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Assessing Vocational Preferences Among Gifted Adolescents Adds Incremental Validity to Abilities: A Discriminant Analysis of Educational Outcomes Over a 10-Year Interval

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The researchers used the theory of work adjustment (R. V. Dawis & L. H. Lofquist, 1984; L. H. Lofquist & R. V. Dawis, 1991) and C. P. Snow's (1959) conceptualization of *two cultures* as theoretical frameworks to analyze the incremental validity of above-level preference assessment (relative to abilities) in predicting humanities, math–science, and other college majors completed 10 years later by intellectually gifted adolescents. Scholastic Aptitude Tests and Study of Values assessments of 432 intellectually gifted adolescents (age 13) provided unique and valuable information for predicting the type of college major completed 10 years after initial assessment. These positive findings add to growing support for the applied utility of teaming preference assessments among the gifted with above-level assessments of ability. For intellectually gifted adolescents, these assessments could facilitate educational planning (and counseling).

An accurate assessment of specific abilities is seen as imperative for working with intellectually gifted people, who by definition are distinguished by their precocious intellectual manifestations. Throughout the 20th century, early detection of intellectual giftedness has been seen as important for facilitating optimal development of talents (cf. Benbow & Lubinski, 1996, 1997; Benbow & Stanley, 1996; Hollingworth, 1927; Paterson, 1957; Pressey, 1946; Stanley, 1977; Terman, 1925). Among talented adolescents, intellectual abilities (quantitative, spatial, verbal) have been shown to be predictive of subsequent educational and vocational choice (Humphreys, Lubinski, & Yao, 1993) and level of success (Benbow, 1992), similar to findings among older, more intellectually heterogeneous samples (Austin & Hanisch, 1990; Wilk, Desmarias, & Sackett, 1995).

Although knowledge of ability profile is certainly necessary, we strongly suspect that it is not sufficient for helping intellectually gifted people choose among competing educational and, eventually, work environments. As is the case among normative adult populations, personal preferences (e.g., interests and values) are also important contributing factors to such decisions, and they deserve attention if one hopes to nurture more optimal development of talent (Scarr, 1996; Tyler, 1992). The systematic assessment of preferences has an impressive history in educational and vocational counseling with more mature populations, yielding consistent relationships with educational and vocational choice, satisfaction, and perseverance (Borgen, 1991; Dawis, 1991, 1992; Hackett & Lent, 1992). However, the early application of preference assessment to intellectually gifted students has only recently come under careful investigation (Schmidt, Lubinski, & Benbow, 1998), perhaps delayed by the generally accepted tenet that preferences do not crystallize in the general population until approximately age 18 (Roe, 1956).

The present study extends the body of research examining preferences among intellectually gifted adolescents by investigating longitudinal predictions of educational choice as a function of ability as well as preference patterns identified in adolescence. Because the validity of using ability tests in an above-level format has already been shown (Benbow & Stanley, 1996), the present research was specifically aimed at ascertaining the incremental validity of using above-level assessment of preferences with the intellectually gifted *relative* to ability. The outcome variable chosen for this study was completed 4-year college major, a milestone attained by these students 10 years after their initial assessment at approximately age 13.

Two recent pieces of evidence provide support for investigating the contribution of preferences in this manner. First,

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research investigating the prevalence of multipotentiality among intellectually gifted adolescents suggests that ability, interest, and value profiles are generally quite differentiated in this population when developmentally appropriate assessment is done (i.e., approximately 95% of participants did not fit the multipotentiality profile; Achter, Lubinski, & Benbow, 1996). A second piece of support comes from the recent finding that, like abilities, the temporal stability of vocational preferences among the intellectually gifted has been demonstrated over longitudinally impressive (adolescence-to-adult) time frames (Lubinski, Benbow, & Ryan, 1995; Lubinski, Schmidt, & Benbow, 1996). However, evidence for the predictive validity of instruments assessing preferences among the gifted must be evaluated before their general use with young adolescents can be seriously entertained. We attempt to provide such evidence here.

Theoretical Organization of the Present Study

This study made use of the theory of work adjustment (TWA; Dawis & Lofquist, 1984; Lofquist & Dawis, 1991) to provide an overarching conceptual framework. Within this framework, C. P. Snow's (1959) formulation of two intellectual cultures was applied to organize college majors into criterion groups.

The Theory of Work Adjustment

TWA integrates abilities and preferences (interests and values) into a coherent theory about work adjustment. Following TWA, person–environment correspondence is conceptualized along two dimensions: *satisfactoriness* and *satisfaction.* To achieve satisfactoriness, there must be correspondence between the person's abilities and the environment's ability requirements or task demands (e.g., occupation or educational track). To reach a high level of satisfaction, on the other hand, the individual's preferences must correspond with the environmental reinforcers provided (e.g., compensation, particular working conditions). The predicted outcome of the joint occurrence of satisfactoriness and satisfaction is *tenure* (viz., the amount of time spent in an environment). The application of TWA to understanding the educational development of intellectually talented adolescents has been applied with much success, as the constituent components of TWA are the same variables that function as determinants of critical decisions antecedent to vocational choice (Lofquist & Dawis, 1991), such as selecting an academic course and choosing a college major (Lubinski, Benbow, & Sanders, 1993).

