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Creativity and Occupational Accomplishments Among Intellectually Precocious Youths: An Age 13 to Age 33 Longitudinal Study

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This study tracks intellectually precocious youths (top 1%) over 20 years. Phase 1 (N = 1,243 boys, 732 girls) examines the significance of age 13 ability differences within the top 1% for predicting doctorates, income, patents, and tenure at U.S. universities ranked within the top 50. Phase 2 (N = 323 men, 188 women) evaluates the robustness of discriminant functions developed earlier, based on age-13 ability and preference assessments and calibrated with age-23 educational criteria but extended here to predict occupational group membership at age 33. Positive findings on above-level assessment with the Scholastic Aptitude Test and conventional preference inventories in educational settings generalize to occupational settings. Precocious manifestations of abilities foreshadow the emergence of exceptional achievement and creativity in the world of work; when paired with preferences, they also predict the qualitative nature of these accomplishments.

Keywords: cognitive abilities, creativity, human capital, intellectual talent, math–science pipeline

This investigation builds on two 10-year longitudinal studies of intellectually precocious youths tracked from ages 13 to 23 on a variety of educational criteria (Achter, Lubinski, Benbow, & Eftekhari-Sanjani, 1999; Benbow, 1992). For this special population, these earlier investigations documented the predictive validity of the Scholastic Aptitude Test (SAT) and the incremental validity of conventional preference assessments for a host of educational criteria. This report extends this line of research to another decade (ages 13 to 33) and another domain by examining the predictive validity of these instruments over a variety of occupational criteria. Specifically, we address two broad questions: (a) whether individual differences in the top 1% in ability assessed at age 13 forecast meaningful individual differences in occupational achievement at age 33 and (b) whether conventional preference assessments add value to SAT–Verbal (SAT–V) and SAT–Mathematics (SAT–M) scores in the prediction of occupational group membership (or the nature of how intellectually precocious youths will express themselves in the world of work). Before proceeding to the particulars of this 20-year follow-up, brief reviews of Benbow's (1992) and Achter et al.'s (1999) studies are in order, as each constitutes a foundational antecedent for this two-component extension to occupational achievement and occupational choice.

Review of Benbow's (1992) and Achter et al.'s (1999) Studies

Phase 1

Over a decade ago, Benbow (1992) examined the educational achievements of 1,996 mathematically precocious youths who were identified by talent searches in the 1970s. All participants scored within the top 1% of their age-mates on the SAT–M and were targeted for longitudinal tracking. Over a 10-year span, Benbow compared the top and bottom quartiles of this highly select population on 37 distinct educational criteria, ranging from standardized achievements to competitive awards earned both in and outside of school. On over 90% of these criteria, statistically and substantively significant effect sizes were observed favoring the top versus the bottom quartile. The current study ascertains whether these two groups, the top and bottom quartiles of the top 1% on SAT–M at age 13, continue to manifest differential outcomes later in life. Specifically, they are examined for proportion of doctorates (i.e., JDs, MDs, PhDs, and EdDs), income, patents, and tenure at a U.S. university ranked within the top 50. Patents and secured tenure posts are especially relevant because the relationship between ability and creativity has been conceptualized as a threshold phenomenon (Getzels & Jackson, 1962; Howe, 2001; Renzulli, 1986), and here we have the capacity to test this long-lived hypothesis not only with a large sample but also within the top 1% of the ability range. Moreover, although number of patents measures only one of the many qualitatively diverse forms of creative expression, Huber (1999) has argued that patents are among the most objective criteria available for quantifying genu-

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ine manifestations of creativity in science and technology. Securing tenure at a top university reflects another form of creativity; candidates are evaluated internally and externally by leaders in the field for outstanding contributions to their discipline.

Phase 2

A second 10-year study conducted during the past decade established that the major area of 4-year college degree for intellectually gifted individuals can be predicted on the basis of age-13 assessments (Achter et al., 1999). This study tracked 432 intellectually precocious youths who took the SAT–V and SAT–M at age 13 and also completed the Study of Values (SOV; Allport, Vernon, & Lindzey, 1970). Three categories were formed for college degrees conferred by age 23 (humanities, math–science, and other). Using a discriminant function analysis, Achter et al. (1999) documented for the first time for this special population that preference assessments add incremental validity to the SAT in predicting educational criteria over an extended time frame. The two subtests of the SAT alone accounted for 10% of the variance in group membership among these three categories; yet when the SOV was added to the analysis, the amount of variance accounted for rose to 23%. Phase 2 of this study extends the very same discriminant functions derived by Achter et al. on college degrees to occupations classified in commensurate terms (humanities, math–science, and other). If discriminant functions derived on criteria secured 10 years earlier and ability-preference assessments secured 20 years earlier can predict occupational group membership at age 33, the validity of teaming the SAT with conventional preference assessments is reinforced for educators and counselors working with intellectually precocious youths. Furthermore, at a more basic level, this would underscore the need to consider these determinants in future developmental studies of intellectually precocious youths.

