Gifted Child Quarterly
2021, Vol. 65(1) 3–28

DOI: 10.1177/0016986220925447
journals.sagepub.com/home/gcq
SAGE

Intellectual Precocity: What Have We Learned Since Terman?

David Lubinski[1] and Camilla P. Benbow[1]

Abstract

Over the past 50 years, eight robust generalizations about intellectual precocity have emerged, been empirically documented, and replicated through longitudinal research. Within the top 1% of general and specific abilities (mathematical, spatial, and verbal) over one third of the range of individual differences are to be found, and they are meaningful. These individual differences in ability level and in pattern of specific abilities, which are uncovered by the use of above-level assessments, structure consequential quantitative and qualitative differences in educational, occupational, and creative outcomes. There is no threshold effect for abilities in predicting future accomplishments; and the concept of multipotentiality evaporates when assessments cover the full range of all three primary abilities. Beyond abilities, educational/occupational interests add value in identifying optimal learning environments for precocious youth and, with the addition of conative variables, for modeling subsequent life span development. While overall professional outcomes of exceptionally precocious youth are as exceptional as their abilities, educational interventions of sufficient dosage enhance the probability of them leading exceptionally impactful careers and making creative contributions. Findings have made evident the psychological diversity within intellectually precocious populations, their meaningfulness, and the environmental diversity required to meet their learning needs. Seeing giftedness and interventions on their behalf categorically has held the field back.

Keywords

basic interpretive, mixed methods, psychometrics, assessment, creativity, gifted

Over the past five decades, many exciting advances about intellectual precocity have been established. Collectively, these findings constitute one of the major achievements of the educational and psychological sciences; and they have informed cross-disciplinary research throughout the biosocial sciences (Lubinski, 2016). The centenary of Lewis M. Terman's celebrated longitudinal study, therefore, seems an appropriate time to review what we know.

When knowledge development in a scientific field reaches a certain point of maturity, it is frequently helpful to list and detail firmly established empirical findings so that future discovery and practice can be guided by and built on them. This is especially true when findings are widely scattered. Over the years, question-and-answer frameworks have efficiently communicated what is known in such instances. For example, up-to-date advances in cognitive abilities (Humphreys, 1991; Kuncel & Hezlett, 2010), actuarial versus clinical prediction (Grove & Meehl, 1996), conducting reliability appraisals (Schmidt & Hunter, 1996), and explicating robust findings in behavioral genetics (Plomin et al., 2016) have been efficiently communicated in this format. Thus, we employ it here to ask and answer eight critical questions about intellectual precocity, for which replications in longitudinal research have produced empirically sound answers. We conclude by detailing some profitable lines for future research.

Question #1

Is there an ability threshold, beyond which more ability doesn't matter? No.

While other things are certainly required for all important life accomplishments, greater ability leads to greater achievement. With two important exceptions (Benbow, 1992; Hollingworth & Cobb, 1928), past scientific and popular writings have perpetuated the myth of an ability threshold due to a lack of understanding that the research relied on was compromised in its design. Determining the significance of individual differences in ability within the

[1]Vanderbilt University, Nashville, TN, USA

Corresponding Author:
David Lubinski, Department of Psychology and Human Development, 0552 GPC, 230 Appleton PL, Vanderbilt University, Nashville, TN 37203-5721, USA.
Email: david.lubinski@vanderbilt.edu

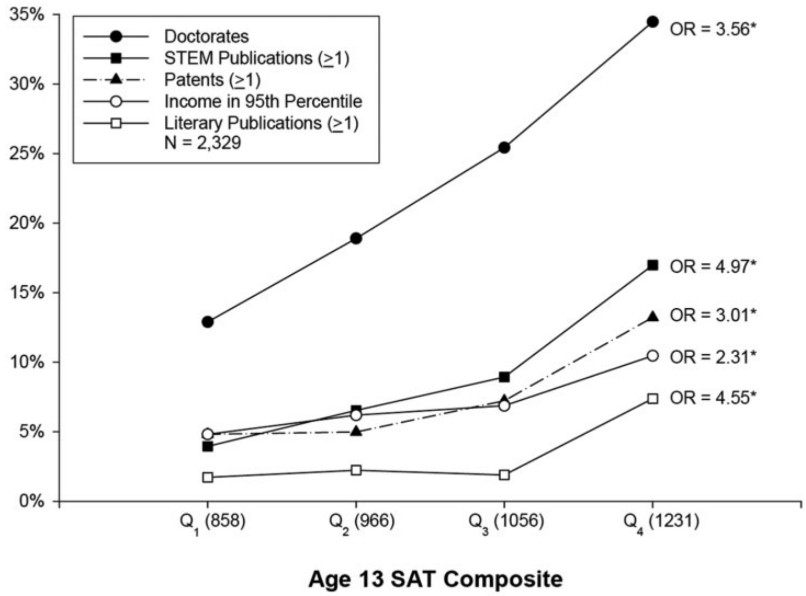

Figure 1. Participants are separated into quartiles based on their age-13 SAT-M + SAT-V composite.
Note. The mean age-13 SAT composite scores for each quartile are displayed in parentheses along the *x*-axis. Odds ratios comparing the likelihood of each outcome in the top (Q4) and bottom (Q1) SAT quartiles are displayed at the end of every respective criterion line. An asterisk indicates that the 95% confidence interval for the odds ratio did not include 1.0, meaning that the likelihood of the outcome in Q4 was significantly greater than in Q1. These SAT assessments by age 13 were conducted before the recentering of the SAT in the mid-1990s; at that time, cutting scores for the top 1 in 200 were SAT-M $\geq$ 500, SAT-V $\geq$ 430; for the top 1 in 10,000, cutting scores were SAT-M $\geq$ 700, SAT-V $\geq$ 630 by age 13. From Lubinski (2009a).

top 1% for educational, occupational, and creative outcomes requires the following four challenging design criteria to be satisfied: (a) intellectual assessments with appropriate ceilings for differentiating individual differences with the top 1% of ability; (b) large samples (for statistical validity); (c) multiple outcome criteria with high ceilings or rare base rates (as there are multiple ways in which exceptional intellectual talent is manifested and constrained outcome criteria limit detecting this); and (d) an appreciable time frame between intellectual and outcome assessments to allow for the development of requisite expertise for outstanding accomplishments and, thereby, documenting predictive validity. When these four design criteria are satisfied, the importance of individual differences within the top 1% is readily seen and the illusion of a threshold effect dissipates.

For example, for above-average ability students, the SAT-Mathematics + SAT-Verbal composite is an excellent measure of IQ or general intelligence (Frey & Detterman, 2004). Summing these two indicators distills an excellent measure of general intelligence for above-average ability samples. Figure 1 presents the age-13 SAT composite scores for over 2,300 participants drawn from the Study of Mathematically Precocious Youth (SMPY; Lubinski & Benbow, 2006; Stanley, 1996); all participants were in the top 1% of ability. Their composite scores were then placed into quartiles; the means for each quartile are on the *x*-axis. Over 25 years later, several outcomes were collected on the following rare accomplishments (normative base rates provided in parenthesis): earning a doctorate (under 2%), publishing a refereed science, technology, engineering, and mathematics (STEM) or literary publication (each under 1%), securing a patent (1%), and having an income in the top 5% of the U.S. population, an especially impressive outcome for people in their mid-30s. The top quartile of the top 1% is at much more promise for these accomplishments than the bottom quartile of the top 1%, even though the latter are gifted and performed well beyond normative base rate expectations for these rare outcomes. Similar findings have been observed when educational level and caliber of the university attended are controlled (Park et al., 2008). Clearly, while other things matter, more ability is better (cf. Kell, Lubinski, & Benbow, 2013; Makel et al., 2016; Park et al., 2007; Wai et al., 2005).

Question #2

Does the pattern of specific abilities matter? Yes. *Is there evidence for multipotenitality?* No.

This is not the place to review the consensus that intellectual abilities are organized hierarchically. Several handbook chapters and articles explicate the hierarchical organizational of and consensus on the robust properties and interrelationships of intellectual abilities (Carroll, 1993; Corno et al., 2002; Hunt, 2010; Jensen, 1998; Lubinski, 2004; Lubinski & Dawis, 1992; Messick, 1992; Snow et al., 1996; Warne, 2015). A core general ability surrounded by three specific abilities—mathematical, spatial, and verbal—affords a parsimonious model of this hierarchy. What is important here is that both the level and pattern of these three specific abilities are essential (Kell, Lubinski, Benbow, & Steiger, 2013; Wai et al., 2009). Each adds value to the other two, such that, no matter how equally gifted students are on any two of these three primary abilities, their educational, occupational, and creative accomplishments differ markedly as a function of the extent to which they differ on the third. There are a number of longitudinal studies of precocious youth that, collectively, demonstrate the importance of level and pattern of mathematical and verbal reasoning in the prediction of educational, occupational, and creative outcomes over multiple decades (Kell, Lubinski, & Benbow, 2013; Makel et al., 2016; Park et al., 2007), but fewer that also involve spatial ability (Kell, Lubinski, Benbow, & Steiger, 2013; Wai et al., 2009). The example that follows, therefore, showcases all three specific abilities (mathematical/spatial/verbal) to highlight the unique role each plays in differential development (Shea et al., 2001).[1]

In the late 1970s, a group of 563 talent search participants, identified in the top 1% with the SAT by age 13, was administered tests of spatial ability designed for high school seniors. Subsequently, they were followed up for information on their educational and occupational outcomes at three time points: ages 18 (after high school), 23 (after college), and 33 (early career). More recently, at age 48 (mid-career), 35 years after their initial identification and assessment, outcome data on their creative accomplishments were collected (Kell, Lubinski, Benbow, & Steiger, 2013). In all studies, the three specific abilities—mathematical, verbal, and spatial—were found to have unique value predicting meaningful outcomes, relative to the other two. Had only two of these abilities been assessed, great precision would have been lost about participants' life paths as well as a more comprehensive psychological understanding of their differential development.

To illustrate this phenomenon, we provide three-dimensional plots in Figure 2 that contain the educational/occupational outcomes of this sample at ages 18 (Panels A and B), 23 (Panel C) and 33 (Panel D). All three abilities are scaled in standard deviation units; mathematical ability is scaled on the *x*-axis and verbal ability is scaled on the *y*-axis; points at the base of each arrow designate the bivariate (math/verbal) mean for each group. Spatial ability is designated by arrows pointing to the right for positive values and to the left for negative values. The arrowheads constitute the trivariate (math/verbal/spatial) means for each group. When these arrows are rotated up from the page for the positive values, at right angles from the *x*- and *y*- axes, and down from the page for the negative values, again at right angles from *x* and *y*, the arrowheads mark the location that each group's trivariate mean occupies in three-dimensional space.

For instance, those who reported humanities and the social sciences as their favorite high school course tend to possess intellectual strengths dominated by verbal ability relative to mathematical and spatial ability; and the opposite pattern was true for students who preferred coursework in STEM. This is not only true for preferences for learning environments but also for their career choices. Individuals with occupations in STEM possessed dominant mathematical and spatial abilities relative to their verbal ability. Importantly, each specific ability provides incremental validity relative to the other two in the prediction of the location of these educational/occupational outcomes. Neglecting any one of these three specific abilities omits an essential determinant and compromises a more complete psychological understanding of precocious development. Furthermore, the longitudinal potency of these intellectual configurations maintained their psychological significance 15 years later, when the midlife creative accomplishments of these participants were examined. At age 48, their creative accomplishments aligned with the same intellectual patterns that structured their educational and career development (Kell, Lubinski, Benbow, & Steiger, 2013). For example, participants who ultimately made literary contributions (e.g., published a refereed article in the humanities or social sciences) had an adolescent intellectual profile characterized by verbal ability > spatial ability, whereas the opposite was true for participants securing patents (viz., verbal ability < spatial ability). Participants securing refereed publications in STEM tended to be high on all three abilities.