The Two Cultures

For this study, the framework used for conceptualizing the ability–preference configurations that discriminate between distinct outcomes was C. P. Snow's (1959) broad demarcation of humanistic and scientific cultures. Snow, reflecting on his experience as both a writer and a scientist, observed that two distinct intellectual cultures exist in Western society, broadly labeled the humanistic and the scientific, which are clearly different in the ways they view the world and approach problem solving. For descriptive purposes, Snow used "literary intellectuals" to exemplify the humanistic culture and "physical scientists" to exemplify the scientific culture, implying that gradations of the characteristics defining these exemplars exist in several fields.

Studies in the ability arena have shown that verbal–linguistic skills are most critical for developing competencies in the humanities, whereas quantitative and spatial reasoning abilities are most important in math–science domains (Humphreys & Lubinski, 1996; Humphreys et al., 1993). With regard to ability–preference combinations, recent reviews by Ackerman (1996; Ackerman & Heggestad, 1997) of research conducted with adult samples revealed robust relationships between math and spatial abilities and Holland's (1985) *investigative interests* (i.e., persons who seek to explore and understand, are analytical, technical, and scientific, and prefer independent work) and *realistic interests* (i.e., persons who like to work with machines, tools, and things and prefer practical work environments). He found similar consistent relationships between verbal abilities and Holland's *artistic interests* (i.e., persons who value creative expression of ideas, emotions, or sentiments and prefer unstructured environments). These ability–interest combinations were also found to be related to knowledge in areas strikingly similar to C. P. Snow's (1959) distinction. The verbal–artistic combination of abilities and interests was highly correlated with self-reported knowledge in the humanities and arts, and the math/spatial–investigative combination was highly correlated with self-reported knowledge in math, physical sciences, and technology (Ackerman, 1996). Ackerman and Heggestad (1997) further reported that the strongest relationships to specific intellectual abilities exist with Holland's realistic, investigative, and artistic interest domains, which are most strongly associated with the two cultures.

C. P. Snow's (1959) two-culture categorization is useful for the present study for several reasons. First, Snow's simple classification system reflected his observations specifically of different types of intellectual environments, making it intuitively appealing for application to a group of intellectually gifted individuals. Second, sample sizes of Study of Mathematically Precocious Youth (SMPY) participants meeting the requirements for inclusion in the study were relatively small for multivariate analyses ($N = 432$), necessitating the use of a relatively small number of criterion groups. Finally, as outlined above, research among normative high school (Humphreys et al., 1993) and adult (Ackerman, 1996) samples helps to highlight specific ability–preference constellations that we would expect to distinguish the two cultures. The use of relatively broad but uniquely pure groups for this study was intended to maximize the prediction of group membership and to uncover meaningful relationships between variables where they exist. The analyses also included gifted students who completed college majors that could not be categorized purely into either a math–science or a humanities group. The inclusion of this heterogeneous "other" category increased the overall sample size and allowed for unique comparisons and contrasts with the humanistic and scientific groups.

Method

Participants

The participants for this study were drawn from Cohorts 1, 2, and 3 of SMPY's planned 50-year longitudinal study of intellectual talent, currently in its third decade (for a comprehensive description of SMPY and all of its five cohorts, see Lubinski and Benbow, 1994). Participants in SMPY were initially identified (through talent searches) at age 12 or 13 by scoring in approximately the top 3% on standardized achievement tests appropriate for their grade level (Cohn, 1991). Then, as part of the talent search, these gifted students took the Scholastic Aptitude Test (SAT), a test designed for college-bound high school students. A select group of talent search participants was subsequently invited for inclusion in the SMPY longitudinal study by meeting specific SAT score criteria established for the cohort being identified at that time (see later descriptions of cohorts); all participants were within the top 1% of intellectual ability in either mathematical or verbal reasoning for their age group. After selection, subsets of SMPY participants were given an additional series of tests and questionnaires for research purposes. Students in the various cohorts were included in the present study if they had completed both the SAT and the Study of Values (SOV; Allport, Vernon, & Lindzey, 1970) by age 12 or 13 and had reported their completed college major as part of a 10-year follow-up questionnaire. Four hundred thirty-two SMPY participants (272 men, 160 women) met these criteria. Brief descriptions of the three SMPY cohorts follow.

Cohort 1 (n = 2,188) includes students (96% Caucasian, 2% Asian, 2% other) who, before age 14, scored 370 or above on the SAT–verbal (SAT–V) subtest or 390 or above on the SAT–math (SAT–M), original scale, as part of SMPY's 1972, 1973, or 1974 talent searches. These score cutoffs represented the average SAT performance of high school girls at that time as well as approximately the top 1% of general intellectual ability for 7th-grade students (Lubinski & Benbow, 1994). These participants were drawn primarily from the state of Maryland, with a large concentration from the greater Baltimore–Washington area; 99 boys and 98 girls met inclusion criteria.

Cohort 2 (n = 778) is made up of talent search participants (89% Caucasian, 6% Asian, 5% other) from 1976, 1978, and 1979 talent searches who scored among the top one third of talent search SAT scores (i.e., SAT–V $\geq$ 430 or SAT–M $\geq$ 500, original scale); they represent approximately the top 0.5% in general intellectual ability for their age group. These participants were drawn from mid-Atlantic states; 113 boys and 47 girls met inclusion criteria.