Phase 1

Method

Participants. Phase 1 participants were taken from Cohorts 1 and 2 of the Study of Mathematically Precocious Youth's (SMPY's) planned 50-year longitudinal investigation of intellectual talent (Lubinski & Benbow, 1994). Participants were identified before age 13 through talent searches using the SAT (an entrance examination for college-bound high school seniors—a population 4 to 5 years older than them).

Cohort 1 includes 2,188 participants (96% Caucasian, 2% Asian, 2% Other) who, by age 13, secured a score of 370 or above on the SAT–V or 390 or above on the SAT–M, original scale, as part of SMPY's talent searches in the early 1970s. This cohort was drawn primarily from the state of Maryland, with a subset from the Baltimore–Washington area.

Cohort 2 includes 778 participants (89% Caucasian, 6% Asian, 5% Other) who scored 430 or above on the SAT–V or 500 or above on the SAT–M, original scale, as part of talent searches in the late 1970s.[1] This cohort was drawn from the mid-Atlantic states.

On the basis of SAT–M scores at age 13, separated by cohort and sex, the top (Q_4) and bottom (Q_1) quartiles were identified for subsequent analyses (i.e., Q_4 = top 25%, Q_1 = bottom 25%). Mean SAT–M scores were 637 (SD = 44) versus 445 (SD = 26) for Cohort 1 Q_4 and Q_1 boys, respectively, and 584 (SD = 36) and 441 (SD = 21) for Q_4 and Q_1 girls, respectively. Similarly, for Cohort 2, mean SAT–M scores were 646 (SD = 44) versus 495 (SD = 25) for Q_4 and Q_1 boys, and 586 (SD = 22) and 449 (SD = 25) for Q_4 and Q_1 girls.[2]

Procedure and design. Twenty years after participants were selected for longitudinal tracking by SMPY they were surveyed at approximately age 33 (Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000). Participants were mailed questionnaires and, if necessary, were later encouraged by mail or phone to complete them. This 20-year follow-up survey included the variables chosen for this study (doctorates, income, patents, and professoriate positions). The collection of this 20-year survey data occurred between 1992 and 1994 for Cohort 1 and between 1996 and 1999 for Cohort 2; the response rates for Cohorts 1 and 2 were 77.1% and 81.5%, respectively. Finally, *America's Best Colleges* (2004) was used to generate a reasonable list of the top-50 U.S. universities. For all participants who reported professoriate positions at the time of their 20-year follow-up, their status for the 2004–2005 academic year was ascertained through their personal or university's Web site.

Statistical analyses. For all four criterion variables (doctorates, primary income, patents, and tenure), descriptive statistics were computed separately for Cohort 1 and Cohort 2 by sex for the top and bottom quartiles. The percentage of doctorates secured was computed for each cell. For income, the percentage greater than or equal to the median for the entire sample within sex was reported (medians were used to control for the potential influence of extreme values on means). For patents and tenure, percentages were calculated. For all four criterion variables, the data for both cohorts and sexes were combined, and effect size differences between the top and bottom quartiles (Q_4 minus Q_1) were computed with an arcsine transformation, h (Cohen, 1988).[3]

Results

Across Cohorts 1 and 2, Table 1 contains data for all four criterion variables: doctorates, income, patents, and tenure at a top-50 U.S. university (partitioned by quartile and sex). Although sex differences are evident (cf. Benbow et al., 2000), the focus

[1] Benbow (1992) conducted her analyses using only Cohort 1, so in addition to extending this earlier study another decade, our analyses here add an additional cohort for replication purposes.

[2] The data for girls throughout is a bit constrained by Q_4 versus Q_1 SAT–M means being closer to one another in contrast to the mean difference for the boys. Because boys have a higher mean and also are more variable on SAT–M, the methodology employed in this study fosters a larger SAT–M difference between boys than girls. This constraint is not a problem for the issue we seek to address here (i.e., Q_4 minus Q_1 outcome differences) because we are not concerned with sex differences in this report (see Achter, Lubinski, & Benbow, 1996, Appendix 2, p. 76; Benbow et al., 2000; and Geary, 1996, 1998, for a discussion of this topic). Moreover, this methodology serves to make tests of statistical significance more conservative. And, indeed, when girls were analyzed separately, in part because of smaller sample sizes but also partially because of lower base rates (e.g., patents), statistical significance was not achieved, although for doctorates and income it was approached.

[3] To examine whether our Phase 1 findings would change if the sexes were mixed, we conducted the following analyses. Within each cohort, top and bottom quartiles were determined for sexes combined. For both cohorts, this procedure resulted in proportionately more boys than girls in Q_4 and proportionately more girls than boys in Q_1. We then ran effect size differences for doctorates, PhDs in math–science, income, patents, and top tenure track positions in the same manner as reported in Phase I; the respective effect sizes for these five (Q_4 minus Q_1) contrasts were h = .23, .29, .21, .26, and .25 ($ps < .001$). These five contrasts are all comparable to those reported in Phase 1 of the results.