More precisely, out of the initial sample of 563 adolescents, 160 had secured at least one of the following creative outcomes by age 48 (sample sizes in parenthesis): refereed publications in the arts, humanities, law, or social sciences (27), biology/medicine (35), STEM (65), or securing a patent (33). These numbers are mutually exclusive and exhaustive inasmuch as 32 participants with publications and patents were placed in the relevant publication category. When a discriminant function analysis was carried out on these data, 10.5% of the variance in these four creative categories was accounted for by their SAT-Math and SAT-Verbal scores. When their spatial ability score was added, however, a statistically significant additional 7.5% of the variance was accounted for (totaling 18%). That this amount of variance could be accounted for in the four categories and over a 35-year interval (age 13 to age 48) is noteworthy;

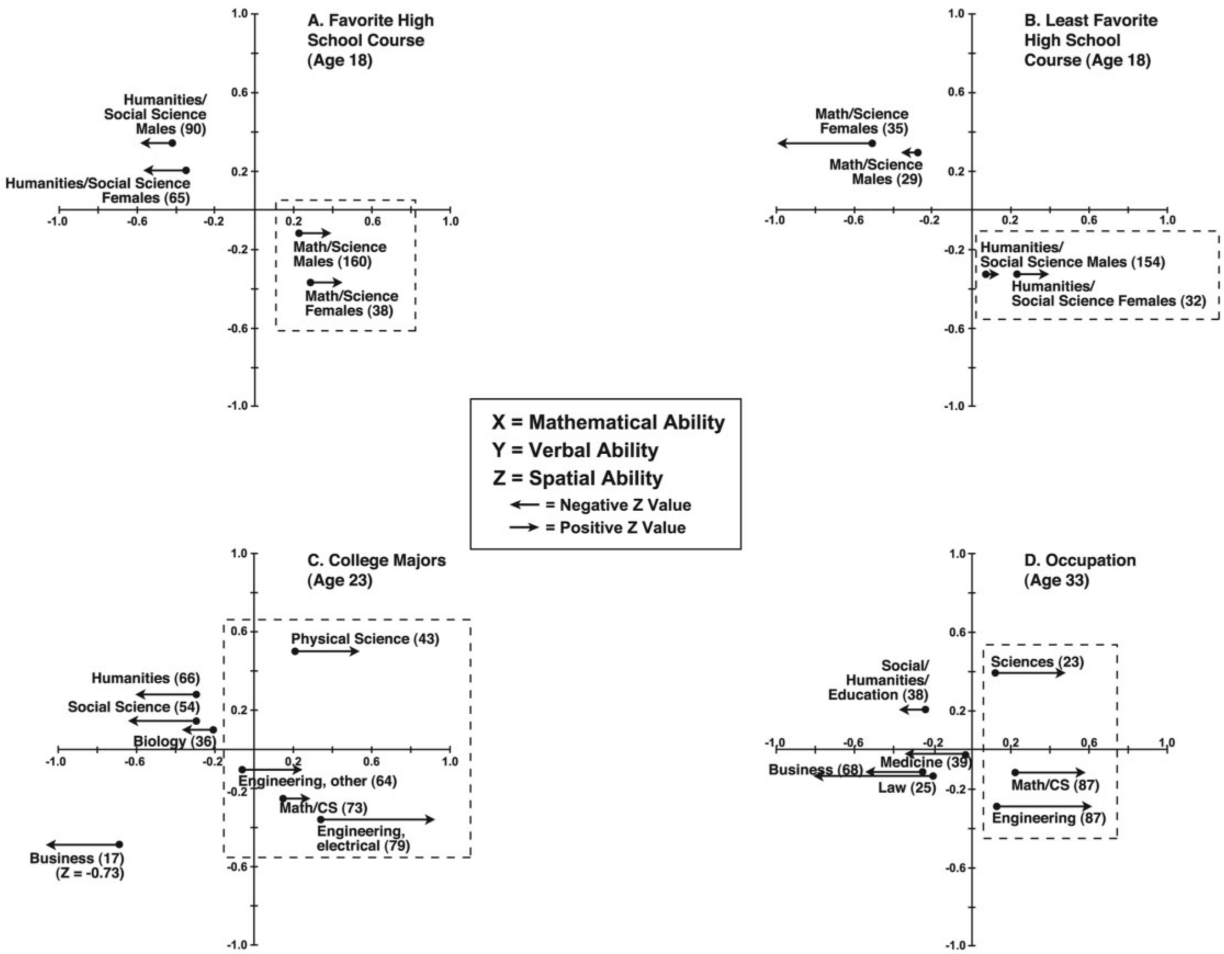

Figure 2. Shown are trivariate (X/Y/Z = Mathematical/Verbal/Spatial) means for (Panel A) favorite and (Panel B) least favorite high school course at age 18, (Panel C) college majors at age 23, and (Panel D) occupation at age 33.
Note. Mathematical, verbal, and spatial ability are on the *x*-, *y*-, and *z*-axes, respectively (arrows to the right indicate a positive *z* value; arrows to the left indicate a negative *z* value). Panels A and B are standardized within gender; Panels C and D are standardized across genders. For Business in Panel C, note that the length of the arrow is actually $z = 0.73$. Adapted from Shea et al. (2001). Dotted rectangles surround the STEM degrees and occupations reveal that their constituents occupy the same intellectual space across time points.
CS = computer science.

it supports Howard Gardner's (1983, p. 192) assertion that "it is skill in spatial ability that determines how far one will go in science [and technology]."

We will revisit findings on these three specific abilities in our concluding section, because they are illustrative of other key generalizations. For now, we would like to emphasize an additional critical point: these findings would not have been observed had this sample of intellectually precocious 13-year-olds been assessed on these measures at age 17 or 18 (the age that these measures were designed for). By that age, essentially all would have hit the ceiling of these instruments (all clustering at the top), which might appear to support the false notion of "multipotentiality" (Achter et al., 1996, 1997).

When developmentally appropriate measures are utilized in above-level testing (Warne, 2012), the scope of each individual's talent does covary with important real-world outcomes observed over protracted time frames. Findings derived from profoundly gifted youth only serve to amplify this finding.

Question #3

Is ability pattern important for students with especially profound intellectual gifts? Yes.

Figure 3 represents bivariate scatter plots of the mathematical and verbal ability distributions of two of the most profoundly gifted samples ever assembled for longitudinal tracking (Makel et al., 2016): A sample of 320 participants (bottom) from SMPY (Kell, Lubinski, & Benbow, 2013) and a sample of 259 participants (top) from Duke University's Talent Identification Program

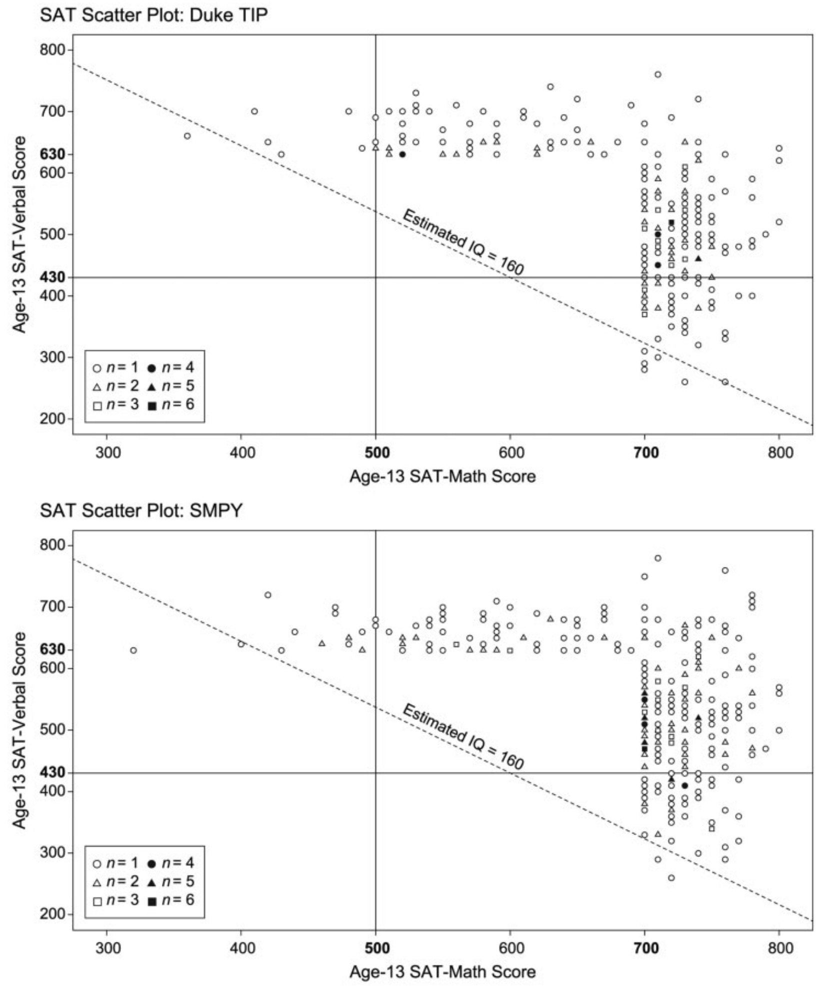

Figure 3. Scatterplot of age-13 SAT-Math (X) and SAT-Verbal (Y) scores for Duke TIP participants (top panel) and SMPY participants (bottom panel).

Note. Open and closed circles, triangles, and squares indicate *ns* for participants with identical bivariate points. The diagonal line in each scatterplot denotes where estimated IQs of 160 fall; bivariate values above the diagonals correspond to estimated IQs above 160. On the axes, the boldface numbers indicate cutoffs for the top 1 in 200 and the top 1 in 10,000 for this age group. Adapted from Makel et al. (2016). SMPY = Study of Mathematically Precocious Youth.

(Duke TIP; Putallaz et al., 2005). Participants were selected based on having SAT-Math or SAT-Verbal scores in the top 1 in 10,000 of their age-matched peers by age 13. One reason these plots are so informative is that they illustrate the intellectual diversity among participants in the top 1 in 10,000 in mathematical or verbal reasoning ability. That is, some participants in the top 1 in 10,000 in mathematical reasoning ability have more impressive verbal scores, whereas others have much more modest verbal scores around the cut score for the top 1%. Because the intellectual diversity of the profoundly gifted is often underappreciated, these plots graphically reveal the vast differences that exist. Selecting individuals by using extreme cut scores on general intellectual ability or on any given specific ability produces a sample with highly diverse intellectual profiles. While essentially all these participants have estimated IQs in the 160+ range (the dotted diagonal line on each scatter plot is where estimated IQs of 160 fall), their ability profiles are quite divergent. Indeed, before age 13, a number of these participants encounter such ceiling constraints on these indicators that the scope of their intellectual prowess is not fully assessed (cf. Muratori et al., 2006). But do these age-13 differences make a difference? Surely all these participants have the capability to pursue whatever career they wish. Makel et al. (2016) tracked their educational, occupational, and creative outcomes over three decades and their creative outcomes are depicted in Figure 4.