The most select group of SMPY participants makes up Cohort 3 (n = 423), which was identified between 1980 and 1983. These students (77% Caucasian, 19% Asian, 4% other) approximate the top 1 in 10,000 (or top 0.01%) in mathematical or verbal reasoning ability by having scored, before age 13, SAT–V $\geq$ 630 and/or SAT–M $\geq$ 700, original scale. These participants were drawn from talent searches throughout the nation; 60 boys and 15 girls met criteria for inclusion.

Data were collapsed across cohorts, resulting in a total sample of 432 participants and representing various segments of the top 1% in intellectual ability. The 432 participants represented a 70% response rate of individuals who completed both the SAT and SOV at age 13. The t tests comparing SAT and SOV means between responders (n = 432) and nonresponders (n = 185) to the 10-year follow-up questionnaire revealed no significant differences on any of the ability or value dimensions (all ps > .05).

Predictive Measures

SAT. The SAT was designed as a college entrance exam, to be taken by college-bound high school juniors and seniors to predict college performance. It consists of mathematical (SAT–M) and verbal (SAT–V) subtests. Scores for each subtest are standardized on a scale ranging from 200 to 800. The following are means and standard deviations for SAT–M and SAT–V subtests for the 432 participants examined in this study: SAT–M (boys), M = 591, SD = 93; SAT–M (girls), M = 526, SD = 78; SAT–V (boys), M = 445, SD = 88; SAT–V (girls), M = 461, SD = 85.

SOV. The SOV (Allport et al., 1970) is a measure of personality-related values, conceptualized as basic motives or interests. The SOV yields scores along six ipsatively scaled dimensions (brief descriptions of personal characteristics associated with each theme are given in parentheses): *theoretical* (concern for the discovery of truth; tend to think in empirical, critical, and rational terms), *economic* (value in what is practical or useful; tend to judge matters in terms of tangible, financial implications), *aesthetic* (dominant value is in form and harmony; sensitive to grace, beauty, and symmetry), *social* (altruistic and genuine philanthropic love of people; tend to be kind, sympathetic, and unselfish), *political* (interested primarily in power, influence, renown, and leadership), and *religious* (value unity; tend to be mystical and seek to relate themselves to a higher reality).

The SOV was standardized on a college population and was created for use with persons from Grade 10 to adulthood. Reliability information reported by the manual (Allport et al., 1970) includes split–half reliability coefficients ranging from .73 (theoretical) to .90 (religious), and test–retest (over 1 month) reliability coefficients ranging from .77 (social) to .92 (economic).

Procedure

At approximately age 13, participants in Cohorts 1 through 3 completed the SAT, an open-ended background questionnaire, and an extensive battery of standardized assessments that included the SOV (Lubinski & Benbow, 1994). Several tests and questionnaires were administered on a limited basis in the early years of SMPY in an effort to determine which would be most effective in understanding gifted students and facilitating their development. The SOV was therefore given systematically to only portions of these cohorts, accounting principally for the relatively small proportion of each larger cohort that contributes to the total sample for this study.

At approximately age 23, participants received 10-year follow-up questionnaires through the mail and were later contacted, if necessary, via mail or telephone to encourage questionnaire completion. This comprehensive questionnaire included the completed college major variable chosen for this study as well as questions covering areas such as educational and occupational achievement, attitudes and interests, and family makeup and achievements. The collection of 10-year follow-up data occurred between 1982 and 1984 for Cohort 1, between 1986 and 1989 for Cohort 2, and between 1990 and 1993 for Cohort 3.

For purposes of analyzing these data, the college major variable was recoded to create three criterion groups—math–science, humanities, and other—based on C. P. Snow's (1959) two-culture demarcation described earlier. Classification proceeded in the following manner. A comprehensive list of fields of study from the Educational Testing Service was used to categorize into the math–science group all majors listed under the headings biological sciences, computer science, engineering, mathematics, and physical sciences. All majors listed under the headings art, English and literature, foreign languages, history and cultures, music, philosophy and religion, and theater arts were classified into the humanities group. Finally, majors listed under other headings (e.g., business, education, health and medical, social sciences) were placed in the "other" group.

Next, we assessed the veracity of this initial categorization by consulting classification data based on Holland's (1985) congruence theory, which asserts that persons seek out and remain in environments that best match their underlying interests and personality types. Holland's system was chosen for the present study on the basis of an extensive network of empirical support for the theory (Hackett & Lent, 1992) and its widespread use by practitioners who help individuals make educational and vocational decisions. On the basis of Holland's (1985) calculus assumption, six themes that simultaneously represent vocational interests and educational–vocational environments are arranged into a hexagonal organization in the following order: realistic, investigative, artistic, social, enterprising, and conventional (referred to in the literature by the acronym *RIASEC;* brief descriptions of the themes relevant to this study can be found in the introduction to this article). By convention, users of Holland's theory employ two- and three-letter codes, corresponding in rank order to the first letters of the predominant themes (i.e., R, I, A, S, E, or C), to characterize both persons and environments. In the case of the aforementioned majors that were classified into the math–science category, IRE (corresponding to investigative, realistic, and enterprising interests, in that order) was the modal three-letter Holland code according to the *Dictionary of Holland Occupational Codes* (*DHOC;* Gottfredson & Holland, 1996; see section titled "Classification of Instructional Programs"). Majors from the initial classification were retained in the math–science group if two of these three themes occupied the first two Holland code positions (i.e., were rank ordered as first or second in characterizing the major). A major was reclassified into the "other" category if this criterion was not met. This screening resulted in the reclassification of only one major, biology, which has a two-letter code of IA. Despite intuitive similarities between biology and majors such as biochemistry, biophysics/bioengineering, and zoology, each of these latter majors possessed a two-letter code of IR according to the *DHOC* and was thus retained in the math–science major grouping.

