributes and the implications for male versus female repre-

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sentation in STEM disciplines. We do not focus on the educational experiences and opportunities, such as appropriate developmental placement (Benbow & Stanley, 1996; Bleske-Rechek, Lubinski, & Benbow, 2004; Colangelo, Assouline, & Gross, 2004; Cronbach, 1996; Lubinski & Benbow, 2000; Stanley, 2000) or involvement in research (Lubinski, Benbow, Shea, Eftekhari-Sanjani, & Halvorson, 2001), which are important for developing talent in STEM areas; rather, we concentrate on the personal attributes that predispose individuals to pursue and achieve highly in STEM careers (Lubinski & Benbow, 1992; Lubinski, Benbow, Webb, & Bleske-Rechek, 2006; Wai, Lubinski, & Benbow, 2005).[1]

This essay is also not about enhancing the scientific literacy of the general U.S. population. That, although critically important, is a different proposition from producing outstanding STEM professionals, the topic of this essay. Through our Study of Mathematically Precocious Youth (SMPY), we have specialized in the latter (Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000; Lubinski & Benbow, 2000, 2001; Lubinski, Benbow, et al., 2001; Lubinski et al., 2006; Wai et al., 2005; Webb, Lubinski, & Benbow, 2002) and draw on that work for this review. Focusing on the talented, as SMPY does, is appropriate, given that most STEM professionals come from those in the top 10% in ability (Hedges & Nowell, 1995).

When examining complex outcomes, such as achieving distinction in STEM, it is important to take into account all the individual differences that factor into commitment and performance and not neglect any personal attributes that are known to be important. Doing so would lead to underdetermined (incomplete) models and violate the *total evidence rule* (taking all of the relevant personal-attribute information into account; see Carnap, 1950; Lubinski, 2000, p. 433; Lubinski & Humphreys, 1997, pp. 190–195). Thus, we try not to commit this error here in reviewing specific abilities, preferences, and commitment, which all help to explain male versus female disparities. In the case of sex differences in participation in math and science, we know (and we will show here) that although the sexes do not differ in general intelligence, they do differ in their specific ability patterns, interests, and number of hours willing to devote to their careers. Studying only one class of attributes will underestimate male versus female disparities in outcomes. Thus, these attributes will be reviewed here. Moreover, it is important to keep in mind that relatively small differences in the general population (or even no mean differences, but sex differences in variability) can eventuate in disparate male versus female ratios at elite levels (Feingold, 1995), as has been found (Hedges & Nowell, 1995; Stanley, Benbow, Brody, Dauber, & Lupkowski, 1992).

[1]There are many different kinds of cognitive abilities (Carroll, 1993; Snow & Lohman, 1989). In our treatment of specific abilities, we focus on those that are longitudinally stable and have been shown to be related to individual differences in the development of scientific expertise.

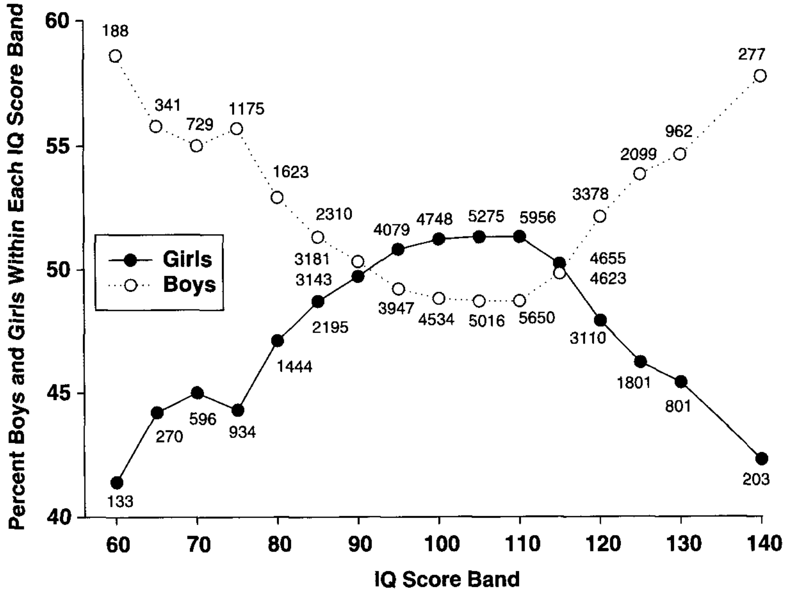

Figure 6.1. Numbers and percentages of boys and girls found within each IQ score band of the Scottish population born in 1921 and tested in the Scottish Mental Survey in 1932 at age 11. The *y*-axis represents the percentage of each sex in each 5-point band of IQ scores. Numbers beside each point represent the absolute numbers of boys and girls in each 5-point IQ score band. From "Population Sex Differences in IQ at Age 11: The Scottish Mental Survey 1932," by I. J. Deary, G. Thorpe, V. Wilson, J. M. Starr, and L. J. Whalley, 2003, *Intelligence, 31,* p. 537. Copyright 2003 by Elsevier. Reprinted with permission.

COGNITIVE ABILITIES

With regard to general ability, Deary, Thorpe, Wilson, Starr, and Whalley (2003) analyzed data collected on the complete population of 11-year-olds in Scotland in 1932 (the entire country was assessed, N = 39,343 girls and 40,033 boys). No appreciable differences in average IQ were found, but variability differences eventuated in marked male versus female ratios at the extremes of intelligence (see Figure 6.1). Thus, just as there are more boys than girls with developmental delays (e.g., mental retardation, learning disabilities), there are more highly able boys than girls. This has been observed repeatedly, with multiple samples (Arden & Plomin, 2006; Hedges & Nowell, 1995; Humphreys, 1988; Jensen, 1998; Lubinski & Dawis, 1992; Strand, Deary, & Smith, 2006).