Figure 4 reveals that even participants identified with profound intellectual gifts by age 13 tend to develop

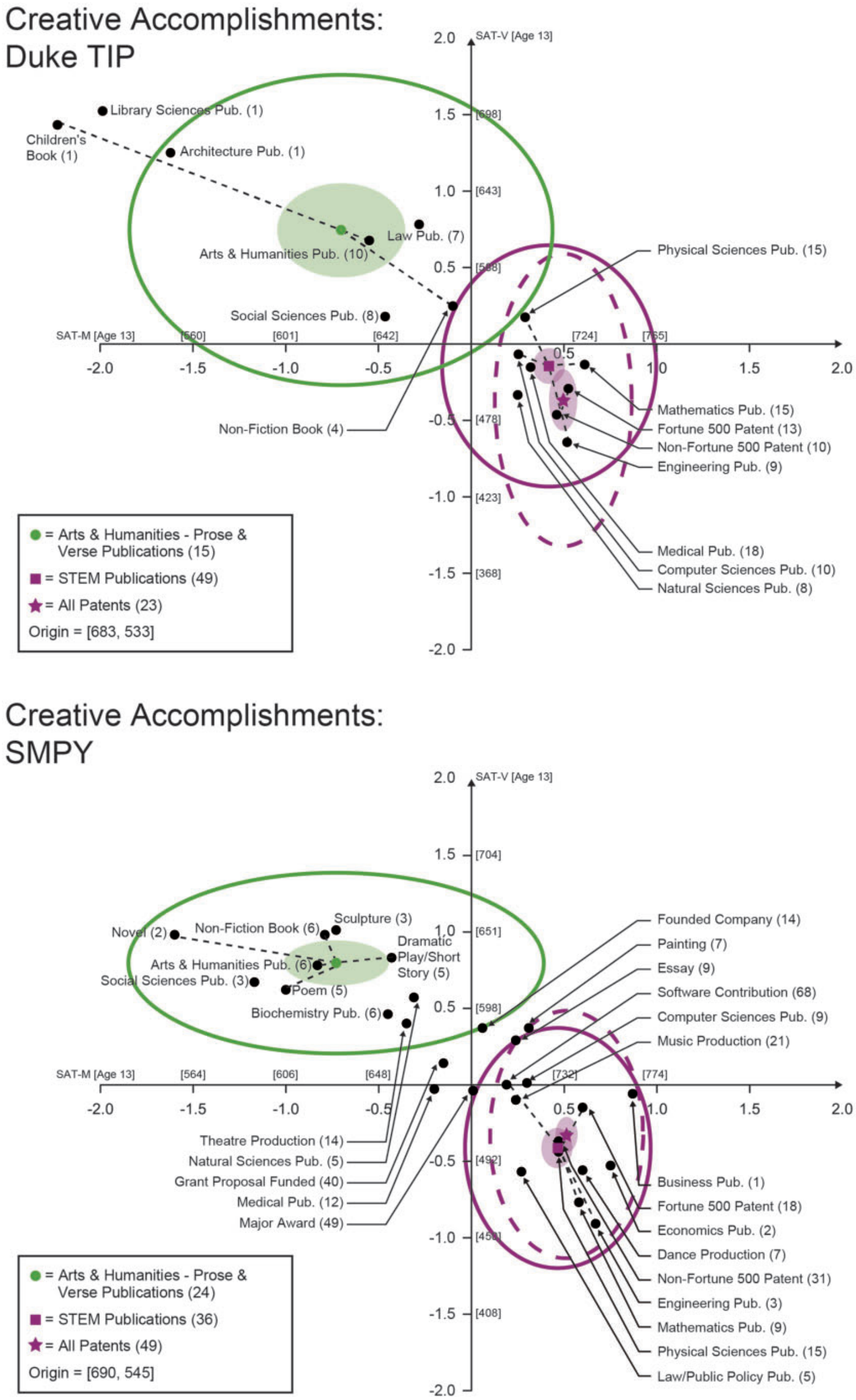

Figure 4. Bivariate means for age-13 SAT-Math (SAT-M; x) and SAT-Verbal (SAT-V; y) scores within categories of creative outcomes for Duke University's Talent Identification Program (TIP) participants (top panel) and the SMPY participants (bottom panel).

Note. Means for individual categories are represented by black circles; the sample sizes for these categories are in parentheses. The green circles and purple squares and triangles represent rationally derived major outcome clusters (*ns* are located in the keys). The dashed lines emanating from the centroids of these major outcome clusters denote the constituents of those clusters. Each centroid is surrounded by two elliptical tiers: an inner ellipse defined by the standard errors of the SAT-M and SAT-V means for individuals within that centroid (i.e., width and height = ±1 SEM for SAT-M and SAT-V, respectively) and an outer ellipse formed by the standard deviations of the SAT scores for these individuals (i.e., width and height = ±1 standard deviations for SAT-M and SAT-V, respectively). Along the axes, unbracketed values are SAT-M and SAT-V scores in *z* score units, and bracketed values are raw SAT scores. Adapted from Makel et al. (2016).
SMPY = Study of Mathematically Precocious Youth.

Table 1. Selected Educational, Occupational, and Creative Accomplishments of the Talent Identification Program (TIP) and the Study of Mathematically Precocious Youth (SMPY) Participants.

Accomplishment	TIP, %	SMPY, %
Doctoral degree	37	44
Doctoral degree from top-10 university[a]	16.3	22.5
Tenure at the college-level	7.5	11.3
Tenure at research-intensive university	4.3	7.5
Peer-reviewed publication (≥1)	39	24
Patent (≥1)	9	15
Fortune 500 patent (≥1)	5	6
Book (≥1)	2	3
NSF grant (≥1)	4 (mean award = $63,700)	6 (mean award = $91,600)
NIH grant (≥1)	1 (mean award = $10,700)	3 (mean award = $18,900)

Note. Standard errors for the percentages reported in this table are as follows: 1% for percentages < 9%; 2% for percentages from 9% through 25%; and 3% for percentages greater than 25%. The one exception is that the standard error for the percentage of tenured professors among TIP participants is 2%. Taken from Makel et al. (2016). NIH = National Institutes of Health; NSF = National Science Foundation.
[a]Identification of the top-10 doctoral programs was based on the National Research Council's (1995) ratings.

Table 2. Outlying Accomplishments of the Talent Identification Program (TIP) and the Study of Mathematically Precocious Youth (SMPY) Participants.

TIP	SMPY
Named as one of "America's Top Physicians" (Consumers' Research Council of America)	Codirector of hospital organ-transplant center serving more than 3 million people
Holder of 43 patents	Produced 100 software contributions
President of chamber of commerce of one of the 100 richest cities in the United States, by per capita income	Raised more than $65 million in private equity investment to fund own company
Associate chief counsel for a U.S. federal agency	Vice president of Fortune 500 company
Member of the Council on Foreign Relations	Deputy assistant to a president of the United States (national policy adviser)
Deputy director of the Office of the Assistant Secretary for a U.S. federal agency	Founder of three companies
Argued more than 10 cases before the U.S. Supreme Court	Producer of 500 musical productions
Professional poker player with annual earnings > $100,000	Marshall Scholar
Rhodes Scholar	Recipient of 8 grants from the National Science Foundation (total funding > $5.5 million)
Recipient of 9 grants from the National Science Foundation (total funding > $6.5 million)	Recipient of 6 grants from the National Institutes of Health (total funding > $1.6 million)
Recipient of 6 grants from the National Institutes of Health (total funding > $1.4 million)	

Note. The accomplishments listed in this table are nonoverlapping, and each refers to the achievement of a single individual. Universities were classified as research-intensive by the Carnegie Foundation (2010) if they were deemed to have "very high research productivity." Taken from Makel et al. (2016).

expertise for learning and work that draws on their specific intellectual strengths. Those whose creative expression is primarily in literary and verbal arenas tend to be more talented in verbal relative to mathematical reasoning, whereas the inverse is true for participants whose creative contributions are in STEM. While Figure 4 captures the *nature* of their accomplishments, it does not speak to the *magnitude* of their accomplishments. Table 1 provides their accomplishments in a host of low-base-rate phenomena; they markedly surpass normative base rate expectations. Furthermore, in comparison with typically gifted participants identified in the top 1% of ability (Lubinski et al., 2014), profoundly gifted participants are more accomplished occupationally and creatively (Kell, Lubinski, & Benbow, 2013; Makel et al., 2016), manifesting the very outcomes inferred from the upper quartile of the top 1% (Figure 1).

In Table 2, idiographic data from both the SMPY and Duke TIP profoundly gifted samples provide an elaboration of individual achievements. Each listing represents the accomplishment of one individual. While perhaps seen as mere interesting anecdotes if examined in isolation, collectively, across both cohorts (consisting of

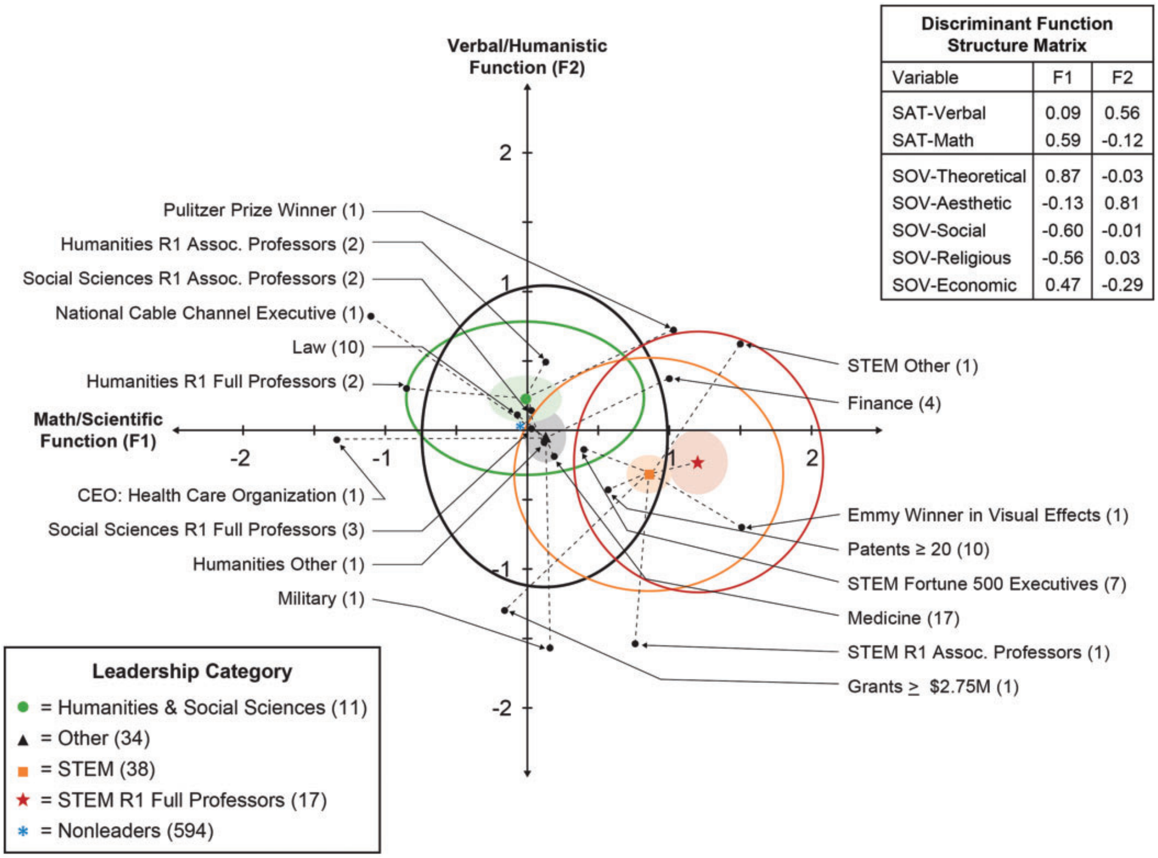

Figure 5. Bivariate means for the math/scientific function (*x*-axis) and the verbal/humanistic function (*y*-axis) scores for eminence/leadership categories.
Note. Three major categories are graphed for eminence in (STEM), Humanities/Social Sciences, and Other disciplines. A subset of the STEM group—full professors in R1 universities—is also graphed. Surrounding these major centroids are ±1 standard error of the mean (inner, shaded ellipse) and ±1 standard deviation (outer, open ellipse) for scores for both functions. Sample sizes appear in parentheses. Broken lines connect idiographic data points to their major centroids. From Bernstein et al. (2019). STEM = science, technology, engineering, and mathematics.

only 259 and 320 participants), they coalesce to demonstrate the extraordinary human potential that can be identified by such early ability assessments. There are important quantitative differences between the gifted (Lubinski et al., 2014) and the profoundly gifted (Kell, Lubinski, Benbow, & Steiger, 2013; Makel et al., 2016). There are also important differences found in their intellectual strengths and relative weaknesses, which eventuate in qualitatively different forms of creative expression and the nature of their ultimate accomplishments.