Because of the smaller sample size in the humanities, all majors from initial classification were retained for the analyses. The majority of these majors (87%) contained the artistic theme from Holland's classification in either the first or second Holland code position. The history majors were the only exception, with two-letter Holland codes of SE or ES. Fifteen of the 67 participants (22%) grouped in the humanities completed majors in history. The final results of classification are contained in Table 1.

Design and Analyses

We used discriminant analysis to analyze the unique contributions of preferences relative to abilities in the prediction of completed college degree field. Discriminant analysis is a technique for predicting group membership, a categorical variable, from a set of continuous predictor variables (Betz, 1987; Tatsuoka, 1988). Discriminant analysis yields a prediction of group membership on the basis of the linear composite or the combination of predictor scores that best captures differences between the groups. Several pieces of information from this analysis were reported: (a) Wilks's lambda, or the proportion of variance in discriminant scores not explained by group membership; (b) hit rates, or the accuracy of the discriminant function in forecasting group membership, which can be compared to base-rate expectations (Huberty, 1984; Meehl & Rosen, 1955); (c) correlations between each variable and the discriminant functions, which can be used to gain a purchase on the psychological character of each discriminant function; and finally (d) group centroids (weighted group means), representing average weighted discriminant scores for each criterion group. These centroids were plotted in standardized form such that the geometric distance between each group directly mirrored effect size (standard deviation) units.

Because the SOV is an ipsative instrument, only five scores provide unique information statistically, and the total variance explained by the SOV in a statistical analysis is the same regardless of which theme is excluded. The five themes chosen for the analyses were theoretical, economic, aesthetic, social, and religious. Although there exists a degree of arbitrariness in choosing which theme to exclude, the political theme was selected because it was believed theoretically to be least central to the task of distinguishing between math–science and humanities groups. On the basis of the Ackerman (1996) and Ackerman and Heggestad (1997) literature reviews highlighting preference categories that most correspond to the sciences and humanities, we expected the strongest positive relationships in this study with theoretical and aesthetic values and negative relationships with religious and social values.

Results

Univariate Analyses

Means for each predictor variable, by gender and criterion group, are depicted in Figure 1. On average, boys scored much higher on SAT–M and girls scored moderately higher on SAT–V. In general, boys produced more differentiated values profiles across themes, with the theoretical value theme dominating all others. Girls, on the other hand, produced more balanced values profiles across themes, with essentially no clear-cut, dominant theme. The pattern of these gender differences is consistent with previous studies of ability and preference profiles among intellectually gifted adolescents (Achter et al., 1996, p. 76; Lubinski & Benbow, 1992; Lubinski et al., 1995, 1996; Schmidt et al., 1998).

We conducted several univariate analyses of variance to examine, at the univariate level, the capacity of individual predictor variables to separate major groups from one another. Wilks's lambda values ranged from .98 (SAT–V) to .86 (theoretical value theme), representing a range from 2% to 14% of variance explained. All values were statistically significant, with $Fs(2, 429)$ ranging from 5.23 for SAT–V ($p < .006$) to 35.29 ($p < .00005$) for all other variables. These results indicate that when considered individually, all ability and value variables contributed to college-major group separation.

Multivariate Analyses

Hierarchical results and hit rates. To test the hypothesis that preferences add incremental validity to abilities in the

Table 1
Categorization of Completed College Major Into Math–Science, Humanities, and Other Groups