Table 1
Percentage of Top and Bottom Quartiles on the SAT–M When Examining Doctorates, Income, Patents, and Tenure at a Top-50 U.S. University

	1972–1974 talent search				1976–1979 talent search			
	SAT–M Q_1		SAT–M Q_4		SAT–M Q_1		SAT–M Q_4	
Sex	% of sample	Frequency	% of sample	Frequency	% of sample	Frequency	% of sample	Frequency
				Doctorates				
Men								
All doctorates	16.7	35/210	34.7	69/199	27.7	31/112	35.2	43/122
Math–science doctorates	1.0	2/210	8.5	17/199	8.0	9/112	22.9	28/122
Women								
All doctorates	18.5	28/151	21.5	28/130	22.0	11/50	42.0	21/50
Math–science doctorates	0	0/151	1.5	2/130	4.0	2/50	4.0	2/50
				Income (percent ≥ median within sex)				
Men	43.8	92/210	56.8	113/199	48.2	54/112	54.9	67/122
Women	45.7	69/151	53.1	69/130	52.0	26/50	52.0	26/50
				Patents				
Men	3.9	7/177	6.7	11/163	8.5	8/94	17.5	18/103
Women	0	0/133	0	0/106	4.7	2/43	4.5	2/44
				Tenure at a top-50 U.S. university				
Men	0.5	1/210	5.5	11/199	0.9	1/112	3.3	4/122
Women	0	0/151	0	0/130	0	0/50	2.0	1/50

Note. SAT–M = Scholastic Aptitude Test—Math; Q_1 = bottom quartile; Q_4 = top quartile.

here is on overall outcome differences as a function of ability level (Q_4 minus Q_1) with cohorts and sexes combined.

The percentage of doctorates attained is found in the first section of Table 1. Within each sex, the top row includes all doctorates (JDs, MDs, PhDs, and EdDs), and the bottom row includes PhDs in math–science to illustrate the significance of SAT–M in the prediction of doctorates in scientific domains. The likelihood of getting a doctorate differs markedly as a function of being in the top versus the bottom quartile. If we combine cohorts and sex, the percentage attained is higher in Q_4 (32.1%) compared with Q_1 (20.0%). Moreover, the same pattern holds for math–science PhDs (viz., Q_4 = 9.8%, Q_1 = 2.5%). Notably, this is within the top 1% of ability; the SAT–M has predictive power across a 20-year interval (ages 13 to 33) for what some consider the ultimate educational credential. Overall, combining cohorts and sexes, the Q_4 minus Q_1 effect size difference h = .28 ($p < .001$). Yet, the likelihood of securing a doctorate in math–science is somewhat more impressive; the Q_4 minus Q_1 effect size difference h = .31 ($p < .001$).

Income data are found in the second panel of Table 1. Reported in each block is the percentage of participants earning an income equal to or greater than the median of their same-sex counterparts within the full top 1% (all four quartiles). The median values for Cohort 1 men and women are $50,000 and $40,000, respectively, and for Cohort 2 males and females, $60,000 and $40,000. The percentages in Table 1 constitute the proportion of participants within each quartile earning incomes at or beyond these values. These percentages exhibit a similar pattern to that observed for doctorates. For example, for Cohort 2 males, Q_4 (54.9%) is somewhat more impressive than Q_1 (48.2%). When cohorts and sexes are combined, the Q_4 minus Q_1 effect size difference h = .16 ($p < .01$). Yet, it is important to keep in mind how far both quartiles and sexes are from the median income for their age mates in the U.S. general population (during the mid-1990s, male *Mdn* = $31,496, female *Mdn* = $22,497; U.S. Census Bureau, 1996, Table A). The range of annual earned income was impressive as well: For Cohort 1, the income range exceeded $10 million; for Cohort 2, the range was $3.5 million. Clearly, the top 1% in ability is far removed from the norm on earned income.

The percentage of patents are reported in the third panel of Table 1. Patents are an indicator of genuine forms of creativity with respect to "inventive and scientific productivity" (Huber, 1999, p. 49). According to Huber, approximately 1% of the adult U.S. population holds at least one patent (personal communication, October 2004). Combining cohorts and sexes, the percentage of produced patents was Q_4 = 7.5% and Q_1 = 3.8% (or 7.5 and 3.8 times base rate expectations). Epidemiologists take notice when base rates double (Lubinski & Humphreys, 1997); therefore, these findings are especially noteworthy. As Huber (1998, p. 61) says regarding the process of securing documentation on intellectual property, "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." Clearly our participants are gathering patents at remarkable rates and distinguishing themselves in an objective realm of creativity in science and technology. Overall, Q_4 is well out in front of Q_1; when cohorts and sexes are combined, the Q_4 minus Q_1 effect size difference h = .18 ($p < .01$).