Question #4

Do educational/occupational interests add value to ability assessments of intellectually precocious youth? Yes.

Among high school students and young adults, applied psychologists have known for decades that specific abilities and interests are important determinants of educational/occupational choices and performance after choice (Dawis, 1992; Lubinski, 2010; Sackett et al., 2017). Both abilities and interests add value to the prediction of important longitudinal outcomes in learning and work; evidence of their role as chief determinants driving differential outcomes in educational and occupational settings is long-standing (Austin & Hanisch, 1990; Gottfredson, 2003; Humphreys et al., 1993; Lubinski, 1996, 2000; Rounds & Tracey, 1990). The same holds true for intellectually precocious adolescents. For example, interest and values assessments initially designed for older participants display impressive 15- to 20-year test–retest reliabilities among intellectually precocious 13-year-olds (Lubinski et al., 1995; Lubinski et al., 1996); they also display commensurate covariance patterns mirroring mature populations and thereby reflect construct validity (Schmidt et al., 1998; Webb et al., 2002, 2007). In the first study to document the incremental validity of educational/vocational interests—relative to abilities—among intellectually precocious 13-year-olds, Achter et al. (1999) showed that the SAT and the Study of

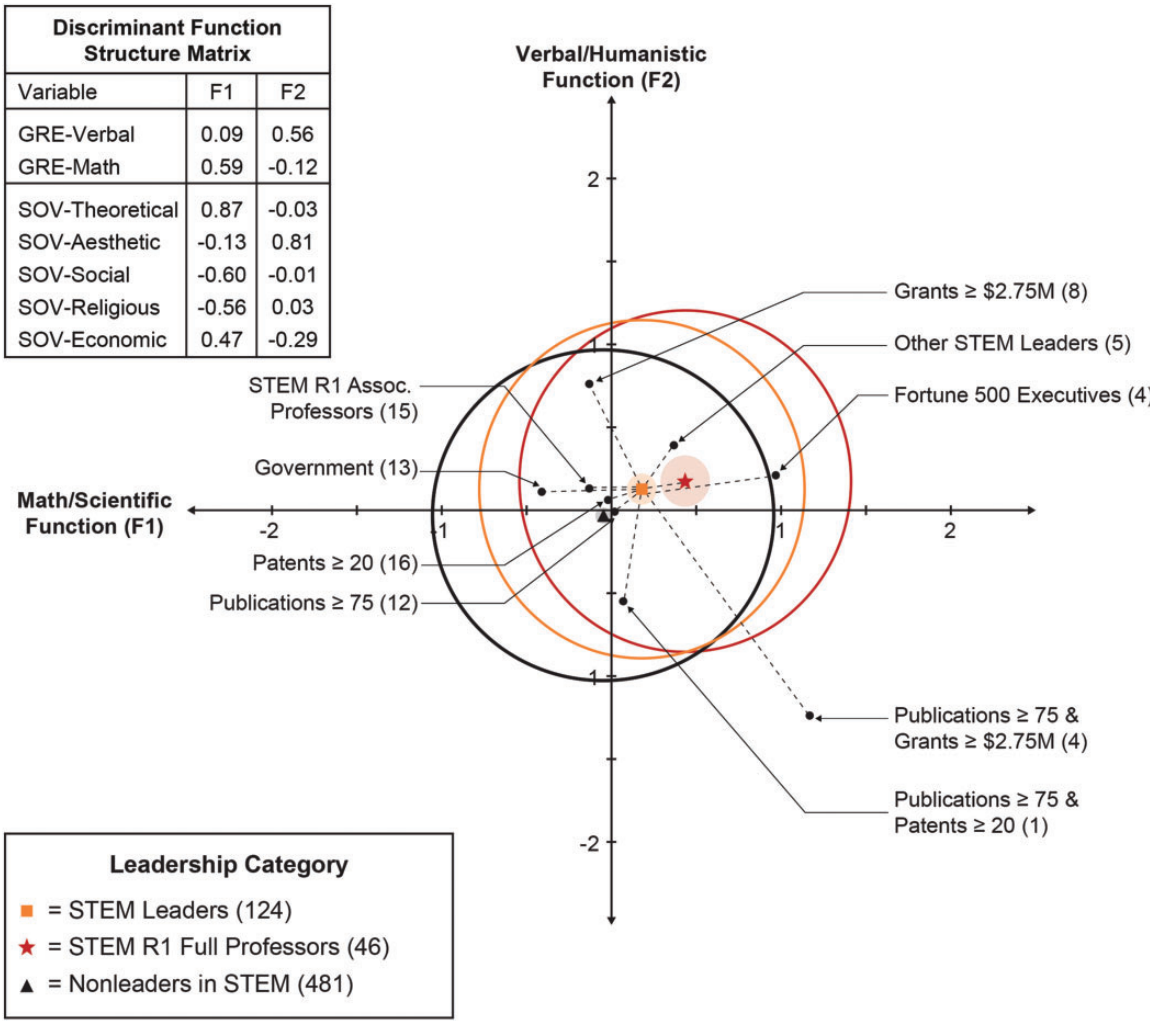

Figure 6. Bivariate means for the math/scientific function (*x*-axis) and the verbal/humanistic function (*y*-axis) scores are plotted for three groups: Nonleaders in STEM, STEM Leaders, and a subset of STEM Leaders (full professors in R1 universities).
Note. Surrounding these major centroids are ±1 standard error of the mean (inner, shaded ellipse) and ±1 standard deviation (outer, open ellipse) for scores for both functions. Sample sizes for constituent categories appear in parentheses, those for major grouping are in the key. Broken lines connect constituent data points comprising the STEM Leaders grouping. From Bernstein et al. (2019). STEM = science, technology, engineering, and mathematics.

Values (Allport et al., 1970) each afford incremental validity relative to the other in the prediction of three classes of conferred college degrees 10 years later: the Humanities, STEM, and Other. Furthermore, the same discriminant functions maintained their longitudinal potency in predicting occupational outcomes 20 years later (Wai et al., 2005), as well as creativity and eminence 35 years later (Bernstein et al., 2019).

Specifically, in the Bernstein et al. (2019) study of 677 intellectually precocious youth, 12% were deemed to have achieved eminence in their careers by age 50. These aforementioned functions (based on age-13 assessments and calibrated against 4-year college degrees) were capable of differentiating three qualitatively different types of distinction denoting creativity/eminence 35 years later (see Figure 5). As well, in the Bernstein et al. (2019) study, the same functions (and similar assessments) were applied to another, but independent, sample of 605 elite STEM graduate students. They had been assessed at age 25 and followed up at age 50. For them, 20% were deemed eminent in their STEM careers by age 50. The same math/science function scaled on the *x*-axis distinguished those who excelled in STEM from those with less distinguished STEM careers or who were pursuing other endeavors in life (see Figure 6). That the same covariance structure generalized from intellectually precocious young adolescents to elite STEM graduate students in the prediction of *ultimate criteria*

(Thorndike, 1949) amounts to an especially compelling *constructive replication* (Lykken, 1968, 1991). This robustly demonstrates that the interrelations among the chief determinants of educational (Achter et al., 1999), occupational (Wai et al., 2005), and creative outcomes (Bernstein et al., 2019) are detectable among intellectually talented youth.

We conclude that the internal ability/interest interrelationships observed early in life (Achter et al., 1996, 1999; Schmidt et al., 1998) mirror external relations among elite performers found later in life on highly *consequential* (Ozer & Benet-Martinez, 2006) and *ultimate* criteria (Thorndike, 1949).

Collectively, these findings support Terman's impression of the gifted field toward the end of his career. In one of his last publications, Terman (1954b, p. 224) reflected on what he had learned by studying intellectually precocious youth for over three decades:

> I am convinced that to achieve greatly in almost any field, the special talents have to be backed up by a lot of Spearman's *g*. . .. [S]uch tests do not, however, enable us to predict what direction the achievement will take, . . . both interest patterns and special aptitudes play important roles in the making of a gifted scientist, mathematician, mechanic, artist, poet, or musical composer.

Modern findings have indeed supported the importance of going beyond general intelligence to assessing the importance of specific abilities. And interest measures developed for young adults add value to specific ability assessments as Terman speculated and had long stressed.

> Both the amount and the direction of one's life accomplishments are determined largely by the factor of interest. Binet once pointed out that the world is as much a battle of wills as of intellects, and he might have added that wills are moved to action by the dynamic power of interests. For understanding an individual's total personality it is absolutely necessary to know something about the kinds and intensity of his interests. As long as this knowledge is lacking, neither educational nor vocational guidance can have a solid foundation. (Terman, 1931, p. xvii)

Question #5

Given the contemporary emphasis placed on the identification and development of human capital in STEM disciplines, are there other important findings from the gifted field germane to this need? Yes.

In addition to the above findings on abilities and interests, the gifted field has moved beyond learning and work attributes to examine competing personal attributes and life priorities outside the world of work among those with potential for developing excellence in STEM (Lubinski et al., 2014; McCabe et al., 2020). With respect to these considerations, we launched a study in 1992 that provided insight in this regard. We turn to it next.

We identified an elite group of 714 STEM graduate students (48% females). They were all first- or second-year doctoral students attending one of the top 15 STEM graduate training programs in the United States. We contrasted them with 756 of their intellectual peers (30% females) who were selected on the basis of their exceptional mathematical ability (Lubinski et al., 2001). The comparison group, that is, was identified as young adolescents by talent searches conducted during 1976-1979 (using only ability measures). The comparison group had mathematical reasoning abilities in the top 1%, and they were followed-up in their mid-20s.

With respect to the STEM graduate students, males and females were highly similar psychologically. Over a host of personal attributes, they exhibited psychological profiles typical of outstanding engineers and physical scientists (Eiduson & Beckman, 1973; Gohm et al., 1998; Humphreys et al., 1993; Lubinski & Benbow, 2006; McCabe et al., 2020; Roe, 1951, 1961, 1965; Snow, 1991; Super & Bachrach, 1957; Terman, 1954a, 1955; Warne et al., 2019; Zuckerman, 1977). Specifically, they displayed precocious mathematical reasoning abilities (conspicuously marked by a mathematical ability $>$ verbal ability pattern), salient scientific interests, regnant theoretical values (appreciably lower religiosity), and their favorite high school courses were mathematics and science. Overall, the patterns found in their educational histories and preferences were highly similar (see Lubinski et al., 2001, Tables 2 and 3). In addition, as graduate students, both males and females were investing 50 hours per week to research and study in STEM.

When these elite STEM graduate students were contrasted with talent search participants, who were selected merely on their outstanding mathematical ability, some conspicuous differences were observed. The male and female STEM graduate students' educational histories and psychological profiles were highly congruent with the male talent search participants. Yet these groups, as able as they were, differed markedly from the female talent search participants. Female talent search participants had a much more uniform ability profile (mathematical ability $\approx$ verbal ability), broader interests and values, and their educational histories were characterized by a more eclectic selection of favorite courses. In short, the female talent search participants were just as impressive academically and intellectually as the other three groups, but they were much less focused on STEM pursuits. Compared with the other three groups, they were more broadly focused. This pattern was descriptive of not only their early but also their current development in their mid-20s.