Math–science (n = 170, 57)	Humanities (n = 34, 33)	Other (n = 68, 70)
Biological sciences	**Art**	**Architecture** (2, 4)
Biochemistry (3, 4)	Art (0, 1)	**Biological sciences**
Biophysics/bioengineering (0, 1)	Film (1, 0)	Biology (9, 9)
Zoology (0, 1)	Fine arts (1, 1)	**Business and commerce**
Computer science (20, 8)	Interior decorating (0, 1)	Accounting (5, 7)
Engineering	Photography (0, 1)	Business and commerce (2, 1)
Aerospace engineering (5, 1)	Studio art (0, 1)	Business management/administration (4, 2)
Chemical engineering (11, 3)	**English and literature**	Data processing (3, 1)
Civil engineering (3, 1)	Creative writing (2, 1)	Finance and banking (1, 2)
Computer engineering (4, 1)	English (3, 8)	Industrial management (1, 0)
Electrical engineering (38, 6)	Literature (1, 1)	Marketing (2, 3)
Engineering, general (7, 0)	**Foreign languages**	Secretarial studies (0, 1)
Engineering sciences (2, 1)	Classical languages (0, 1)	**Communications** (1, 2)
Industrial engineering (3, 1)	Foreign languages (0, 1)	**Education**
Materials science (0, 1)	French (0, 1)	Elementary education (0, 2)
Mechanical engineering (10, 1)	Linguistics (1, 1)	Health education (0, 1)
Petroleum engineering (1, 0)	Russian (0, 4)	**Geography** (1, 1)
Mathematics	**History and cultures**	**Health and medical**
Mathematics (27, 17)	American history (3, 2)	Health and safety (0, 1)
Quantitative studies (1, 0)	European history (2, 0)	Medical assisting (1, 0)
Physical sciences	History and cultures (7, 1)	Nursing (0, 6)
Astronomy (1, 0)	**Music**	Premedicine (0, 3)
Chemistry (7, 5)	Instrumental music (1, 2)	Pre–veterinary medicine (0, 1)
Earth science (2, 0)	Music (2, 0)	**Psychology** (4, 4)
Geology (2, 1)	**Philosophy and religion**	**Social sciences**
Meteorology (1, 0)	Philosophy (5, 1)	Anthropology (1, 1)
Physical sciences (1, 0)	Religion (3, 3)	Criminal justice (0, 1)
Physics (21, 4)	**Theater arts**	Economics (17, 2)
	Drama (1, 0)	Government service/politics (1, 1)
	Theater arts (1, 1)	International relations (1, 1)
		Political science (9, 3)
		Social sciences, general (0, 2)
		Social work (0, 2)
		Sociology (0, 4)
		General studies (2, 1)
		Other (1, 1)

Note. Educational field headings are in boldface type. The *n*s for individual majors are in parentheses, by gender (men, women).

prediction of completed college major, we performed a hierarchical discriminant function analysis, with the two SAT scales entered initially and the five value themes from the SOV entered subsequently. The complete model (abilities plus values) produced a 13% increase in between-groups variance explained over the model that included abilities only, denoted by a decrease in Wilks's lambda from .90 (SAT scales alone) to .77 (SAT scales plus SOV themes). The statistical significance of this increment was evaluated by means of multiple regression (by dummy coding the three-category major variable), producing Wilks's lambda and Pillai's Trace test statistics significant at $p < .0001$. As hypothesized, the analysis of the full ability–value discriminant model also produced an increase over the ability-only model in the percentage of participants accurately classified into groups (direct hits increased from 54% to 60%). Both the ability-only and ability–value models produced hit rates that were meaningfully above base-rate expectations ($ps < .001$).

For parity, a hierarchical analysis was also performed with the values themes entered first followed by abilities, providing an index of the incremental validity of abilities, relative to values. In this case, the complete model (abilities plus values) produced a 2% increase in between-groups variance explained, denoted by a decrease in Wilks's lambda from .79 (SOV themes alone) to .77 (SAT scales plus SOV themes). A multiple regression analysis comparing the partial, values-only model to the complete ability–value model produced Wilks's lambda and Pillai's Trace test statistics significant at $p < .01$. In this case, overall hit rates were equal for both analyses (60%), although an examination of the individual cells for each group revealed that the addition of abilities improved discrimination of group membership in the humanities, with hit rates increasing from 9% (values alone) to 18% (abilities plus values).

Dummy coding gender and adding it to the prediction equation did not result in additional variance explained (Wilks's lambda = .76) or further discrimination among college-major groups (direct hits = 60%). Following a rec-