Finally, the percentages of those securing tenure at a top-50 U.S. university are reported in the last panel of Table 1. Achieving tenure at a top university is an excellent measure of creativity with infinitesimal base rate expectations in the general population. Overall, that 1.8% of our participants in the top and bottom quartiles achieved this distinction is exceptionally high; but what is more impressive is the difference between the top and bottom quartiles (with cohorts and sexes combined): Q4 = 3.2% versus Q1 = 0.38%. The Q_4 minus Q_1 effect size difference is h = .28 ($p < .001$).

Phase 2

Method

Participants. Phase 2 participants were taken from SMPY's Cohorts 1, 2, and 3 (Lubinski & Benbow, 1994). All students were within the top 1% of intellectual ability of their age group according to their scores on either the SAT–M or SAT–V. Participants were included in the second phase if they had completed the SAT and the Study of Values (SOV; Allport et al., 1970) by age 13 and had reported their occupation in the 20-year follow-up survey. Because Cohorts 1 and 2 were described in Phase 1, only a summary of Cohort 3 is needed here. However, it is important to note that a small subset of Cohort 1 and 2 participants did not have SAT–V scores at age 13. Therefore, using Cohort 1 and 2 participants with complete data sets and high school SAT–V scores secured during their age-18 follow-up after high school, we created a regression equation to back-predict age-13 SAT–V from high school SAT–V. This equation was then applied to Cohort 1 and 2 participants who were not assessed on SAT–V at age 13 but who had reported their high school SAT–V scores on their age-18 follow-up questionnaire. Using this regression imputation procedure, we added 36 Cohort 1 and 2 participants to this phase of our study.

Cohort 3 includes 432 participants (77% Caucasian, 19% Asian, 4% Other) who, before age 13, scored 630 or above on the SAT–V or 700 or above on the SAT–M as part of talent searches conducted between 1980 and 1983. These participants were drawn from across the nation and represent the top 1 in 10,000 (top 0.01%) in math or verbal reasoning ability within their age group (cf. Lubinski, Benbow, Webb, & Bleske-Rechek, in press; Lubinski, Webb, Morelock, & Benbow, 2001).

Collectively, our final sample consisted of 511 participants who met all selection criteria; that is, they were assessed on the SAT–M, SAT–V, and SOV at or before age 13 and also reported their occupation on the 20-year follow-up survey (131 men, 114 women from Cohort 1; 117 men, 61 women from Cohort 2; and 75 men, 13 women from Cohort 3).

Predictive measures. The SAT was referenced in Phase I. In our Phase 2 sample, age-13 assessments revealed the following means (and standard deviations): For boys, SAT–M = 599 (SD = 96) and SAT–V = 447 (SD = 89), and for girls, SAT–M = 521 (SD = 72) and SAT–V = 449 (SD = 84).

The SOV is a measure of values related to personality and interests. This ipsative measure includes a score for each of six dimensions: theoretical, economic, aesthetic, social, political, and religious. The SOV's longitudinal stability and construct validity for this special population is documented in Lubinski, Schmidt, and Benbow (1996) and Schmidt, Lubinski, and Benbow (1998). Achter et al. (1999) documented the incremental validity of this instrument, relative to age-13 SAT–M and SAT–V assessments, over a 10-year time frame (by predicting college degrees). Here, we examine the generalizability of this finding to the world of work (by predicting occupations).

Procedure, design, and analyses. The 20-year follow-up survey was described earlier for Cohorts 1 and 2. In parallel to Phase 1, the collection of 20-year data for Cohort 3 was completed in early 2004 (over the Internet). To extend the Achter et al. (1999) analysis, occupations were coded according to the categorization scheme following C. P. Snow's (1959) two cultures (viz., humanistic and scientific). On the basis of this framework, three criterion groups were formed: humanities, math–science, and other. Table 2 reports how occupations were classified, and the frequencies of participants falling into these categories (along with a denotation for sex).

In the Achter et al. (1999) study, the predictor variables were the SAT–M and SAT–V as well as the following five SOV themes: theoretical, aesthetic, social, religious, and economic, all taken by age 13. (Only five of SOV's six scales were used in the discriminant function analysis because the SOV is an ipsative measure, so each scale relative to the other five is completely redundant; thus, if all six scales were employed for multivariate analyses, it would not be possible to invert the **R** matrix.)

The discriminant function structure matrix reported by Achter et al. (1999) is presented here as Table 3. As Table 3 reveals, results of the two discriminant functions support a psychological reality to C. P. Snow's (1959) two cultures. High scores on Function 1 (F1) capture a number of psychological attributes that characterize scientists, that is, high SAT–M and SOV–Theoretical scores, with relatively lower SOV–Social and SOV–Religious values. Function 2 (F2), on the other hand, captures two important characteristics of humanists, high SAT–V and SOV–Aesthetic scores. We use these two discriminant functions here to ascertain the percentage of occupational groupings (observed at age 33) that fall into the psychological space outlined by Achter et al., using age 13 predictor assessments and age-23 criterion assessments.