These findings are illuminating for several reasons. First, the elite STEM graduate student females constituted the first large group of young women with world class promise for STEM occupations to be profiled comprehensively and then longitudinally tracked for multiple decades. Not only did they possess truly outstanding potential for STEM but also their educational histories and psychological profiles reflected those of their male counterparts. Second, for developing a cumulative scientific foundation (Camerer et al., 2018; Open Science Collaboration, 2015) for identifying and nurturing exceptional STEM talent, these findings fit with decades of longitudinal research (Eiduson & Beckman, 1973; Gohm et al., 1998; Humphreys et al., 1993; Jackson & Rushton, 1985; Lubinski & Benbow, 2006; Roe, 1951, 1953, 1961, 1965; Su et al., 2009; Super & Bachrach, 1957; Terman, 1954a; Zuckerman, 1977). The ability, interest, and values profiles of these young men and women as well as their facility in and passion for mathematics and science were conspicuous at an early age. Their individuality factored into the selection of learning experiences both in and out of school, which were focused on STEM well before college (Lubinski et al., 2001, p. 314). Third, the gender differences among the talent search participants reflected robust findings observed in normative samples (Geary, 2010; Humphreys et al., 1993; Wai et al., 2009) and intellectually precocious youth (Lubinski & Benbow, 2006).

This might help explain why many findings on the development of STEM expertise for the math/science pipeline often fail to replicate, because these critical determinants are frequently not measured in their full scope and the importance of both ability strengths and differential passions for learning and work are neglected in causal modeling (Lubinski, 2010). This also may explain why, although intellectually talented males and females earn advanced degrees at similar rates (Okahana & Zhou, 2018; Snyder et al., 2019), they differentially populate contrasting disciplines (e.g., women receive around 68% of the doctorates in education, over 70% in health and medical sciences, over 75% in public administration and services, 75% in veterinary medicine, and 80% in developmental psychology).

Recently, an age-50 follow up of these 714 elite STEM graduate students (McCabe et al., 2020) found several determinants, assessed early in graduate school, which, for both genders, distinguished participants who went on to achieve eminence in STEM versus those who pursued other endeavors in life or whose careers in STEM were less impressive. The STEM leaders were more interested in STEM content, less interested in other topics, and devoted more time and energy to their STEM careers. In addition, the STEM leaders manifested a different constellation of personality attributes as assessed by a broad-spectrum personality inventory, the Adjective Check List (ACL; Gough & Heilbrun, 1983). Thus, while this cohort as a whole was occupationally extremely impressive, the STEM leaders scored higher on ACL scales measuring "self-confidence," "dominance," and "creative personality," relative to the nonleaders; in addition, they also scored lower compared with the nonleaders, on "abasement," "succorance," and "unfavorable characteristics" (McCabe et al., 2020). These aspects of their personality combine with their abilities, interests, and STEM focus to result in a subset of particularly impressive STEM innovators and leaders.

A parsimonious explanation of these findings might be generalizable to other domains of exceptional performances: exceptional performers do not necessarily possess unique qualities but, rather, they are exceptional because they possess more of the known qualities that jointly contribute to distinguished careers.

Question #6

Can educational interventions enhance learning and ultimate levels of creative expression? Yes.

Educational acceleration has amassed robust empirical support as an effective intervention for responding to the advanced learning needs of intellectually precocious students. International teams of experts (Assouline, Colangelo, & Vantassel-Baska, 2015, Assouline, Colangelo, Vantassel-Baska, & Lupkowski-Shoplik, 2015; Colangelo et al., 2004), meta-analytic reviews (Kulik & Kulik, 1984, 1992; Rogers, 2004; Steenbergen-Hu, & Moon, 2011), and the National Mathematics Advisory Panel (2008) all consider it one of the best practices. Two 100-year reviews (Lubinski, 2016; Steenbergen-Hu et al., 2016), published in the *Review of Educational Research* to feature compelling empirical findings on the centenary of the American Educational Research Association, documented the educational efficacy of academic acceleration for students who learn abstract, complex, symbolic material rapidly and eagerly crave for more. In the words of former Secretary of Labor, Robert Reich (1991), the population being referred to with respect to acceleration also can be described as the future workforce of "symbol analysts," those especially adroit at manipulating, storing, and utilizing symbolic material in instrumentally effective ways, which is why they are in high demand in modern conceptual economies (Kuncel & Hezlett, 2007; Schmidt & Hunter, 1998).

So, what does the research say about acceleration and its efficacy for enhancing creativity? Beyond assimilating knowledge in formal learning settings (Benbow et al., 1996; Benbow & Stanley, 1983, 1996; Stanley, 2000), two large scale 25-year longitudinal studies revealed that intellectually precocious youth who had experienced more acceleration produced greater creative output years later (e.g., refereed STEM publications) relative to their intellectual peers (Park et al., 2013; Wai et al., 2010). These latter studies on enhancing creativity are relatively unique. They are worth highlighting further, because they also demonstrate the important operative construct of "educational dose."

As with other interventions in education and the psychological sciences, different opportunity and therapeutic modalities are frequently contrasted against one another. And it is well-known that clients and students have strong preferences for some relative to others for whatever reasons. The concept of educational dose honors the potential for different modalities (i.e., educational interventions) to have functional equivalence, thus allowing clients and students to choose among available opportunities for how they wish to develop without concern for differential long-term impact (Scarr, 1996; Scarr & McCartney, 1983). Just as there are multiple ways to construct an optimal diet or exercise program, perhaps, there also may be varied ways to design an optimal educational curriculum for students to be appropriately challenged as a function of their differential capabilities, personal preferences, and available opportunities. Wai et al. (2010) developed the concept of educational dose by this analogy. Their idea is that there is not one specific type of advanced learning experience that an intellectually talented student should receive. Rather, each student should be appropriately challenged by learning environments that structure the pace and depth so as to be responsive to their capacity for assimilating abstract/complex/symbolic material.

If meeting the educational needs of precocious learners can be done in multiple ways (Assouline, Colangelo, Vantassel-Baska, & Lupkowski-Shoplik, 2015; Colangelo et al., 2004; Worrell et al., 2019) and several prove to be functionally equivalent (Southern & Jones, 2004; Wai et al., 2010), it affords flexibility in choosing among available opportunities on the basis of personal preferences. The important point is that the minds of intellectually precocious youth must be stimulated. They require, as all students require, *appropriate developmental placement* (Lubinski & Benbow, 2000). That means presenting each student with an educational curriculum/experience at the depth and pace with which they best assimilate new knowledge and that challenges them intellectually. For precocious students, above-level assessments are useful in determining when and how far beyond typical an above-level curriculum (acceleration) is needed. But like individually tailored diets or exercise programs, there are many interchangeable parts and ideal mixes can vary. Wai et al. (2010) provided some promising findings that warrant further consideration of this framework.

While accelerative practices have generated positive results for precocious students for decades (Pressey, 1949, 1955; Seashore, 1922; Stanley, 1977), periodic concerns are routinely expressed about long term social and emotional costs based largely on anecdotal evidence (Stanley, 1977; Worrell et al., 2019). To address this unease, an extensive longitudinal analysis of the long-term implications of educational acceleration for psychological well-being was conducted. This investigation involved three cohorts of precocious youth ($N = 1,636$), tracked for 35 years, a host of well-known measures of psychological well-being, and uncovered no evidence for this concern (Study 1; Bernstein et al., in press). In addition, a constructive replication using an independent high-potential sample of 478 participants reinforced this conclusion (Study 2; Bernstein et al., in press).

Question #7

Beyond ability, interest, and opportunity, are conative attributes important? Yes.

Arguably the most widely agreed on finding in the talent development literature is the inordinate amount of time truly outstanding performers give to their craft (Eysenck, 1995; Simonton, 1988, 1994, 2014; Wilson, 1998; Zuckerman, 1977). Those exceptional individuals at the forefront of their disciplines, who routinely advance creative products, and take on demanding leadership roles at premier universities, scientific and technical institutes, major law firms, and industry (to list but a few) do not just put in 40-hour work weeks. Many high impact occupational roles also require an appreciable amount of travel or other disruptions to one's personal life. Just like people in general, exceptionally talented populations view opportunities and the associated trade-offs differently. Being at the top of one's profession requires a certain lifestyle that for many involves making some hard decisions, such as less time with family or for leisure. This is one of the reasons why truly outstanding creative and occupational accomplishments are so rare (Bernstein et al., 2019; Hakim, 2000, 2006; Lubinski et al., 2014; McCabe et al., 2020; Pinker, 2008; Rhodes, 2004; Simonton, 1988, 1994). This is true from the zenith of human accomplishments to more typical forms of outstanding careers.

After 5 years of intense research, Murray (2003) published *Human Accomplishment*, which, among other things, contains a series of humbling histograms distilling the rank ordering of what are probably the most impactful creators of all time. Art, Music, Mathematics, Literature, Physics, Chemistry, Philosophy, and Technology were among the 21 disciplines whose leading contributors were scaled using

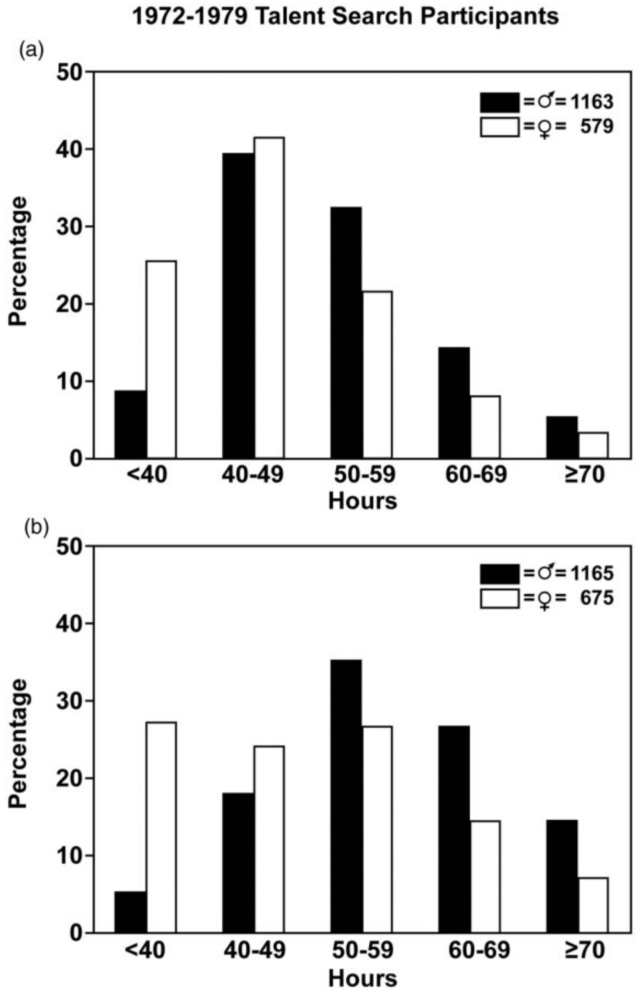

Figure 7. Number of hours SMPY participants in Cohorts 1 and 2 worked per week (a) and were willing to work per week in their ideal job (b), by gender.
Note. Participants were surveyed when they were in their mid-30s; they were asked how many hours per week they typically worked (top panel; homemakers were excluded from this question) and how many hours per week they were willing to work, given their job of first choice (bottom panel). Adapted from Lubinski and Benbow (2000). SMPY = Study of Mathematically Precocious Youth.