However, specific abilities beyond general intelligence, mathematical reasoning, and spatial visualization in particular are especially critical for STEM pursuits (Humphreys, Lubinski, & Yao, 1993; Shea, Lubinski, & Benbow, 2001). Here, the sexes do differ, with males being higher in overall level as well as variability (Benbow, 1988; Hedges & Nowell, 1995; Humphreys et al., 1993; Lubinski & Humphreys, 1990; Smith, 1964).[2] Thus, there are many more males than females with high levels of these necessary (Benbow & Stanley, 1980, 1983; Gohm, Humphreys, & Yao, 1998; Lubinski & Benbow, 1992; Lubinski, Benbow, et al., 2001; Strand et al., 2006). Compounding the impact of this gender asymmetry in mathematical reasoning and spatial visualization is the tendency, even among those with more than the requisite abilities, for students to focus on their area of relative strength when choosing educational and career paths (Gottfredson, 2002, 2003; Humphreys et al., 1993; Lubinski, Benbow, et al., 2001; Lubinski, Webb, Morelock, & Benbow, 2001). Mathematically gifted individuals who are appreciably more talented in verbal than in mathematical areas are more likely to pursue careers outside of STEM. Conversely, verbally gifted individuals who are appreciably more talented in quantitative reasoning are more likely to pursue careers within STEM. That mathematically gifted females are, as a group, more verbally talented than males and more balanced in their ability profiles explains, in part, their greater attraction to intellectually demanding fields that are outside of STEM.[3]

Also taking into account the importance of spatial abilities affords an even more refined understanding of how gender disparities in STEM emerge. Shea et al. (2001), for example, tracked a group of 563 individuals representing the top 0.5% in general intellectual ability for over 20 years. They demonstrated that verbal, mathematical, and spatial abilities, all assessed in early adolescence, were related in distinctive ways to subsequent educational–vocational group membership in engineering, physical sciences, biology, humanities, law, social sciences, and business. Across developmentally sequenced

[2]Strand et al. (2006) published an analysis of a large and representative sample of 320,000 school pupils assessed at ages 11 through 12 in the United Kingdom. Because of the size and recency of the sample (assessed between September 2001 and August 2003), the Appendix is provided to highlight male versus female differences among the extreme scorers on measures of verbal reasoning, quantitative reasoning, and nonverbal reasoning.

[3]That specific abilities can be enhanced through learning is of course true, but a common finding is that the relationship is not linear: Those who begin with more ability typically profit more from such opportunities (Ceci & Papierno, 2005; Gagne, 2005; Jensen, 1991, p. 178; Kenny, 1975; Robinson, Abbott, Berninger, & Busse, 1996; Robinson, Abbott, Berninger, Busse, & Mukhopadhyah, 1997). For example, adolescents scoring 500 or more on SAT—Mathematics (SAT–M) or SAT—Verbal (SAT–V) before age 13 (top 1 in 200) routinely assimilate a full high school course (chemistry, English, mathematics) in 3 weeks time at summer residential programs for intellectually precocious youth; however, those scoring 700 or more (top 1 in 10,000) routinely assimilate at least twice this amount (Benbow & Stanley, 1996; Colangelo et al., 2004; Stanley, 2000). This nonlinearity is intensified by considering the full range of ability and students with developmental delays who assimilate much less than typically developing students even in the best of conditions. To the extent that all students are afforded learning opportunities individually tailored to their rate of learning, all students learn more, but individual differences in achievement are increased. Ceci and Papierno (2005, p. 149) nicely depicted this phenomenon in their subtitle: "When the 'Have Nots' Gain but the 'Haves' Gain Even More." For coming to terms with attributes of promise for exceptional achievement and creativity, it is important to keep in mind that the top 1% on essentially any ability distribution contains over one third of the ability range (e.g., for IQs, this range begins at approximately 137 and extends beyond 200); and individual differences within this 63+ IQ point range constitute differences that make a difference (Lubinski et al., 2006; Wai et al., 2005).

educational–vocational outcomes over a 20-year span, each specific ability added what statisticians term *incremental validity* (Sechrest, 1963) to the prediction of group membership relative to the other two. This is illustrated in Figure 6.2.

In Figure 6.2, longitudinal outcomes are shown for favorite and least favorite high school classes (at age 18), bachelor's degree majors (age 23), and occupations (age 33), organized around mathematical (x-axis) and verbal (y-axis) ability. For each grouping, the direction of the arrow represents whether spatial abilities (z-axis) were above (right) or below (left) the grand mean for spatial ability (A and B are within sex, C and D are combined across sex). These arrows were scaled on the same units of measurement as the SAT scores (viz., Z scores). Thus, one can envision how far apart these groups are in three-dimensional space as a function of these three abilities in standard deviation units. Across the time frames (ages 18, 23, and 33), exceptional verbal ability, relative to mathematical and spatial ability, is characteristic of group membership in the social sciences and humanities, whereas higher levels of math and spatial abilities, relative to verbal abilities, characterize group membership in engineering, math, and computer science. Engineering, for instance, is relatively high math, high spatial, and relatively low verbal. Other sciences appeared to require appreciable amounts of all three abilities. Among other things, these findings illustrate that important individual differences in ability pattern do factor into choices and outcomes, whether or not they are explicitly assessed. Indeed, spatial ability is rarely assessed. Yet, individual differences in this attribute markedly influence whether STEM domains are approached or avoided by students.

These patterns also hold for profoundly gifted participants (i.e., those scoring 700 or more on the SAT before age 13). Lubinski, Webb, et al. (2001) divided their sample of 320 profoundly gifted participants (top 1 in 10,000 students) into three groups on the basis of individual ability profiles. Two groups were "tilted" (either High-Math or High-Verbal) and one group was more intellectually uniform or "flat" (High-Flat). The High-Flat group had SAT–M and SAT–V scores that were within one standard deviation of the other. The other two groups had contrasting intellectual strengths: The High-Math group had an SAT–M score greater than one standard deviation above their SAT–V score, whereas the High-Verbal group exhibited the inverse pattern. These three ability patterns, determined from age-13 assessments, eventuated in distinct developmental trajectories. For example, age-13 assessments of specific abilities anticipated differential course preferences among these three groups in high school and college (see Figure 6.3). The High-Math group consistently preferred math and science courses relative to the humanities, whereas the inverse was true for the High-Verbal group; results among the High-Flat group were intermediate.