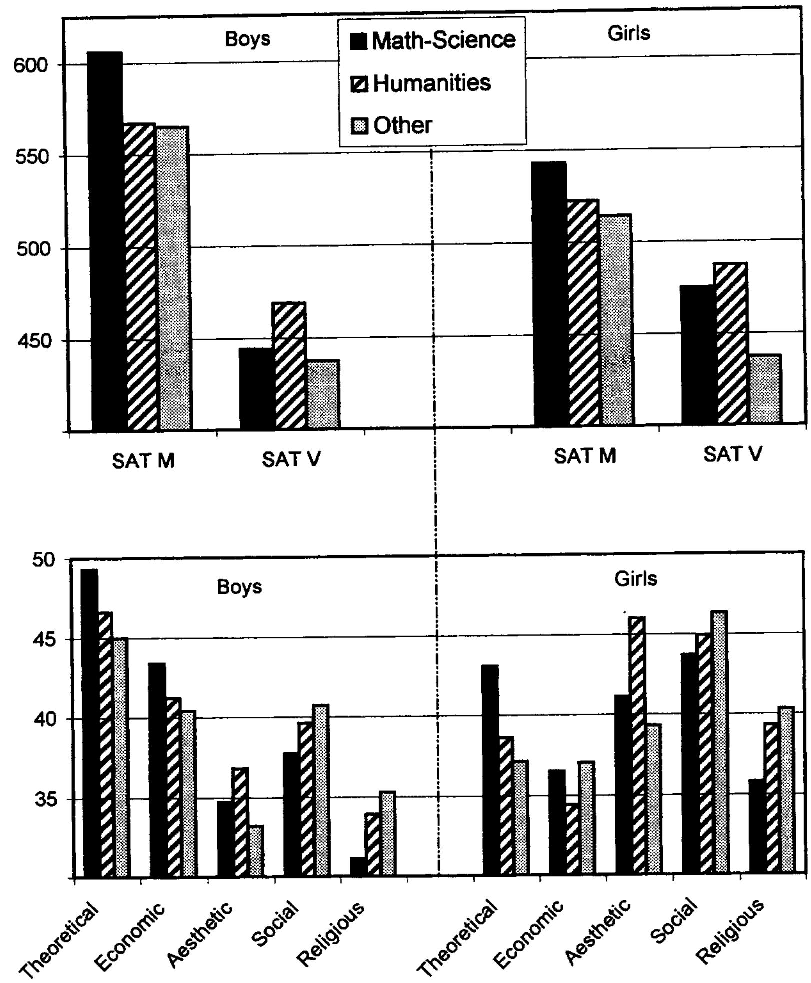

Figure 1. Scholastic Aptitude Test (SAT; top) and Study of Values (bottom) means by criterion grouping and sex (numerical values can be obtained in table format from the authors). M = math; V = verbal.

ommendation of one of the referees for this article, we assessed the unique effects of gender by entering it first into the equation, resulting in a Wilks's lambda of .93 (7% of variance explained), and a classification algorithm that predicted no participants in the humanities group. Both abilities and values added incremental validity to the forecasting efficiency of gender. Finally, logistic regression analyses tested for possible interaction effects in the prediction of membership in math–science or humanities majors: Cohort × Ability, Cohort × Gender, and Cohort × Value. These analyses revealed no statistically significant results.

A detailed breakdown of classification results for the combined (ability and value) analysis is contained in Table 2. As noted previously, total classification accuracy was approximately 60%. The hit rates for the three criterion groups were all above base-rate expectations and ranged from 18% to 79%. The hit rates for the math–science and other groups were statistically significant ($p < .001$), whereas for the humanities group, the hit rate was not significant ($p > .10$). Poor prediction of humanities group membership in this study was affected by the heavy bias in the present sample toward math–science college majors and would likely improve if group sizes were more balanced. The statistical problem of predicting rare events has been discussed at length by Meehl and Rosen (1955).

Table 2
Predicted and Actual Group Classification Using Discriminant Functions

	Predicted group			
Actual group	Math–science	Humanities	Other	Total
Math–science	**179 (79%)***	5 (2%)	43 (19%)	227 (53%)
Humanities	37 (55%)	**12 (18%)**	18 (27%)	67 (16%)
Other	66 (48%)	4 (3%)	**68 (49%)***	138 (32%)
Total	282 (65%)	21 (5%)	129 (30%)	432 (100%)

Note. Values on the diagonal are hits and are in boldface type. There are a total of 259 hits, or 60%. 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.
$^*p < .001$.

Table 3
Discriminant Function Results Using All Predictor Variables

Discriminant function	Eigenvalue	% of variance	Canonical correlation	After function removed	Wilks's Λ	*p*
				0	.77	<.00005
1	.22	75	.42	1	.93	<.00005
2	.07	25	.26			

Discriminant content and dimensionality. Detailed results of the combined (ability and value) discriminant function analysis are presented in Table 3. Two statistically significant discriminant functions were yielded, with a Wilks's lambda of .77, indicating that approximately 23% of variance between major groups in this sample was explained by differences in participants' ability and value profiles. The first function accounted for 75% of the explainable variance; the second function, the remaining 25%.

To illustrate the amount of group separation achieved by this discriminant analysis, Figure 2 depicts plots of the bivariate group centroids (average discriminant scores assigned to members of each group) in two-dimensional discriminant space. Each group's centroid defines a tip of the solid triangle. All three 4-year-degree groups claimed a unique territory in this space relative to the other two, and clearly, the effect-size differences between all three pairs of group centroids were large. More precisely, with respect to