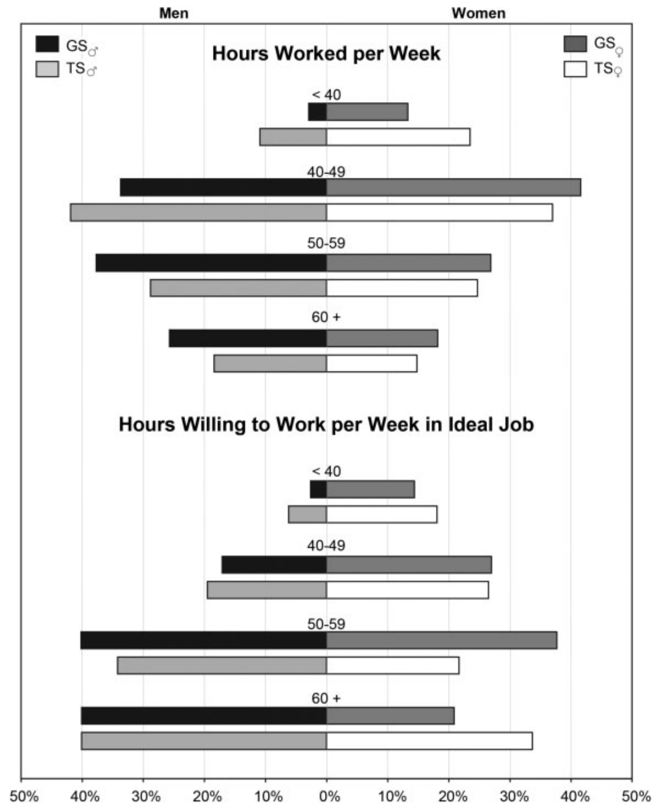

Figure 8. Number of hours elite STEM graduate-student (GS) and profoundly gifted talent-search (TS) participants worked per week and were willing to work per week in their ideal job for SMPY Cohorts 3 and 5, by gender.
Note. The data for hours worked are based on *n*s of 276 and 264 for male and female GS participants, respectively, and 217 and 54 for male and female TS participants, respectively. The data for hours participants were willing to work are based on *n*s of 269 and 263 for male and female GS participants, respectively, and 206 and 57 for male and female TS participants, respectively. From Lubinski et al. (2006). SMPY = Study of Mathematically Precocious Youth; STEM = science, technology, engineering, and mathematics.

historiographic and other methods in terms of their impact on the world stage. When asked in an interview, if those at the top of this heterogeneous collection of creative geniuses had anything in common, Murray's (Bates, 2010) response was succinct, "How hard they worked."

Figures 7 and 8 display data for four SMPY cohorts in their mid-30s identified over a 20-year period from 1972 to 1992, the age around which elite performers have completed their formal education and contrasting career trajectories begin to markedly diverge. These findings highlight the very substantial individual differences in not only how much one works but how much time one is willing to devote to career development, even when given the opportunity to have an ideal job. Intellectually prodigious populations are similar to more typical individuals in that they display striking differences in how much time they are willing to devote to their career as opposed to doing other things (Ferriman et al., 2009; Geary, 2010; Gino et al., 2015; Hakim, 2000; Lubinski et al., 2014; Pinker, 2008). This is critical to consider when modeling the differential development of intellectually prodigious populations (as is true for all populations).

Just as Terman has been erroneously criticized for not having a single Noble Laureate in his 1,528 sample (due to base rate expectations in predicting rare events), many have criticized educational programs for gifted youth because of the perceived "underperformance" of intellectually talented participants on the basis of preconceived notions of what individuals within the top 1% of ability should be doing with their time. What we know from the past few decades of longitudinal research is that determinants beyond ability, interests, and opportunity are needed for understanding the choices and life decisions people make in developing meaningful and productive lives for themselves (Benbow et al., 2000; Lubinski et al., 2014; Lubinski & Benbow, 2001). Even among elite STEM graduate students trained in the best universities in the world, only a small subset ultimately become STEM leaders and creators, although most are impressive professionals and solid contributors in the STEM workforce (McCabe et al., 2020); few establish a legacy. The expectations parents, teachers, and university administrators have for prodigiously talented adolescents and young adults are frequently not the expectations these individuals have for themselves. That is a discussion not about science, but values. As wise deans and counselors of students have long suggested (Tyler, 1974, 1992; Williamson, 1965), best practices should provide students with an understanding of their individuality, their potential, and the opportunities and investments needed for contrasting life paths. Ultimately, it should be each student's choice of how to develop and what to become. These are important factors to consider when evaluating the longitudinal potency of educational interventions as well as modeling differential developmental trajectories.

We know from Terman's studies that many of the women therein expressed regrets with regard to their professional achievements in later life. At the same time, their opportunities were severely constrained. Today intellectually talented women have more opportunities, and while there still are marked gender differences in the educational/occupational opportunities intellectually talented women pursue (Ceci et al., 2014; Ceci & Williams, 2011), there appear to be few midlife gender differences in psychological well-being, life and relationship satisfaction, or in how successful they perceive themselves to be (Lubinski et al., 2014). There are many ways to create a meaningful, satisfying, and successful life. Of course, these women (like the men) are still in the process of becoming at age 50. So, the story is not told yet.

We can conclude that, when conceptualizing life paths comprehensively, longitudinal research has shown that the full force of all determinants of life outcomes—abilities, personal preferences, priorities, and life circumstances—needs to be considered (cf. "Total Evidence," Lubinski, 2000, p. 433; Lubinski, 2010, p. 230).

Question #8

Has the study of intellectual precocity contributed to its parent disciplines in the educational and psychological sciences? Is there a common theme that cuts across the above empirical generalizations, which have been replicated over multiple decades? Yes. And yes.

One feature that cuts across the 7 points detailed above is that they all derive from familiar concepts and findings in the educational and psychological sciences. They constitute systematic extensions to higher levels of intellectual performance of findings that are routinely observed across the general population, provided developmentally appropriate assessments and meaningful criteria are employed for longitudinal study. The underlying principle is that covariation requires variation; when intellectual and criterion assessments are jointly conducted with appropriate ceilings to capture rare capabilities and accomplishments, ability/outcome patterns that mirror those in typically developing populations are readily seen. When instruments with ceiling constraints are utilized, this is not possible and faulty conclusions are drawn. The outcomes observed among intellectually prodigious populations are of the same nature as those seen in typically developing populations. It is just that the magnitude of their educational, occupational, and creative contributions tends to be greater.

Atypical intellectual capacities give rise to atypical accomplishments. Intellectual precocity is "simply" a region of promise on the spectrum of developmental potential or "preparedness" (Seligman, 1970). This view fits with broader frameworks in behavioral genetics and psychopathology wherein continua are the focus and categories are uncommon exceptions (Plomin et al., 2016). In those two disciplines, atypical is considered typical and abnormal is considered normal, because what is atypical for an individual is typical for a population. The continua graphed and reported in this article provide no basis for thinking of those with intellectual precocity as a discrete category. Rather, they more parsimoniously reflect a spectrum systematic sources of individual differences found in the human condition at the extreme.

A continuous linear relationship between ability and performance is routinely observed in typically developing populations (Arneson et al., 2011). And similarly, the differential strengths in mathematical versus verbal reasoning reviewed earlier have been shown to reflect robust cross-cultural educational and occupational outcomes as a function of mathematical versus verbal ability strengths (Stoet & Geary, 2015, 2018), which also mirror those previously reported (Figures 3 and 4). To ground these findings more comprehensively and firmly connect them to normative patterns across mathematical, verbal, *and* spatial reasoning, we provide Figure 9, which represents data from 400,000 participants taken from Project TALENT (Flanagan et al., 1962). Project TALENT is a stratified random sample of U.S. high schools. Due to its comprehensiveness and size,

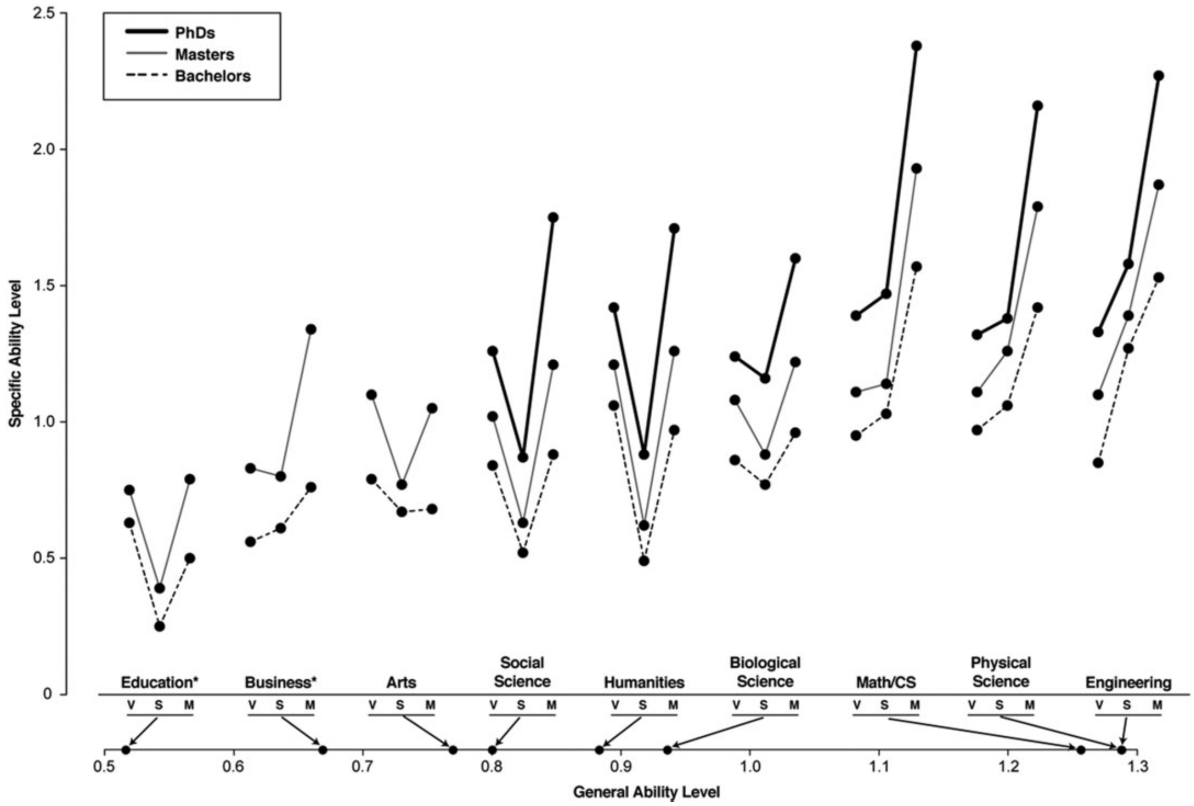

Figure 9. Average z scores of participants on verbal, spatial, and mathematical ability for terminal bachelor's degrees, terminal master's degrees, and doctoral degrees are plotted by field.
Note. The groups are plotted in rank order of their normative standing on g (verbal [V] + spatial [S] + mathematical [M]) along the x-axis, and the lines with arrows from each field indicate where these disciplines average in general mental ability in z-score units. This figure is standardized in relation to all participants with complete ability data at the time of initial testing. Respective Ns for each group (men + women) were as follows for bachelor's, master's, and doctorates, respectively: engineering (1,143, 339, 71), physical science (633, 182, 202), math/computer science (877, 266, 57), biological science (740, 182, 79), humanities (3,226, 695, 82), social science (2,609, 484, 158), arts (615, 171 [master's only]), business (2,386, 191 [master's + doctorate]), and education (3,403, 1,505 [master's + doctorate]).
*For education and business, master's degrees and doctorates were combined because the doctorate samples for these groups were too small to obtain stability ($n < 30$). Adapted from Appendix A in Wai et al. (2009); see also Lubinski (2010, p. 232).

longitudinal findings from Project TALENT are among the most compelling evidence that illustrates how findings on intellectually precocious youth align with those found in national probability samples.

Project TALENT's initial data collection occurred in 1960 and consisted of a stratified random sample of the U.S. high school population. Students in the 9th through 12th grades were assessed on a wide range of ability and information tests, interest and personality questionnaires, and an extensive biographical information form (Austin & Hanisch, 1990; Gohm et al., 1998; Humphreys et al., 1993; Lubinski & Humphreys, 1990, 1992). Assessments were conducted over a 1-week period, and the entire sample included roughly 50,000 males and 50,000 females per grade level, 9 through 12, for a total N of approximately 400,000 students. Germane for our purposes were several measures of general intelligence and specific abilities (mathematical/spatial/verbal). Follow-ups were conducted at 1, 5, and 11 years after graduation from high school (Wise et al., 1979); and attention was devoted to educational and occupational attainments.