Results

For Phase 2, the 20-year occupational data classified in Table 2 were used to ascertain whether the discriminant functions derived at earlier time points by Achter et al. (1999) with educational criteria generalize to the world of work.

The discriminant function plot in Figure 1 is partitioned to parallel Achter et al. (1999, p. 783). The open triangle in the center was established with predictors assessed at age 13 and calibrated against 4-year college degrees secured 10 years later. This triangle is defined by the bivariate group centroids (or means) for the two discriminant functions, calculated for the three educational categories (humanities, math–science, and other) at the 10-year follow-up. The bisecting lines are also the same as those reported in Achter et al. (1999); they were created by connecting each group's centroid to the midpoint of the other two groups. Then, 20-year data were plotted on this existing structure, as described below.

The shaded triangle in Figure 1 is defined by the centroids for the three occupational groups. In addition, individually plotted bivariate means for specific occupational groupings are included to illustrate where they fall in this psychological space. For occupational group membership, there was a significant amount of accuracy in isolating members of each group. The science region captured 60% hits, other 47% hits, and humanities 43% hits (see Table 4), with each of these cells achieving statistical significance, overall $\chi^2(4, N = 439) = 50$ ($p < .001$).[4] Total classification

[4] The positive bias of the percentage of successful classifications in discriminant analysis is well known (see Dillon, 1979, and references therein). However, the fact that our results are (a) based on a small number of predictors and a reasonable sample size, (b) replicate across a substantial time interval, and (c) involve a generalization probe from educational group membership to occupational group membership expressed in commensurate terms suggests that this bias is not a cause for concern in this study. We are indebted to James H. Steiger for bringing this matter to our attention and for offering points a and b for why this is unlikely to be problematic herein.

Table 2
Categorization of Occupations Into Math–Science, Humanities, and Other Groups

Math–science (n = 142, 38)	Humanities (n = 21, 23)	Other (n = 110, 105)	
Natural scientists	**Teachers, postsecondary**	**Executive, administrative, and managerial occupations**	**Sales occupations**
Physicists and astronomers (4, 0)	Psychology teachers (0, 1)	Chief executive/general admin (6, 1)	Supervisors and proprietors, sales (4, 1)
Chemists, except biochemists (0, 2)	Economics teachers (2, 0)	Financial managers (7, 3)	Real estate sales occupations (0, 1)
Geologists and geodesists (1, 0)	History teachers (1, 0)	Managers, marketing, advertising, and public relations (5, 11)	Sales engineers, chemicals (0, 1)
Physical scientists, NEC (3, 0)	Art, drama, and music teachers (1, 1)	Administrators, education related (2, 0)	Sales representatives, mining, manufacturing, and wholesale (0, 1)
Biological and life scientists (3, 2)	English teachers (1, 0)	Managers, properties/real estate (0, 1)	Sales support occupations, NEC (0, 1)
Medical scientists (1, 2)	Foreign language teachers (0, 2)	Managers and admin, NEC (24, 16)	**Administrative occupations**
Engineers	Theology teachers (1, 0)	Accountants and auditors (4, 7)	Secretaries (0, 3)
Architects, engineers (3, 3)	**Teachers, except postsecondary**	Other financial officers (6, 5)	Information clerks, NEC (1, 0)
Aerospace engineers (3, 2)	Teachers, pre/kindergarten (1, 1)	Management analysts (2, 1)	Billing clerks (0, 1)
Metallurgical and materials engineers (1, 0)	Teachers, secondary school (0, 3)	Personnel, training, and labor relations specialists (1, 0)	Expediters (0, 1)
Petroleum engineers (0, 1)	Teachers, NEC (4, 2)	Business and promotion agents (1, 0)	Administrative support, NEC (0, 1)
Chemical engineers (1, 1)	Nursery workers (0, 1)	Management related, NEC (16, 6)	**Construction trades**
Nuclear engineers (2, 0)	**Social scientists**	Public relations specialists (1, 0)	Carpenters (1, 0)
Civil engineers (1, 0)	Economists (2, 0)	**Supervisors, other**	Electricians (1, 0)
Electrical and electronics engineers (10, 1)	Social scientists, NEC (1, 1)	Supervisors, general office (0, 1)	**Other**
Mechanical engineers (2, 2)	Social workers (1, 1)	Supervisors, firefighting, and fire prevention occupations (2, 0)	Librarians (0, 1)
Engineers, NEC (36, 6)	Clergy (1, 1)	Supervisors, NEC (0, 1)	Engineering technicians (1, 0)
Math and computer scientists	Religious workers, NEC (0, 2)	**Health occupations**	Airplane pilots and navigators (3, 0)
Computer analysis and scientists (33, 11)	**Writers, artists, and entertainers**	Dentists (1, 1)	Electronic repairers, communications, and industrial equipment (1, 0)
Operations/Systems researchers/analysts (5, 0)	Authors (0, 1)	Veterinarians (1, 1)	Guides (0, 1)
Actuaries (2, 2)	Technical writers (0, 1)	Health practitioners, NEC (1, 0)	Homemaker (0, 13)
Mathematical scientists, NEC (6, 0)	Musicians and composers (1, 0)	Registered nurses (0, 8)	Self-employed (0, 3)
Computer programmers (11, 1)	Photographers (0, 1)	Pharmacists (0, 1)	Student (10, 3)
Teachers, postsecondary	Artists, performers, NEC (2, 2)	Physical therapists (1, 1)	Unemployed (1, 0)
Chemistry teachers (1, 0)	Editors and reporters, publishers (3, 2)	Clinical lab technologists and technicians (1, 1)	Career military officer (4, 1)
Physics teachers (1, 0)	Public relations, lobbyists (1, 0)	Licensed practical nurses (0, 1)	Federal government, NEC (1, 3)
Natural science teachers, NEC (1, 0)		Health technicians, NEC (0, 1)	Other (0, 1)
Engineering teachers (1, 0)			
Mathematical science teachers (3, 0)			
Computer science teachers (2, 0)			
Medical science teachers (5, 2)			