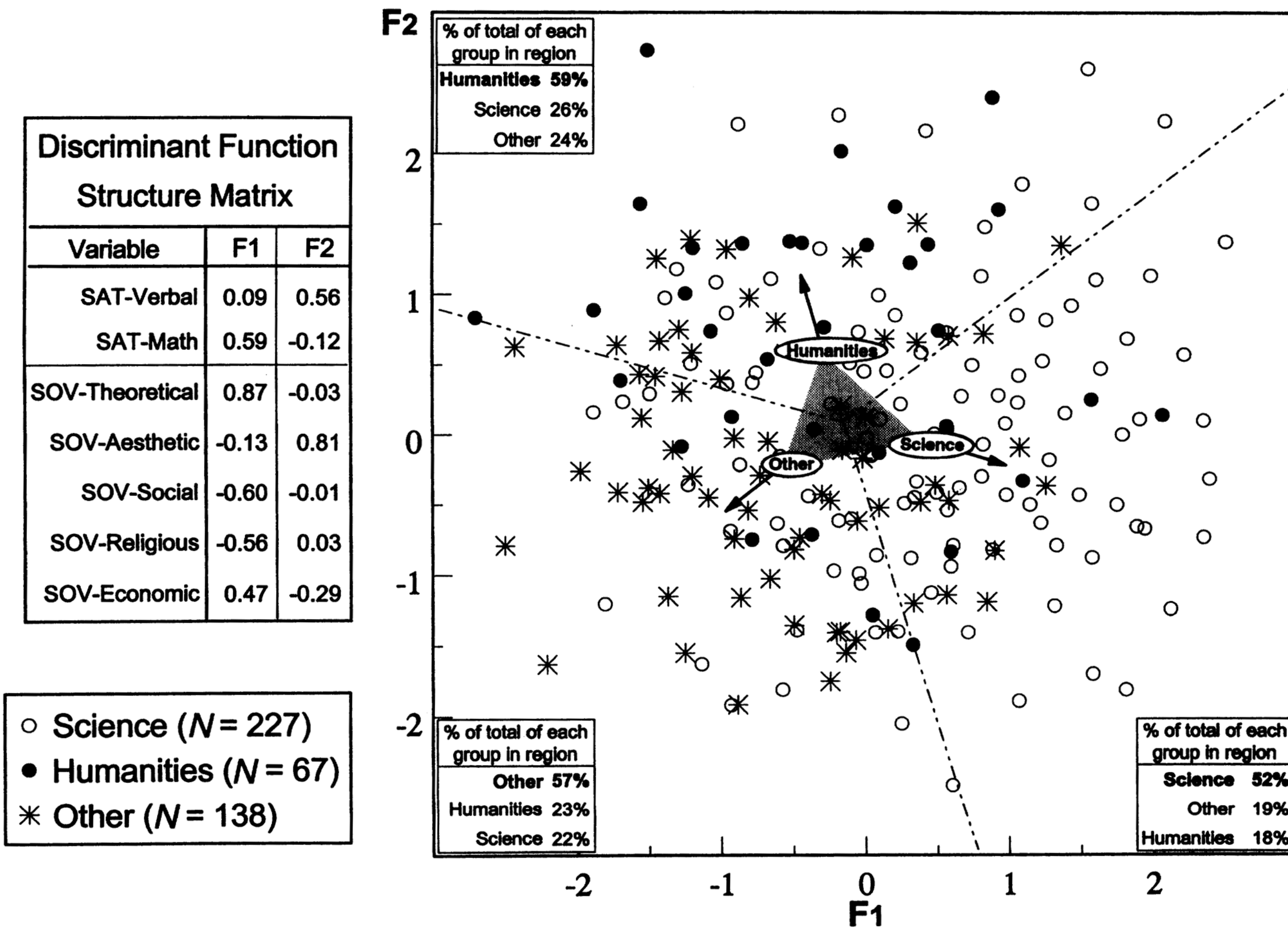

Figure 2. Group centroids and discriminant structure matrix. The bivariate group centroids for the total sample were (Function 1, followed by Function 2): math–science (.43, −.05); humanities (−.29, .60); other (−.57, −.21). To make the scatter plot less cluttered, each bivariate point represents an average of two participants' discriminant scores (most typically the closest geometrically). Percentages were computed using all individual data points. SOV = Study of Values; SAT = Scholastic Aptitude Test; F1 = Function 1; F2 = Function 2.

Function 1, the effect-size difference of the math–science group from the humanities and other groups was .72 and 1.0, respectively. With respect to Function 2, the effect-size difference of the humanities group from the math–science and other groups was .55 and .81, respectively.

In addition to these bivariate group means, individual participants' bivariate discriminant scores also are provided. Simply for descriptive purposes, the figure was parsed into three regions by extending a line from the solid triangle's centroid through the midpoint of each centroid pair. The arrows emanating from each centroid are 180° extensions of these dividing lines, representing the direction of maximal separation from the other two groups. An analysis of these regions revealed an impressive degree of accuracy in capturing members belonging to each group, especially as individual bivariate points move toward the outer area of each region. The percentages of "correctly placed" participants in these regions (see inset boxes) is analogous to the hit rates that might be achieved if base rates in each group were roughly equal (i.e., 33%).

The discriminant function structure matrix presented in Figure 2, in conjunction with the plotted group centroids, allows for a content evaluation of the two statistically significant discriminant functions. The structure matrix depicts correlations between each predictor variable and the standardized discriminant functions, and these correlations are used to interpret function content (Betz, 1987). The patterns found among group centroids and within the structure matrix make possible the substantive interpretation of Function 1 as a math–scientific function and Function 2 as a verbal–humanistic function. An examination of Function 1 revealed that it separated participants completing math–science majors (large positive centroid) from both the humanities and other groups (large negative centroids). Higher scores on theoretical values and math abilities (high positive correlations) and lower scores on social and religious values (high negative correlations) characterized the math–science group. Function 2, on the other hand, separated participants completing majors in the humanities (large positive centroid) from the other two groups (negative centroids), with higher scores on aesthetic values and verbal abilities (high positive correlations) characterizing the humanities group.

Discussion

The predictive accuracy and amount of group separation achieved by the combined (ability–value) analysis, as well as the existence of theoretically interpretable discriminant functions, lend support for the conclusion that vocational preference inventories administered to intellectually gifted 13-year-olds add incremental validity to their ability assessments in predicting meaningful educational outcomes 10 years later. Impressively, 23% of the variance in college-major group membership at age 23 was explained by participants' age-13 ability and value scores, with values accounting for 13% of the variance over and above abilities.