Figure 9 graphs the general and specific ability profiles of students in Project TALENT who earned their terminal degree (i.e., either a bachelor's, master's, or doctorate) in one of nine disciplines. Because highly consistent findings were found in Grades 9 through 12, within grade z scores were averaged. On the x-axis, an equally weighted (mathematical + verbal + spatial) ability composite was computed to assess general intelligence and plotted in z score units; on the y-axis, the z scores for verbal (V), spatial (S), and mathematical (M) ability are plotted.

So, how do these findings from the general population align with those from intellectually precocious groups? First, findings on the nine areas of concentration scaled on the *x*-axis have been observed for decades (Harmon, 1961; Humphreys et al., 1993; Lubinski, 2010; Wai et al., 2009) and are consistent with those who are precocious intellectually. On average, students who secure STEM degrees typically possess higher levels of general intelligence relative to students in other disciplines. In addition, on the *y*-axis, within every area of concentration, successively more advanced educational credentials are associated with higher ability levels: 4-year degrees → master's degrees → doctorates. Hence, greater ability matters. As well, for all three STEM educational groupings (and every advanced degree category within these groupings), a spatial ability > verbal ability pattern is seen; whereas, for the other six disciplines, ranging from Education to Biology, the inverse pattern is found, spatial ability < verbal ability (save 4-year degrees in business). Students who secure advanced degrees in STEM typically display a spatial/verbal ability pattern opposite that of students who ultimately earned advanced degrees in other areas; the same is true for intellectually precocious populations.

The above findings confirm that the impact of different intellectual architectures for learning and work pertain across the full range of human talent. Individuals who pursue STEM disciplines have a different intellectual problem-solving orientation; they approach learning, work, and novel challenges with a different configuration of talents. They possess a different intellectual design space for problem solving and creative thought. The findings on spatial ability found throughout this article are especially intriguing because few students, parents, and teachers think about spatial ability. It also is rare for spatial ability assessments to be used in educational selection (Gohm et al., 1998; Humphreys et al., 1993; Lubinski, 2010; Snow, 1999; Wai et al., 2009). Yet research demonstrates that they play a significant role in structuring consequential outcomes in both gifted and typically developing populations.

Another angle to approach the questions posed in this section is to look at the work of Ackerman (1996; Ackerman & Heggestad, 1997; von Strumm & Ackerman, 2013). He has marshalled evidence for four distinct trait clusters, based on highly replicated patterns of covariance cutting across specific abilities, interests, and personality found in the general population. Two examples are *science–math* (mathematical/spatial abilities + scientific and technical interests) and *intellectual–cultural* (verbal ability + aesthetic/humanistic interests). These amalgams of individual differences attributes are known as "aptitude complexes" in educational psychology (Corno et al., 2002; Snow et al., 1996) and "taxons" in the world of work (Dawis, 2005; Dawis & Lofquist, 1984; Lofquist & Dawis, 1991). These clusters are firmly in place by adolescence in typically developing populations (Humphreys et al., 1993), and the same is true for intellectually precocious young adolescents (Schmidt et al., 1998). These constellations of psychological attributes structure development as students encounter more choices in navigating the educational system (Gottfredson, 1981, 2002, 2005; Scarr, 1996).

The findings reviewed here help demystify intellectual precocity. It is simply one of the many regions in the psychological tapestry of humanity. This is important to understand for meeting the needs of all students. As Hobbs (1958) pointed out in his classic, *The Compleat Counselor*, however, the outer envelope of intellectual potential defines the human capital at greatest promise to solve the most vexing challenges of our time (Lubinski, 2018). While in 1958, Hobbs drew on the challenges of STEM innovation stimulated by Sputnik, we now have challenges such as cybersecurity, climate change, and global pandemics. Each specific ability dimension has a characteristic covariance pattern with passions for different pursuits. Optimally nurturing the phenomenon of differential potential for the benefit of both students and society requires the same general principles as does nurturing all human potential—being responsive to each person's individuality.

What intellectual precocity appears to be is the high-end extreme of systematic sources of individual differences within a multivariate psychological space of familiar dimensions. Because each of the specific abilities covaries with a unique pattern of interests, distinct "types of intelligence" are frequently posited when specific-ability extremes are isolated. Because each specific ability pulls with it distinct qualities, specific ability extremes result in the appearance of *qualitatively* different types (Lubinski & Benbow, 1995, 2000). But these multifaceted intellectual embodiments are most likely simply contrasting constellations of continua.

Understanding intellectually precocious students (and indeed all students), requires understanding the critical psychological significance of longitudinally stable dimensions of human individuality. Regardless of whether they are measured, they structure important aspects of learning and psychological development. For typically developing populations, the words of Rounds and Tracey (1990, p. 17) are more scientifically supported today than when they were stated:

> [V]ocational interests, work values, and cognitive abilities are stable and show valid relationships with criteria that counselors and clients believe are important career counseling outcomes. Counselors who do not avail themselves and their clients of this valuable information do a disservice to their clientele.

In the decades since Terman (1954b), this wisdom has become empirically solidified and seamlessly generalizable to intellectually precocious youth as well (Bernstein et al., 2019; Lubinski, 2016; Schmidt et al., 1998; Webb et al., 2002, 2007).

What Is Now Needed?

The above findings suggest lines of research likely to strike rich scientific ore. Perhaps the line of research with most potential for immediate impact is a talent search for spatially talented students (Lubinski, 2016; Lubinski & Kell, 2018, pp. 492–493). What Terman did for IQ, Julian Stanley did for specific abilities (Benbow & Lubinski, 2006; Keating & Stanley, 1972; Stanley, 1977, 1996, 2000). However, Stanley selected participants for SMPY with above-level tests of mathematical and verbal reasoning ability only. As such, approximately half of spatially gifted students in the top 1% of ability are not identified by modern talent search procedures (Wai et al., 2009; Wai & Worrell, 2016). They constitute the largest pool of untapped intellectual talent of which we are aware (Gohm et al., 1998; Humphreys et al., 1993; Wai & Worrell, 2016; Webb et al., 2007). All of the studies reviewed here were published after the following observation by Richard E. Snow (1999, p. 136), arguably the leading figure of his time on the educational significance of spatial ability:

> There is good evidence that [visual-spatial reasoning] relates to specialized achievements in fields such as architecture, dentistry, engineering, and medicine…. Given this plus the long-standing anecdotal evidence on the role of visualization in scientific discovery, … it is incredible that there has been so little programmatic research on admissions testing in this domain.

Second, the aptitude complexes discussed here provide an excellent conceptual framework for examining the relative effectiveness of different forms of acceleration for intellectually precocious youth (Corno et al., 2002). The three specific abilities combined with Holland's (1996) RIASEC model of educational/occupational interests (Lubinski & Benbow, 2000, 2006) provide an excellent framework for conducting more holistic appraisals of human individuality and examining aptitude/treatment interactions (Corno et al., 2002).

Third, in modeling intellectual precocity over the life span, determinants beyond ability, interest, and opportunity are needed (Ferriman et al., 2009; Lubinski et al., 2014; McCabe et al., 2020). Lifestyle preferences and priorities need to be considered in particular, as well as how people wish to invest their time. Life is ipsative. And different individuals define success differently. While there is no absolute right or wrong, neglecting these personal attributes or priorities likely underestimates the educational efficacy of important interventions (Bleske-Rechek et al., 2004; Park et al., 2013). Thus, models of differential positive development will be underdetermined (Lubinski, 2010), resulting in less impressive predictions.

Finally, one criterion for evaluating the scientific worth of a field is the extent to which concepts and findings from that area have informed scientific pursuits in others. Longitudinal research on intellectually precocious populations has informed economics and sociological groupings as well as behavioral genetics and the neurosciences (Lubinski, 2016). The populations isolated here using three primary abilities promise to continue to serve as an organizational hub for both behavioral genetics (Lee et al., 2018; Plomin, 2018; Plomin et al., 2016; Spain et al., 2016; Zabaneh et al., 2018) and the neurosciences (Colom & Thompson, 2011; Haier, 2017; Jung & Haier, 2007). That these findings will continue to be built on is, therefore, guaranteed.

Conclusion

We have learned many exciting things over the past 50 years. The future promises to be even more exciting. Perhaps the biggest challenge facing those of the next generation with passion for advancing scientific knowledge on intellectual precocity is choosing which path to take. The possible paths are as diverse as the multidimensionality of intellectual precocity.

Addendum

Four helpful referees made several suggestions for our revision regarding further nuances on the science of human individuality and its measurement, while acknowledging that some are beyond the scope of our article. Because many of their remarks on human individuality are addressed in the introduction to a special issue marking the 100-year anniversary of Spearman's discovery of general intelligence (Lubinski, 2004), and in a 100-year review of intellectual precocity, marking American Educational Research Association's centennial (Lubinski, 2016), readers are referred to these publications (including the Supplementary Notes in the 2016 article's online version). For the educational philosophy stemming from the science of human individuality, see Benbow and Stanley (1996) and Stanley (2000) for intellectual precocity and, for educational and counseling contexts more generally, Williamson (1965). We do, however, want to address three queries raised by the referees and do so below.

1. Given the attention replication has received in the social sciences (Camerer et al., 2018; Open Science Collaboration, 2015), could not the authors stress a bit more how consistent findings are in the field of intellectual precocity?

We agree that when traditional individual dimensions (mathematical, spatial, and verbal reasoning abilities) are assessed in their full scope increased clarity is obtained regarding the multiple ways in which intellectual precocity unfolds. To allow these dimensions to go unmeasured enhances the likelihood of unstable results because they structure important outcomes regardless of whether they are measured. Individuals within all populations, across the spectrum of developmental delays to precocity, vary widely in their pattern of specific abilities—their respective capacities to reason with numbers (quantitatively), shapes (spatially), and words (linguistically). Such intraindividual differences in the capacity to store and manipulate the various forms of symbolic media differentially structure outcomes throughout the life span. To the extent that individuals vary on these dimensions, they are differentially responsive to contrasting affordances in learning and work settings (Lubinski, 1996, 2000, Scarr, 1996; Scarr & McCartney, 1983). When samples are studied or interventions implemented without assessing these determinants, outcomes will vary in undetectable ways to the extent that the samples under analysis differ in ability level and pattern. Cronbach (1957) stressed the importance of assessing individual differences in aptitude to calibrate differential responsiveness to interventions and opportunities long ago. Going beyond this, however, the practice of routinely assessing these dimensions has another advantage—it seamlessly integrates intellectual precocity with the broader fabric of humanity and connects the findings reviewed here with highly replicated models of human individuality (Lubinski, 2000, 2004). Doing so provides a robustness appraisal of the scientific significance of the parameters under analysis (Lubinski, 2016). This is especially true when linkages are formed to other biosocial disciplines.

When precocity is conceptualized within a multidimensional space of human individuality (with no discrete boundaries), connections emerge with phenomena in other branches of the educational and psychological sciences. Just as our discussion of creativity and exceptional career stature suggests, unique qualities may not be needed to understand extreme (atypical) accomplishments or extreme (atypical) talent. Perhaps "simply" more of known qualities can explain both phenomena. Colleagues in special education (Douglas Detterman, Doug Fuchs, and Lynn Fuchs, personal communication, May 2016) with whom we have discussed the issue resonate to the idea that much of what constitutes developmental delays amounts to the bipolar opposite of the exceptional levels of the general and specific abilities discussed here (Figures 2 and 9); that is, they are delays in general intellectual functioning or, more specifically, in mathematical, spatial, or verbal reasoning (Lubinski, 2016, p. 935). As we propose here, when dealing with all human populations, atypical is typical because what is atypical for an individual is typical for a population. And population differences are always modest relative to individual differences within all populations. There are always bidirectional extremes ranging from delayed to accelerated growth. To advance research and practice requires assessing aspects of human individuality that we know structure educational and career development in typical and atypical (extreme) populations. This practice has many benefits. It enhances the likelihood of replicating empirical research findings, forms contiguous connections across developmental delays → typical development → precocity, and provides robust dimensions for organizing phenomena throughout the biosocial sciences (Geary, 2010; Haier, 2017; Lubinski, 2016; Pinker, 2008; Plomin, 2018).