Lubinski, Webb, et al. (2001) also categorized the accomplishments and awards of these precocious participants into one of three clusters: Hu-

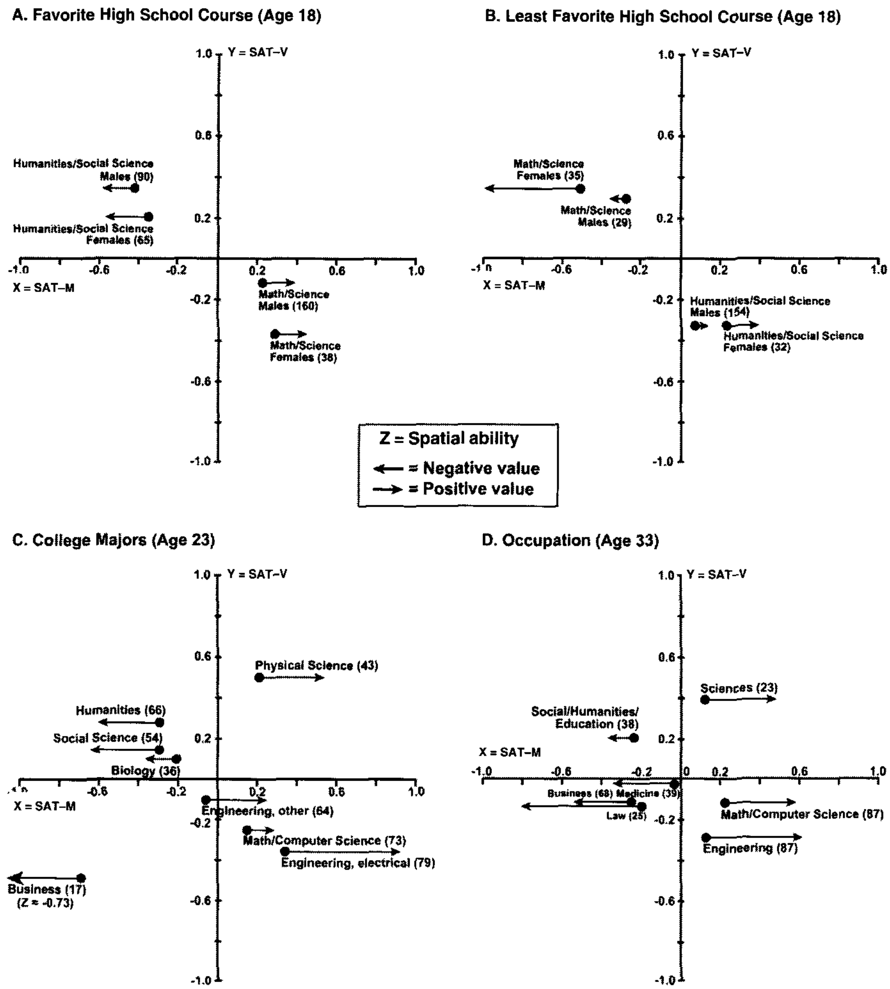

Figure 6.2. Trivariate means for (A) favorite high school course at age 18, (B) least favorite course at age 18, (C) conferred bachelor's degree at age 23, and (D) occupation at age 33. Group sample sizes are in parentheses. SAT–V = Verbal subtest of the Scholastic Assessment Test; SAT–M = Mathematical subtest of the Scholastic Assessment Test; and spatial ability = Z (a composite of two subtests of the Differential Aptitude Test: space relations + mechanical reasoning). Panels A and B are standardized within sexes, panels C and D between sexes. The large arrowhead in panel C indicates that this group's relative weakness in spatial ability is actually twice as great as that indicated by the displayed length. From "Introduction to the Special Section on Cognitive Abilities: 100 Years After Spearman's (1904) 'General Intelligence,' Objectively Determined and Measured," by D. Lubinski, 2004, *Journal of Personality and Social Psychology, 86,* p. 104. Copyright 2004 by the American Psychological Association.

manities and Arts, Science and Technology, and Other (see Figure 6.4). They then went back to ascertain whether these three clusters were occupied differentially by their three ability groups. As shown in the bottom-right panel of Figure 6.4, three-fourths of the classifiable accomplishments of High-Math