Note. Occupational field headings are in boldface type. The sample sizes for individual occupations are in parentheses, by sex (men, women). NEC = not elsewhere classified; admin = administration.

accuracy was 52%. Lawyers and physicians are not factored into these percentages, because they were not unambiguously classifiable into one of our three groups. Hence, the classification percentages are based on a sample size of 439, because lawyers and physicians are omitted from the analysis. However, to show where they appear in this space, they are plotted individually with sample sizes in parentheses. Beyond the preponderance of each group falling into the forecasted category (a convergent pattern), another important observation is that if a bivariate point is located in the humanities space, there is an excellent chance that the person is not in a math–science occupation, and conversely, if the point is located in the math–science space, then there is an excellent chance that the person is not in a humanities occupation (a discriminant pattern). Overall, this constitutes an impressive convergent–discriminant pattern along the lines of C.P. Snow's (1959) two cultures.

We find it interesting that nurses and homemakers appear to be psychological opposites in this space from math–computer scientists and electrical engineers. There is a clear-cut people versus things—or perhaps more generally an organic versus inorganic dimension—running from just above the negative x-axis to just below the positive x-axis. The same pattern of results held when highest graduate degree earned was plotted in this space, for example, degrees in religious studies (N = 8; F1 = −1.325, F2 = 0.768) and physics (N = 16; F1 = 2.073, F2 = −0.179). This plot is available from David Lubinski.

Table 3
Discriminant Function Structure Matrix

Variable	F1	F2
SAT–Verbal	0.09	0.56
SAT–Math	0.59	−0.12
SOV–Theoretical	0.87	−0.03
SOV–Aesthetic	−0.13	0.81
SOV–Social	−0.60	−0.01
SOV–Religious	−0.56	0.03
SOV–Economic	0.47	−0.29

Note. The bivariate group centroids for the 10-year data using college degree were (Function 1, followed by Function 2): humanities (−.29, .60), math–science (.43, −.05), and other (−.57, −.21). Taken from Achter et al. (1999, p. 783). F1 = Function 1; F2 = Function 2; SAT = Scholastic Aptitude Test; SOV = Study of Values.

Discussion

Ability intensity and pattern tell an important story about intellectually precocious youths at a young age. Assessments as early as age 13 capture important psychological information about the individuality of this special population and their lifelong development. Above-level ability and preference assessments are particularly relevant for predicting their individual differences in achievement and creativity 20 years later; they also hold prophecy for the domains in which adult accomplishments are likely to occur.

Without question, early SAT assessments measure much more than book learning potential and predictive validity for first-year college grades. They differentiate important systematic sources of individuality that subsequently factor into individual differences in occupational performance and creative expression. With respect to the importance of assessing ability differences within the top 1%, it has long been assumed by some that beyond a certain point an ability threshold is reached, and more ability does not matter. For example, in Howe's (2001) recent book, *IQ in Question: The Truth About Intelligence*, the concluding chapter is titled "Twelve Well-Known Facts About Intelligence Which Are Not True." Howe's 11th point supposes, "At the highest levels of creative achievement, having an exceptionally high IQ makes little or no difference. Other factors, including being strongly committed and highly motivated, are much more important" (p. 163).[5] Similarly, in a recent letter published in *Science* (Muller et al., 2005, p. 1043), 79 authors stated, "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. Too many other factors are involved."