Theoretical Implications

These results help to organize prior findings. First and most generally, the results add to a growing number of studies that successfully utilize the broad rubric described by the TWA to answer questions about the educational development of intellectually gifted adolescents, through the application of developmentally appropriate assessments of abilities and preferences (Benbow & Lubinski, 1996; Lubinski & Benbow, 1994). Support for the adjustment dimensions of TWA (satisfaction and satisfactoriness) was supplied indirectly with the completed college major criterion, which, because it requires 4 years (on average) of sustained commitment, is one measure of tenure.

Second, the organizational patterns of abilities and values found in this study accord with previous research among adults and affirm the budding presence of C. P. Snow's (1959) two cultures among the intellectually gifted, even at age 13. The "other" category, arbitrarily created for this study, allowed limited interpretation, inasmuch as it seemed to be dominated by more of an orientation toward people contact than the other two categories.

Applied Implications

This study supports the idea that preferences are sufficiently crystallized among intellectually gifted adolescents to achieve forecasting utility (see also Lubinski et al., 1995, 1996; Schmidt et al., 1998) and lends justification to teaming above-level preference assessment with above-level ability testing when assisting gifted adolescents in educational decision making.

Some general suggestions for educators and counselors emanate from the present study—but first, a caveat. We are in agreement with the sentiment that expanding breadth of knowledge, especially at this age, is very important and indeed should be encouraged. But this should not preclude educators from making very general suggestions to gifted students at an early age if it can begin to help them more intentionally structure their educational pursuits. We submit that if early knowledge of certain dominant patterns increases the chances of optimal development of talents (Lubinski & Benbow, in press), then educators should pay careful attention to them, rather than simply hoping that gifted students will find their own way (cf. Achter, Benbow, & Lubinski, 1997; Benbow & Stanley, 1996). In keeping with these tenets, our discriminant analysis forecasted only general trends that are based on a broad categorization of college majors, leaving much room for individuation.

In practical terms, the more intensely focused an individual's ability and preference patterns are, in the direction of the general patterns found in a specific criterion group (i.e., math–science or humanities), the more confident one can be in encouraging further development in that general area. So, to the degree that the intensity of a student's verbal-ability–aesthetic-value clustering stands out relative to other profile combinations, encouraging further development of talents in the humanities may be ventured with greater confidence. To the extent that a student's math-ability–theoretical-value clustering is dominant relative to other ability–value combinations, on the other hand, he or she might be encouraged to think about math–science domains for more intensive development. To the extent that neither of these clusterings is evident (but others are, such as a high-social–low-theoretical values combination), exploration into other fields (e.g., business, politics) becomes more appropriate. These gradations of confidence must be assessed on a case-by-case basis according to the uniqueness offered by each individual's profile.

Whereas male and female gifted students' ability and value profiles differed in score intensity, gender did not add to the prediction of college major grouping. Indeed, the relative pattern of scores on the dimensions examined here was the same across genders (Figure 1 illustrates this graphically). That is, it appears that differences across genders were adequately captured in the discriminant analysis by the individual differences present in their ability and preference profiles. Thus, although it is important for educators and counselors to be aware of gender differences among intellectually talented students (e.g., girls tend to have more competing interests, boys more distinct interests), awareness of the relative patterns delineated previously should prove equally useful across genders.

Limitations and Implications for Future Research

Some limitations of the present study deserve mention. First, the study was not all-inclusive in its assessment of prominent ability domains relevant to educational choice. In particular, spatial ability, a third major marker of general intelligence (Carroll, 1993; R. E. Snow & Lohman, 1989), was not assessed, making for an ability predictor set that was underdetermined. It is likely that the inclusion of a three-dimensional, spatial-visualization measure would have further refined prediction of group membership achieved by abilities alone (Austin & Hanisch, 1990; Humphreys & Lubinski, 1996; Humphreys et al., 1993). In addition, the selection bias toward mathematically gifted students inherent in much of the SMPY sample contributed to smaller sample sizes in humanities majors, resulting in less reliable prediction into that group. It is a modest inference to suggest that more equal group sizes would have improved prediction into the humanities. Finally, the breadth and small number of criterion groups and the use of only one outcome measure are two other limitations. Future research with larger, more heterogeneous samples could correct for these limitations, allow for meaningful cross-validation of results, and provide refinements to conclusions drawn here.

Summary

By demonstrating the incremental validity of preferences with respect to abilities among the top 1% of adolescents in intellectual ability, this study adds to a growing body of evidence illustrating that preference intensity and pattern (Achter et al., 1996, 1997) among gifted adolescents deserves serious attention alongside ability intensity and pattern (Benbow, 1992; Benbow & Lubinski, 1997) in guiding decisions regarding optimal educational and vocational pursuits. By adding preferences to their assessment repertoire, educators and counselors are equipped with a more complete set of tools to help gifted students tease out, and more readily apprehend, the most salient features of their individuality in connection with capacity and motivational attributes (Lubinski & Benbow, 1994, in press). Such information could serve to help gifted students select environments in which they are more likely to achieve excellence (rather than merely competence) and experience fulfillment (as opposed to merely contentment). Of course, this focus on optimal development (Lubinski, 1996; Scarr, 1996), appropriate for educational counseling among intellectually gifted students, is something that the individual-differences tradition in psychology stresses for students within all ability ranges (Lubinski, in press; Tyler, 1992; Williamson, 1965).

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