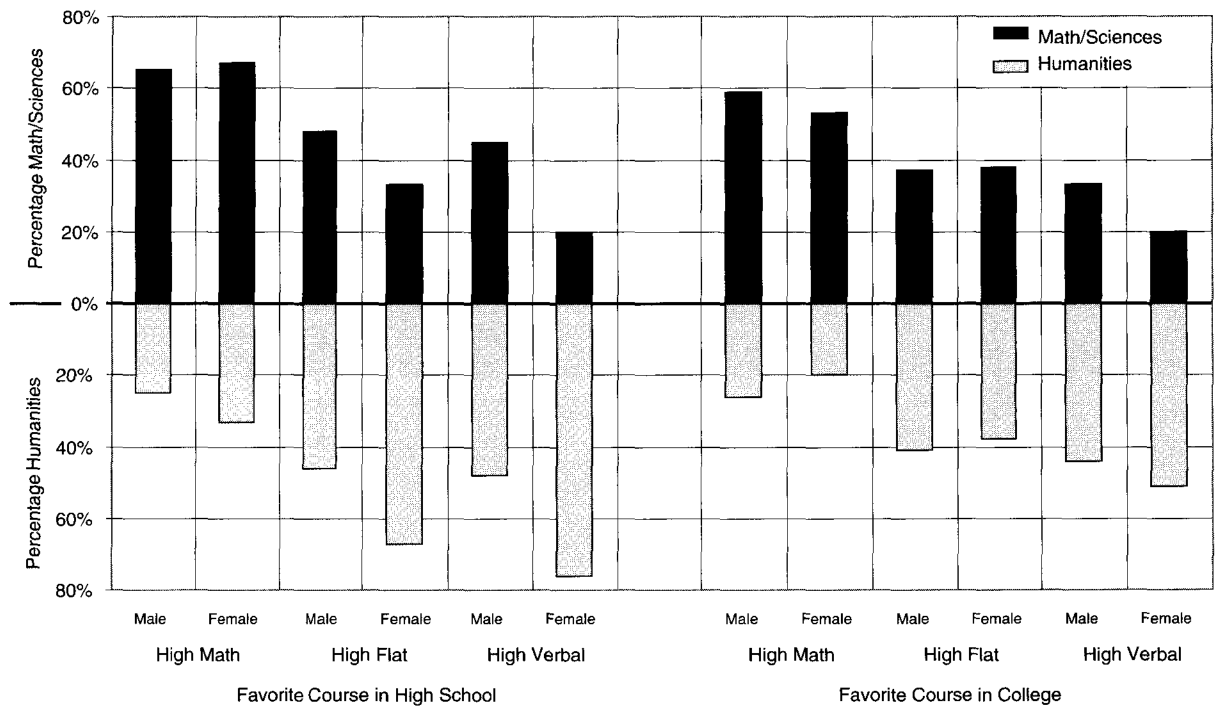

Figure 6.3. Participants' favorite course in high school and in college. Percentages in a given column do not necessarily sum to 100% because only participants indicating either math and sciences or humanities courses are displayed. Significance tests for differences among groups for favorite course are as follows: high school math and science, $\chi^2(2, N = 320) = 20.7$, $p < .0001$; college math and science, $\chi^2(2, N = 320) = 18.2$, $p < .0001$; high school humanities, $\chi^2(2, N = 320) = 36.6$, $p < .0001$; and college humanities, $\chi^2(2, N = 320) = 30.2$, $p < .0001$. From "Top 1 in 10,000: A 10-Year Follow-Up of the Profoundly Gifted," by D. Lubinski, R. M. Webb, M. J. Morelock, and C. P. Benbow, 2001, *Journal of Applied Psychology, 86,* p. 722. Copyright 2001 by the American Psychological Association.

Sciences and Technology	Humanities and Arts
Scientific publications (11)	Creative writing (7)
Software development (8)	Creation of art or music (6)
Inventions (4)	Fulbright award (2)
National Science Foundation fellowship (2)	Wrote proposal for a novel voting system for new South African constitution.
Designed image correlation system for navigation for Mars Landing Program.	Solo violin debut (age 13) Cincinnati Symphony Orchestra.
The American Physical Society's Apker Award	Mellon Fellow in the humanities
Graduated from MIT in 3 years at age 19 (entered at 16) with perfect (5.0) GPA and graduated from Harvard Medical School with MD at age 23.	Presidential Scholar for creative writing
Teaching award for "Order of Magnitude Physics."	Hopwood writing award
	Creative Anachronisms Award of Arms
	First place in Midreal-Medieval poetry
	Foreign language study fellowship
	International predissertation award

Other
Phi Beta Kappa (71)
Tau Beta Pi (30)
Phi Kappa Phi (14)
Entrepreneurial enterprises (2)
Omicron Delta Kappa
Olympiad Silver Medal
Finished bachelor's and master's in 4 years.
Received private pilot's license in 1 month at age 17.

	Sciences and Technology	Humanities and Arts
High Math	16	5
High Flat	6	6
High Verbal	7	13

Figure 6.4. Awards and special accomplishments. Numbers in brackets represent the number of participants indicating each accomplishment. All other entries represent a single individual. From "Top 1 in 10,000: A 10-Year Follow-Up of the Profoundly Gifted," by D. Lubinski, R. M. Webb, M. J. Morelock, and C. P. Benbow, 2001, *Journal of Applied Psychology, 86,* p. 725. Copyright 2001 by the American Psychological Association.

participants were in science and technology. By comparison, two-thirds of the classifiable accomplishments of High-Verbal participants were in the humanities and arts. High-Flat participants reported similar numbers of accomplishments in the sciences and humanities clusters. It is evident that ability patterns relate to the types of activities to which these individuals devoted time and effort.

These findings on course preferences, individual awards, and creative pursuits illustrate a common finding in counseling and vocational psychology, namely, that ability pattern is critical for choice (Dawis, 1992; Gottfredson, 2003). Administering one test in isolation to a group of talented adolescents is not enough to appreciate the psychological diversity among intellectually precocious youth. All three groups had exceptional SAT–M and SAT–V scores for age 13. For example, the High-Verbal group had mean SAT–M/SAT–V scores = 556/660; in contrast, the High-Flat and High-Math groups SAT–M/SAT–V means = 719/632 and 729/473, respectively.

All three groups had impressive mathematical and verbal abilities, but tilted profiles were highly related to differential development (Achter, Lubinski, & Benbow, 1996; Lubinski, Benbow, et al., 2001; Stanley et al., 1992; Strand et al., 2006). Yet there are other personal attributes highly relevant to talent development and accomplishment in STEM areas that are outside of the cognitive domain. And these too display sex differences. We turn to them next.

INTERESTS

The nearly 100-year history of research on interests is based on the truism that just because people are capable of doing something does not mean they enjoy doing it or will do it (Campbell, 1971; Dawis, 1992; Savickas & Spokane, 1999; Strong, 1943; Tyler, 1974).[4] One of the largest sex differences uncovered by psychologists studying individual differences is interest in people versus things. And, this dimension turns out also to be critical for choosing and pursuing STEM educational and career tracks.