Other factors are indeed important, and we agree that being strongly committed and highly motivated is critical for high achievement (Lubinski, 2004; Lubinski & Benbow, 2000; Lubinski, Benbow, Shea, Eftekhari-Sanjani, & Halvorson, 2001). Yet, the data reported here on secured doctorates, math–science PhDs, income, patents, and tenure track positions at top U.S. universities collectively falsify the idea that after a certain point more ability does not matter. Indeed, our criterion variables constitute only a subset of the important markers of achievement and creativity (moreover, each requires an appreciable commitment, and their normative base rates are small); nevertheless, despite these constraints, across all four comparisons, the top versus bottom quartiles of the top 1% revealed statistically significant effect sizes favoring the top quartile. When sample sizes are sufficient to establish statistical confidence and criteria with high ceilings are employed, measures that validly assess individual differences within the top 1% of ability reveal important outcome differences between the able and the exceptionally able (even on outcomes that are exceedingly rare). A recent 20-year longitudinal study of 380 profoundly gifted participants (Lubinski et al., in press), the top 1 in 10,000 on quantitative or verbal reasoning (viz, SAT–M $\geq$ 700 or SAT–V $\geq$ 630, before age 13), reinforces this idea. These participants, by their mid-30s, secured tenure track positions at top U.S. universities at the same rate as a comparison group of 586 1st- and 2nd-year graduate students attending top-15 math–science training programs and tracked for 10 years.[6]

Phase 2 of this study also reveals that age-13 ability and preference patterns critical for determining the discipline in which one is likely to later earn a 4-year degree generalize to occupational settings. For intellectually precocious youths, antecedents for the development of contrasting expertise emerge at an early age. More specifically, for this special population, nascent qualities giving rise to C. P. Snow's (1959) two cultures, humanists and scientists, appear readily detectable by early adolescence. We hypothesize that with larger samples, more predictor variables, and a greater number of criterion categories, more refined predictions would be possible. For example, one limitation of this study is that our predictor set is underdetermined because of the lack of inclusion of spatial ability measures, which would have most likely added precision to our forecasts (Corno et al., 2002; Gohm, Humphreys, & Yao, 1998; Humphreys, Lubinski, & Yao, 1993; Lubinski, 2004; Shea, Lubinski, & Benbow, 2001). Future research designed to track the development of this special population would be enhanced by incorporating mathematical, verbal, and spatial ability measures. Just as our criterion measures do not capture the full range of relevant criteria for creative expression, our selection measures do not capture all facets of intellectual talent.

Overall, these findings support theoretical ideas about niche

[5] Many people would take issue with other "untrue" conclusions offered by Howe (2001); see, for example, Gottfredson (1997). For a sophisticated and statistically informed analysis of Howe's 11 other points, readers are referred to Bartholomew's (2004) excellent book, *Measuring intelligence: Facts and fallacies*. For a recent study on the appreciable overlap between the SAT and conventional IQ measures, see Frey and Detterman (2004).

[6] A reviewer wondered about the extent to which socioeconomic status (SES) differences might contribute to the success of these participants. Because the correlation between general intellectual ability and SES is around .40, our participants come from homes that average about one standard deviation above the normative mean in SES. To address this concern, recent within-family analyses of ability differences are enlightening (Lubinski, 2004, pp. 100–102; Murray, 1998). They reveal that although SES influences a number of outcomes beyond cognitive abilities, ability differences among biologically related siblings reared together foster distinctly different outcomes, and these contrasting outcomes are highly commensurate with expectations for similar ability discrepancies among unrelated individuals.