Interests in working with people versus things can be traced back to at least Thorndike (1911), with females and males consistently displaying a mean difference of at least one standard deviation on this dimension. Girls and women, as a group, tend to prefer to learn about and work with people (or organic content), whereas boys and men, as a group, tend to prefer to learn about and work with things (or inorganic content). This dimension of individual differences routinely presents itself on educational–vocational interest inventories. Yet, current literature often fails to highlight the relevance of mean differences on this dimension for STEM pursuits, despite voluminous evidence supporting its importance (Achter et al., 1996, p. 76; Campbell, 1971; Lubinski, 2000; Lubinski, Benbow, & Ryan, 1995; Lubinski, Schmidt, & Benbow, 1996; Savickas & Spokane, 1999; Schmidt, Lubinski, & Benbow, 1998; Strong, 1943; Tyler, 1974).

How big is this sex difference today? Lippa (1998) published three studies on this robust dimension of individuality and the role it plays in personality development. Although he did not report sex differences, we were able to obtain them from him. The effect sizes (male–female differences in standard deviation units) for all three studies were greater than 1.20 (R. Lippa, personal communication, summer, 1998). This preference difference, also evident in our SMPY sample, contributes to the preponderance of females with profound mathematical gifts (viz., SAT–M $\geq$ 700, before age 13) choosing to become physicians rather than engineers and physical scientists. By contrast,

[4]That constellations of abilities, preferences, and conative factors are critical for coming to terms with individual differences in learning rates and occupational performance has a long history in educational, counseling, and industrial psychology (Bouchard, 1997; Corno et al., 2002; Cronbach & Snow, 1977; Dawis, 2001; Dawis & Lofquist, 1984; Snow, 1991, 1993, 1994, 1996). Scarr (1992, 1996; Scarr & McCartney, 1983) in particular has provided a developmental context for these ideas.

males with profound mathematical gifts are much more likely to become engineers and physical scientists than physicians (discussed subsequently).

A study by Webb, Lubinski, and Benbow (2002) underscores the importance of individual differences in interests for understanding educational–vocational outcomes. Webb et al. tracked 1,110 adolescents who were identified as mathematically precocious (top 1%) at age 13 and reported plans to major in math or science at the onset of their undergraduate studies. Webb et al. then compared those who eventually completed a degree in math or science with those who completed a degree in other areas. They found that more women than men eventually chose to pursue degrees in areas outside of math or science, a finding that appears negative in terms of the nation's need for more female STEM professionals. An in-depth analysis of the participants' educational, vocational, and life outcomes, however, revealed several positive findings and yielded new interpretations of the human capital that math and science domains attract.

First, Webb et al. found that individual differences in ability pattern and interests, not biological sex, surfaced as the central predictors of who actually completed a degree in math or science and who completed a degree outside of math or science. It thus appears that group status (i.e., sex) is a frail proxy variable for specific individual differences (Lubinski & Humphreys, 1997), such as ability and preference patterns, which (more centrally) guide educational–vocational choices.

Second, Webb et al. found that those who completed degrees in math or science and those who completed degrees outside of math or science showed similar levels of success, career satisfaction, and life satisfaction. For example, participants who completed their undergraduate degrees outside of math and science, regardless of sex, earned graduate degrees at comparable rates with participants within math and science; they just secured their graduate degrees in different areas. This finding mirrors other research from SMPY and other studies demonstrating that women and men with similar ability profiles achieve baccalaureate and postbaccalaureate degrees at the same rate. Yet women are more likely than men to pursue their credentials in organic fields, such as the social sciences, law, biology, and medicine. Men, in contrast, are more likely than women to pursue their credentials in inorganic fields such as engineering and the physical sciences (Achter, Lubinski, Benbow, & Eftekhari-Sanjani, 1999; Benbow et al., 2000; Lubinski, Webb, et al., 2001). This is readily seen in findings from Benbow et al.'s (2000) 20-year longitudinal follow-up of nearly 2,000 mathematically precocious youth (see Table 6.1).

CONATIVE FACTORS

It takes more than the right mix of specific abilities and interests to excel in STEM (Lubinski & Benbow, 2000, 2001; Lubinski, Benbow, et al.,

TABLE 6.1
Twenty-Year Follow-Up of Mathematically Precocious Youth

	Cohort 1 (Males = 840, Females = 543)						Cohort 2 (Males = 403, Females = 189)					
	Bachelor's		Master's		Doctorate		Bachelor's		Master's		Doctorate	
Major	M	F	M	F	M	F	M	F	M	F	M	F
Mathematics	7.5	6.3	1.0	0.9	0.4	0.2	10.3	9.7	2.2	2.1	2.2	0.5
Engineering	22.9	8.1	9.3	3.5	1.6	0.6	35.0	15.6	13.6	5.3	5.2	0.0
Computer science	7.0	4.4	3.9	2.4	1.2	0.0	10.3	2.7	6.5	0.5	2.0	0.0
Physical sciences	9.3	4.4	2.5	0.7	2.4	0.6	10.3	7.0	3.7	1.6	3.7	1.6
Biological sciences	8.1	13.5	0.5	2.4	1.1	1.3	5.8	9.6	0.5	1.6	2.2	2.1
Medicine/ health	0.7	7.7	0.5	2.0	9.9	10.7	0.3	1.6	0.5	1.1	7.4	11.6
Social sciences	17.3	19.6	2.5	2.8	1.2	0.6	9.8	19.3	2.2	6.9	0.7	2.6
Arts/ humanities	10.1	14.8	2.1	3.7	0.5	0.6	12.3	24.8	3.9	6.3	1.5	1.6
Law					7.9	6.5					6.7	11.6
Business	10.5	12.0	12.4	10.9	0.4	0.0	2.8	4.3	9.1	8.4	0.2	0.5
Education	0.5	3.1	1.1	3.1	0.1	0.2	0.0	1.6	0.0	2.6	0.0	0.0
Other fields	3.7	5.7	2.5	4.8	0.4	0.2	4.0	5.3	3.5	4.2	0.2	0.0
Math/ inorganic science	*43.7*	21.6	*16.2*	7.7	*5.5*	1.3	*63.5*	34.4	*25.3*	9.5	*13.2*	2.1
Life science/ humanities	33.7	*52.6*	5.6	*10.5*	12.4	*12.7*	27.0	*53.7*	7.2	*15.9*	11.2	*18.0*
All majors	86.9	89.5	36.8	36.1	26.2	20.7	95.2	97.3	43.2	40.2	31.1	31.9

Note. Numbers shown are percentages. The numbers do not reflect postsecondary studies under way at the time of the follow-up (Cohort 1: 2.3% of males, 4.1% of females; Cohort 2: 5.5% of males, 9.5% of females). In the summary statistics, the numbers in italics highlight a gender-differentiating trend for math and inorganic sciences and for life sciences and the humanities: Males tend to receive more degrees in the former, females the latter. F = females; M = males. From "Sex Differences in Mathematical Reasoning Ability: Their Status 20 Years Later," by C. P. Benbow, D. Lubinski, D. L. Shea, and H. Eftekhari-Sanjani, 2000, *Psychological Science, 11,* p. 475. Copyright 2000 by Blackwell Publishing. Reprinted with permission.

2001; Tyler, 1974; Williamson, 1965). Conative variables (somewhat distinct from abilities and preferences, e.g., endurance for time on task, industriousness, zeal) are highly important but underappreciated relative to abilities and interests. Their neglect has been partly caused by the difficulty associated with measuring these personal attributes. Nevertheless, regardless of the domain of exceptionality (securing tenure at a top university, making partner at a prestigious law firm, or becoming CEO of a major organization), notable accomplishments are rarely achieved by those who work 40 hours per week or less (Eysenck, 1995; Gardner, 1995; Zuckerman, 1977). World-class performers work on average 60 to 80 hours per week. They possess zeal and exhibit passion.

Consider the remarks of Dean Simonton (1994), a leading authority on the development of eminence:

> [M]aking it big is a career. People who wish to do so must organize their whole lives around a single enterprise. They must be monomaniacs, even megalomaniacs, about their pursuits. They must start early, labor continuously, and never give up the cause. Success is not for the lazy, procrastinating, or mercurial. (Simonton, 1994, p. 181)

Consider this statement by the distinguished biologist, E. O. Wilson (1998):

> I have been presumptuous enough to counsel new Ph.D.'s in biology as follows: If you choose an academic career you will need forty hours a week to perform teaching and administrative duties, another twenty hours on top of that to conduct respectable research, and still another twenty hours to accomplish really important research. This formula is not boot-camp rhetoric. (E. O. Wilson, 1998, pp. 55–56)

Figure 6.5 is based on two questions from the SMPY 20-year follow-up of nearly 2,000 intellectually precocious youth, described in Benbow et al. (2000); at age 13, their cognitive abilities were in the top 1% of their age mates. At age 33, they were asked, first, how much they would be willing to work in their "ideal job" and, second, how much they actually do work. Lubinski (2004) graphed the results, and they are displayed in Figure 6.5. Figure 6.6 is based on the same two questions administered to our top 1 in 10,000 group and the top math and science graduate students when both samples were in their mid-30s (Lubinski et al., 2006). These figures, which represent high-ability cohorts assimilated at multiple time points over 20 years, reveal an important *noncognitive* factor for exceptional achievement, willingness to work long hours, which exhibits a wide range of individual differences and an appreciable sex difference. One only needs to imagine the differences in research productivity likely to accrue over a 5- to 10-year interval between two faculty members working 45- versus 65-hour weeks (other things being equal) to understand its possible impact. The same pattern would

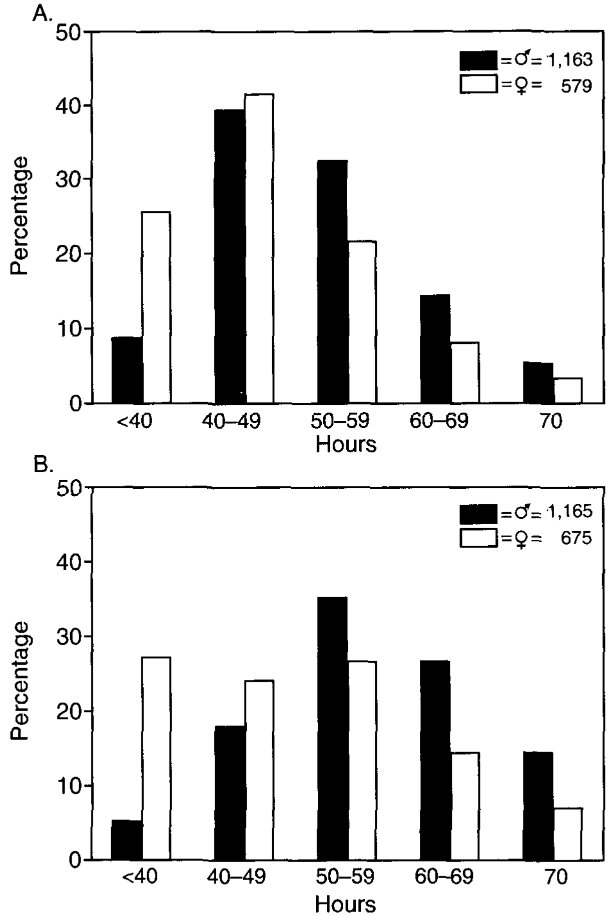

Figure 6.5. 1972–1979 talent search participants at age 33: Time devoted to work and time willing to devote to work. In the 1970s, participants were identified as having quantitative reasoning abilities in the top 1% of their age group. At age 33, they were asked (A) how many hours per week they typically work, by sex (excluding homemakers); and (B) how many hours per week they were willing to work, given their job of first choice, by sex. From "Introduction to the Special Section on Cognitive Abilities: 100 Years After Spearman's (1904) 'General Intelligence,' Objectively Determined and Measured," by D. Lubinski, 2004, *Journal of Personality and Social Psychology, 86,* p. 107. Copyright 2004 by the American Psychological Association.

emerge for advancing and achieving distinction in any other demanding pursuit (Eysenck, 1995; Gardner, 1995; Zuckerman, 1977).