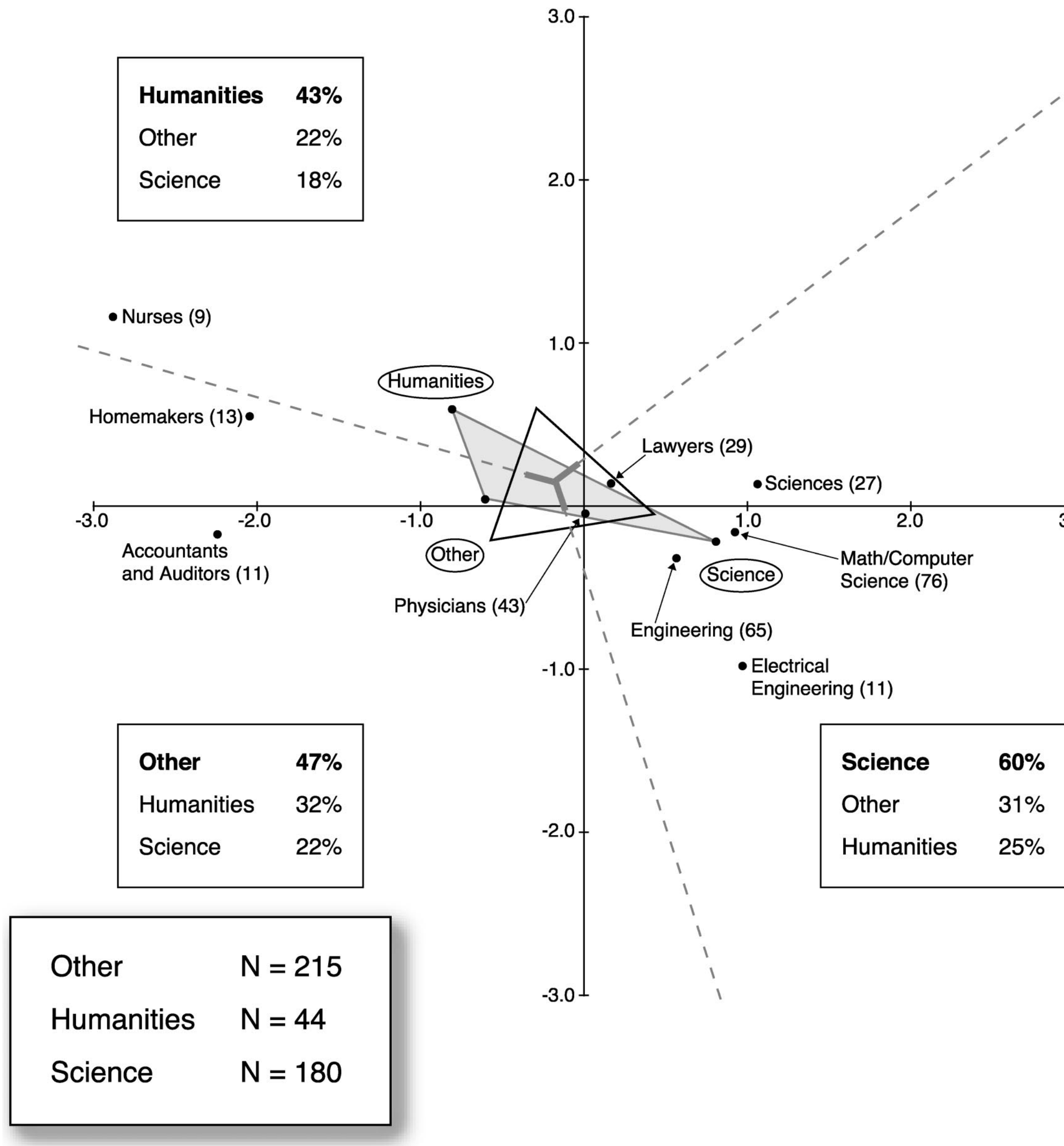

Figure 1. Group centroids for occupations. The open triangle is defined by F1 and F2 group centroids (means) for age 23 college majors. The shaded triangle is defined by F1 and F2 group centroids (means) for age 33 occupational groups. The bivariate group centroids for the 20-year data using occupations were (F1, F2) humanities (−80, .59), math–science (.80, −.21), other (−.60, .04). We computed percentages using individual data points. Lawyers, physicians, and various occupations are plotted with respective sample sizes in parentheses. Science = math–science occupations; F1 = Function 1; F2 = Function 2.

building (Scarr, 1996; Scarr & McCartney, 1983)—that is, the tendency for individuals (especially during adult development) to select dispositionally congruent learning and work environments (Dawis & Lofquist, 1984; Lofquist & Dawis, 1991; Lubinski, 1996, 2000; Webb, Lubinski, & Benbow, 2002). Therefore, they have important implications for tracking the developmental trajectory of this special population. They also hold important practical implications. Above-level ability and preference assessments are likely to aid practitioners interested in developing more effective interventions for enhancing the educational experiences of intellectually precocious youths through appropriate developmental placement (Lubinski & Benbow, 2000). These early assessments index important features of individuality, which factor into developmental outcomes over protracted intervals. Finally, educational practices and policies designed to respond to the vast amount of individuality manifested among all special populations (Dawis, 1992; Tyler, 1974; Williamson, 1965), and intellectually precocious youths in particular (Benbow & Stanley, 1996; Bleske-

Table 4
Predicted and Actual Group Classification Using Discriminant Functions

	Predicted group							
	Humanities		Math–science		Other		Total	
Actual group	*n*	% of sample	*n*	% of sample	*n*	% of sample	*n*	% of sample
Humanities	**19**	**43%***	11	25%	14	32%	44	10%
Math–science	33	18%	**108**	**60%***	39	22%	180	41%
Other	48	22%	66	31%	**101**	**47%***	215	49%
Total	100		185		154		439	100%

Note. Values on the diagonal are hits and are in boldface type. There are a total of 228 hits, or 52%. For the purpose of classification, prior probabilities (base rates) of group membership were based on sample probabilities for each group. These base rates are listed in the "Total" column.
* $p < .001$.

Rechek, Lubinski, & Benbow, 2004; Colangelo, Assouline, & Gross, 2004; Colangelo & Davis, 2003; Cronbach, 1996; Stanley, 2000), are supported by these findings as well.

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