These figures also reveal an interesting sex difference: An inordinate number of these exceptionally talented women were working and preferring to work 40 hours or less per week. These data fit with a number of reports in the popular press indicating that many women graduating from elite colleges are opting out of the career track, preferring to become stay-at-home moms (Story, 2005). These data also fit with normative data on hours worked (Browne, 2002).

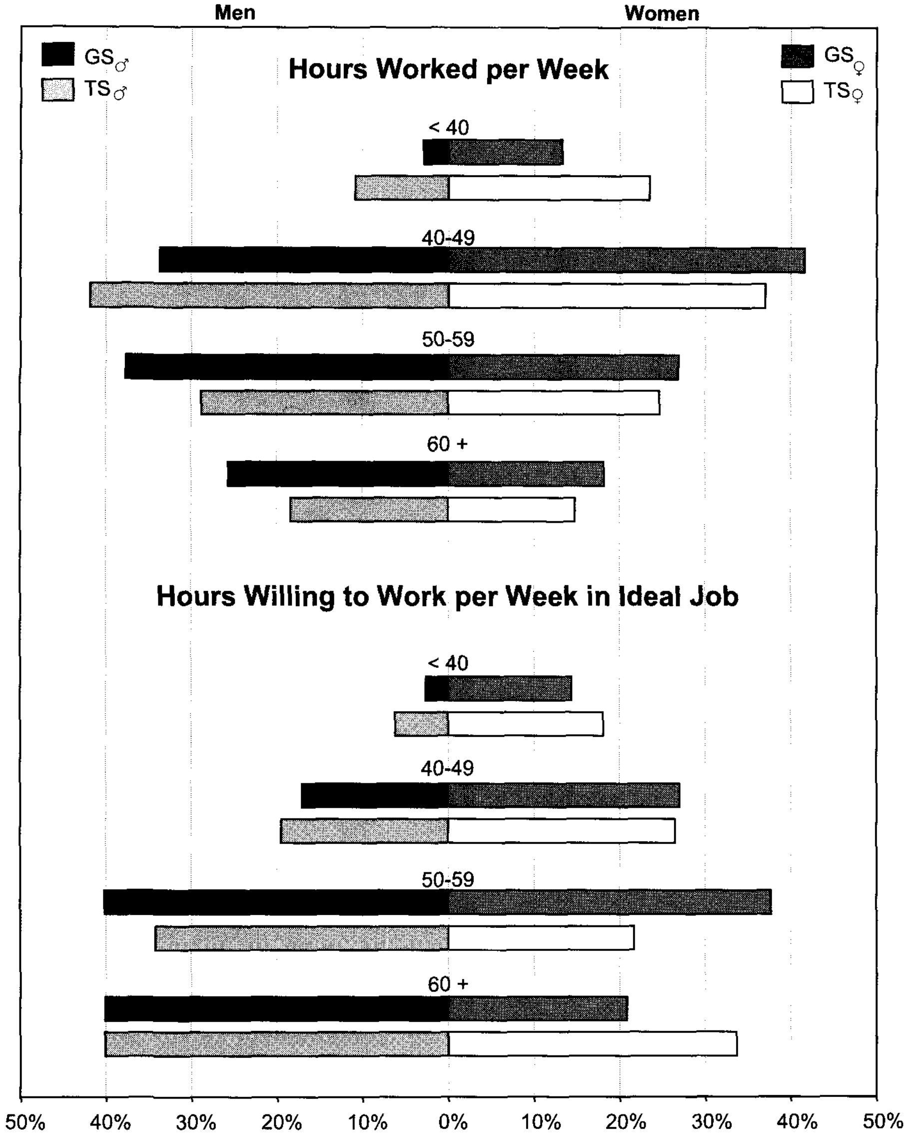

Figure 6.6. Twenty-year longitudinal follow-up, age 33, of talent search (TS) participants scoring in the top 1 in 10,000 on SAT—Mathematics or SAT—Verbal (at age 13), and a 10-year follow-up of top science, technology, engineering, and mathematics (STEM) graduate students (GS), initially identified as first- or second-year graduate students and surveyed again in their mid-30s. From "Tracking Exceptional Human Capital Over Two Decades," by D. Lubinski, C. P. Benbow, R. M. Webb, and A. Bleske-Rechek, 2006, *Psychological Science, 17,* p. 198. Copyright 2006 by Blackwell Publishing. Reprinted with permission.

It is reasonable to assume that these sex differences in time devoted to (and willing to devote to) work, if they persist, will engender large sex differences in performance and work-related outcomes with time. Indeed, Benbow et al. (2000) found that controlling for number of hours worked eliminated the commonly observed statistically significant sex differences in income.

How much time individuals are willing to devote to their careers also could engender different professional opportunities, especially in STEM areas. One aspect of STEM careers is that they are technologically rich and rapidly changing, with technical skills requiring continuous updating. More and more areas are experiencing this, but it is probably most intense in STEM. In STEM areas, taking a leave of absence for a number of years is possible, but doing so reduces significantly the probability of achieving a high-impact leadership role in subsequent employment.

CONCLUSION

Intellectually talented males and females are both achieving highly by their mid-30s. They are, however, achieving in different areas and appear to be on different developmental trajectories. Sex differences in personal attributes relevant to commitment to and excellence in STEM careers include but are not limited to ability pattern, interests, and commitment to work. These differences would predict an overrepresentation of males in STEM when males and females are free to choose how they would like to develop, other things being equal. Similarly, it is anticipated from these differences that females will be more represented in the life sciences, helping professions, and areas that place relatively greater demands on verbal skills and relatively more emphasis on a people orientation. This is exactly what SMPY and many other studies are discovering.

The findings reviewed here indicate that providing similar educational and vocational opportunities for males and females is not enough to ensure similar outcomes. When two groups differ in the ability or motivational pattern for learning and work (Corno et al., 2002; Cronbach & Snow, 1977), differential outcomes are predictable (Bleske-Rechek et al., 2004; Lubinski & Humphreys, 1997; Sackett, Schmitt, Ellingson, & Kabin, 2001). This may explain why, even though sex differences in formal math and science course-taking in high school are now negligible, women are not equally represented in engineering and the physical sciences as compared with medicine, law, biology, psychology, and many other areas (which often have a greater proportion of women). Sex differences in willingness to work long hours also have implications for how far men and women will progress, once their educational and occupational choices are made.

APPENDIX 6.1
MALE AND FEMALE DIFFERENCES AMONG EXTREME SCORERS ON COGNITIVE ABILITY TESTS

Strand et al. (2006) analyzed scores from four subtests of the Cognitive Abilities Test (CAT) from a large and representative sample of pupils in the United Kingdom (see Figure A6.1). Measures are scaled in stanines: 1 (bottom 4%), 2 (next 7%), 3 (next 12%), 4 (next 17%), 5 (middle 20%), 6 (next 17%), 7 (next 12%), 8 (next 7%), and 9 (top 4%). The sample comprised over 320,000 students, ages 11–12 years (between September 2001 and August 2003). The CAT includes separate nationally standardized tests for Verbal Reasoning (VR), Quantitative Reasoning (QR), and Nonverbal Reasoning (NVR). The mean VR score for girls was 2.2 standard score points higher than the mean for boys, but only 0.3 standard points in favor of girls for NVR, and 0.7 points in favor of boys for QR. However, for all three tests there were substantial sex differences in the standard deviation of scores, with greater variance among boys. Boys were overrepresented compared with girls at both the top and the bottom extremes for all tests, with the exception of the top 10% in verbal reasoning. On some verbal tests, more girls than boys are found at the extremes (as is found here), but results are mixed for this specific ability (cf. Lubinski & Dawis, 1992; Stanley et al., 1992).

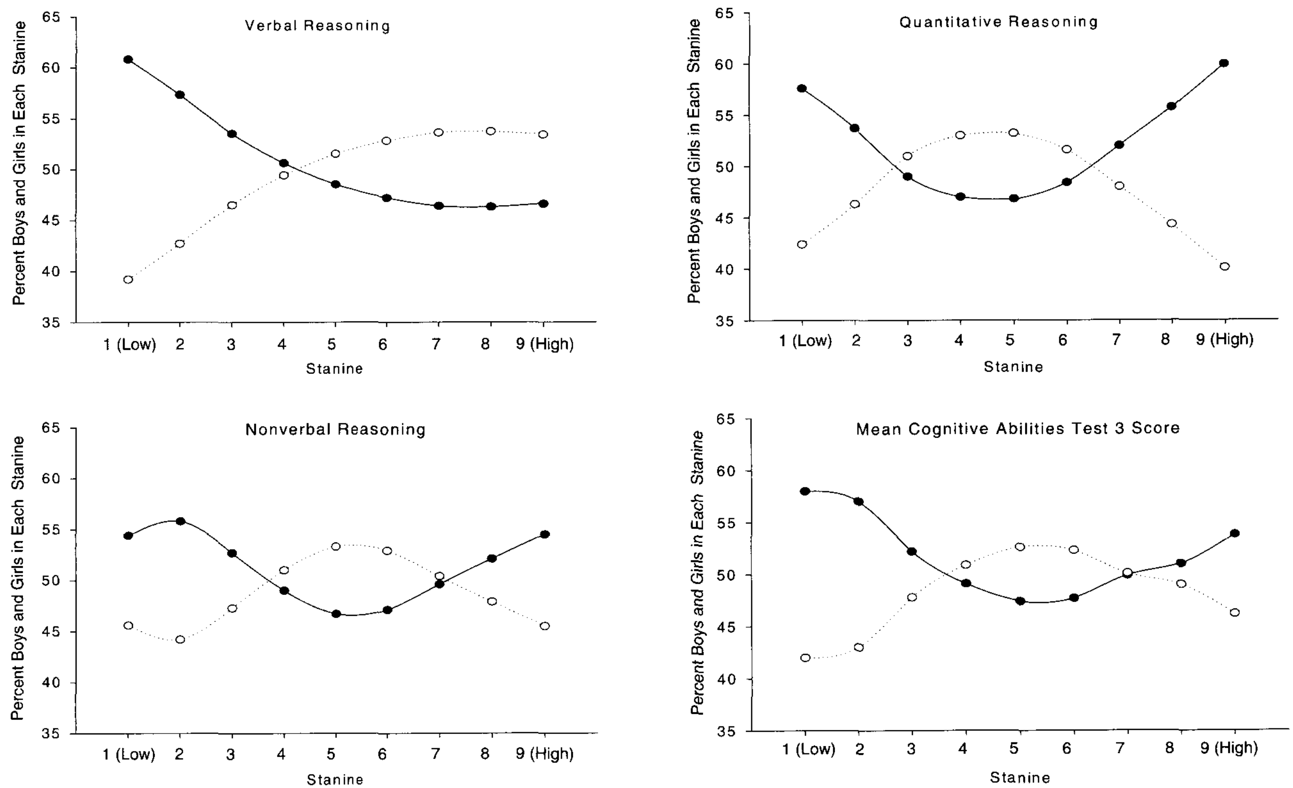

Figure A6.1. Four subtests of the Cognitive Abilities Test. From "Sex Differences in Cognitive Abilities Test Scores: A UK National Picture," by S. Strand, J. I. Deary, and P. Smith, 2006, *British Journal of Educational Psychology, 76*, p. 473. Copyright 2006 by the British Psychological Society. Reprinted with permission.

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