2. What is the relationship between IQ and specific abilities?

Aggregating specific ability assessments systematically forms an excellent measure of the general factor of intellectual functioning ("IQ") that minimizes the composite's uniqueness; specific ability measures in isolation contain large components of both general ability and specific abilities (see Lubinski, 2004, Figure 1, p. 99). The latter is why Cronbach and Snow always stressed that whenever specific ability measures engender meaningful results, it is an empirical question as to whether the source of influence was the general factor, a specific factor, or both (Corno et al., 2002; Cronbach & Snow, 1981). Figure 9 was designed in part to reveal how different sources of general and specific variance factor into differential outcomes in the magnitude and the nature of successively more impressive educational accomplishments. Essentially, this constitutes a demonstration of construct validity, tracing the psychologically operative sources of variation in each indicator to external empirical phenomena (Cronbach, 1989; Meehl, 1999). Because the general factor accounts for appreciable variance in educational and occupational outcomes, it was necessary that specific abilities go beyond what the general factor had achieved to demonstrate their psychological significance. In the words of Cronbach and Snow (1981, p. 511),

> Even when especially interested in one characteristic of the learner, the investigator should measure additional aptitudes. If chiefly concerned with a specialized ability, he nonetheless should include one or more general measures. This will allow him to reject (or support) the hypothesis that general ability explains the . . . regressions [of the] narrower test. The foregoing . . . is in line with the first two recommendations of Campbell and Fiske: that

indicators reflecting promising counterhypotheses should be included in any validation study.

These remarks are especially germane when developing innovative assessment techniques; for innovative instruments to provide a scientific advance (and inform practice), they must capture variation in external learning or relevant outcomes beyond that which can already be accounted for with preexisting assessments. Skipping this crucial step in the validation process is inimical to scientific progress and has frequently resulted in iatrogenic practices (Lubinski, 2009b; Lubinski & Humphreys, 1997).

3. What is the relationship between socioeconomic status (SES) and IQ?

Humphreys (1985) has an excellent treatment of this topic wherein he stresses that because IQ and SES covary approximately .40, it behooves talent searches to cast a wide net. Sackett et al. (2009) is a compelling contribution on the importance of examining intellectual abilities and SES simultaneously to establish their relative significance in educational and other settings (but see also Kuncel & Hezlett, 2010; Sackett et al., 2001; Sackett et al., 2004; Sackett et al., 2008). There is a long history in educational and psychological research of treating SES as causal when it comes to its covariates, a practice Oyama (2000) referred to as "unprincipled privileging." Namely, covariation = causation when it comes to SES and its many correlates without scrutinizing other putative determinants to establish an empirically based form of competitive support (Meehl, 1970; Sackett et al., 2009). Applications designed to untangle the overlap between cognitive abilities and SES, without committing the "partialing fallacy" (Meehl, 1970), are available (Bouchard, 2009; Lubinski, 2004, 2009b; Lubinski & Humphreys, 1992; Murray, 1998; Plomin et al., 2016; Waller, 1971).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Editors' Note

This paper was originally accepted for publication by Jennifer L. Jolly and Russell T. Warne in their role as guest editors for a special issue, *The Terman Longitudinal Study: A Century of Findings, Questions, and Controversy*, which was terminated by NAGC.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Support for this investigation was provided by a research and training grant from the John Templeton Foundation (Grant ID #61368) and by the Eunice Kennedy Shriver National Institute of Child Health and Human Development under Award No. U54HD083211. We thank Brian O. Bernstein, Kira O. McCabe, and Frank Miele for valuable input as we developed this article. Correspondence on this article may be sent to: david.lubinski@vanderbilt.edu or camilla.benbow@vanderbilt.edu

ORCID iD

David Lubinski https://orcid.org/0000-0003-1605-4698

Notes

1. Among other things, the use of specific ability measures (viz., mathematical and verbal reasoning abilities) in identifying intellectual precocity has facilitated the identification of intellectual talent missed by general ability measures or IQ alone. Using these specific ability measures was justified because longitudinal research has repeatedly documented that they capture important learning and real-world outcomes missed by IQ. However, SMPY findings on spatial ability highlight a limitation (Benbow & Lubinski, 2006; Clynes, 2016; Lubinski & Benbow, 2006). The SMPY spatial ability findings were all based on participants who made the top 1% cut on either mathematical or verbal reasoning abilities. As other research has shown (Gohm et al., 1998; Humphreys et al., 1993; Wai et al., 2009), modern talent searches restricted to mathematical and verbal reasoning abilities miss over half of the top 1% in spatial ability (a large source of neglected talent). Moreover, given that spatial ability covaries less with SES relative to mathematical and verbal reasoning abilities (Austin & Hanisch, 1990), in the neighborhood of .30 rather than .40, utilizing measures of spatial ability to identify talent pools comes with the attractive corollary of identifying a greater number of participants from economically challenged homes. To our knowledge, this talent pool constitutes the largest source of neglected intellectual potential. For a 14-minute documentary on the history of SMPY and how the assessment measures utilized in this study are put into practice, see: https://www.youtube.com/watch?v=XkPQHIUHWwc
2. Interestingly, central aspects of this design were anticipated by Terman. To advance knowledge on the personal attributes and environmental diversity required for nurturing exceptional STEM professionals, Terman (1954b, p. 40) suggested, "[I]t would be more economical to have, instead of a single group of subjects with high IQ's, two gifted groups closely matched for superior IQ but otherwise unlike as possible with respect to scientific promise . . .. we could therefore examine . . ." . . . " . . . special abilities and interests believed to be symptomatic of scientific talent."
3. This is worth pointing out as people strive to be innovatively original and to invent fresh concepts and measures for

understanding atypical individuals. It is important to determine whether they are covering new ground or mapping what we already know and applying new labels to commit the "Jangle Fallacy" (Kelley, 1927, p. 64). Many examples of fruitless research efforts are available and are traceable to investigators choosing not to build on what we already know, and documenting that innovative assessments capture variance in important external phenomena that was heretofore unaccounted for (see critiques by Cattell, 1958; Hunt, 1999, 2008; *Intelligence*, 2003; Lubinski, 2010; Messick, 1992; Sanders et al., 1995).

References

Achter, J. A., Benbow, C. P., & Lubinski, D. (1997). Rethinking multipotentiality among the intellectually gifted: A critical review and recommendations. *Gifted Child Quarterly*, *41*(1), 5–15. https://doi.org/10.1177/001698629704100102

Achter, J. A., Lubinski, D., & Benbow, C. P. (1996). Multipotentiality among intellectually gifted: "It was never there and already it's vanishing." *Journal of Counseling Psychology*, *43*(1), 65–76. https://doi.org/10.1037/0021-9010.75.1.77

Achter, J. A., Lubinski, D., Benbow, C. P., & Eftekhari-Sanjani, H. (1999). Assessing vocational preferences among gifted adolescents adds incremental validity to abilities: A discriminant analysis of educational outcomes over a 10-year interval. *Journal of Educational Psychology*, *91*(4), 777–786. https://doi.org/10.1037/0022-0663.91.4.777

Ackerman, P. L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence*, *22*(2), 227–257. https://doi.org/10.1016/S01602896(96)90016-1

Ackerman, P. L., & Heggestad, E. D. (1997). Intelligence, personality, and interests: Evidence for overlapping traits. *Psychological Bulletin*, *121*(2), 218–245. https://doi.org/10.1037/0033-2909.121.2.219

Allport, G. W., Vernon, P. E., & Lindzey, G. (1970). *Manual: Study of values*. Houghton Mifflin.

Arneson, J. J., Sackett, P. R., & Beatty, A. S. (2011). Ability–performance relationships in education and employment settings: Critical tests of the "more is better" and the "good enough" hypotheses. *Psychological Science*, *22*(10), 1336–1342. https://doi.org/10.1177/0956797611417004

Assouline, S. G., Colangelo, N., & Vantassel-Baska, J. (2015). *A nation empowered* (Vol. I). Belin-Blank Center.

Assouline, S. G., Colangelo, N., Vantassel-Baska, J., & Lupkowski-Shoplik, A. (2015). *A nation empowered* (Vol. II). Belin-Blank Center.

Austin, J. T., & Hanisch, K. A. (1990). Occupational attainment as a function of abilities and interests: A longitudinal analysis using Project Talent data. *Journal of Applied Psychology*, *75*(1), 77–86. https://doi.org/10.1037/0021-9010.75.1.77

Bates, T. (2010, June 23). *ISIR 2009 Distinguished Interview: Charles Murray* [Video]. Vimeo. https://vimeo.com/12793181

Benbow, C. P. (1992). Academic achievement in mathematics and science between ages 13 and 23: Are there differences among students in the top one percent of mathematical ability? *Journal of Educational Psychology*, *84*(1), 51–61. https://doi.org/10.1037/00220663.84.1.51

Benbow, C. P., & Lubinski, D. (2006). Julian C. Stanley, Jr. (1918–2005). *American Psychologist*, *61*(3), 251–252. https://doi.org/10.1037/0003-066X.61.3.251

Benbow, C. P., Lubinski, D., Shea, D. L., & Eftekhari-Sanjani, H. (2000). Sex differences in mathematical reasoning ability: Their status 20 years later. *Psychological Science*, *11*(6), 474–480. https://doi.org/10.1111/1467-9280.00291

Benbow, C. P., Lubinski, D., & Suchy, B. (1996). The impact of SMPY's educational programs from the perspective of the participant. In C. P. Benbow & D. Lubinski (Eds.), *Intellectual talent: Psychometric and social issues* (pp. 266–300). Johns Hopkins University Press.

Benbow, C. P., & Stanley, J. C. (Eds.). (1983). *Academic precocity: Aspects of its development*. Johns Hopkins University Press.

Benbow, C. P., & Stanley, J. C. (1996). Inequity in equity: How current educational equity policies place able students at risk. *Psychology, Public Policy, and Law*, *2*(2), 249–293. https://doi.org/10.1037/1076-8971.2.2.249

Bernstein, B. O., Lubinski, D., & Benbow, C. P. (2019). Psychological constellations assessed at age 13 predict distinct forms of eminence 35 years later. *Psychological Science*, *30*(3), 444–454. https://doi.org/10.1177/0956797618822524

Bernstein, B. O., Lubinski, D., & Benbow, C. P. (in press). Academic acceleration in gifted youth and fruitless concerns regarding psychological well-being: A 35-year longitudinal study. *Journal of Educational Psychology*. https://doi.org/10.1037/edu0000500

Bleske-Rechek, A., Lubinski, D., & Benbow, C. P. (2004). Meeting the educational needs of special populations: Advanced placement's role in developing exceptional human capital. *Psychological Science*, *15*(4), 217–224. https://doi.org/10.1111/j.0956-7976.2004.00655.x

Bouchard, T. J., Jr. (2009). Strong inference: A strategy for advancing psychological science. In K. McCartney & R. A. Weinberg (Eds.), *Understanding development: A Festschrift for Sandra Scarr* (pp. 39–59). Taylor & Francis.

Camerer, C. F., Dreber, A., Holzmeister, F., Ho, T. H., Huber, J., Johannesson, M., Kirchler, M., Nave, G., Nosek, B. A., Pfeiffer, T., Altmejd, A., Buttrick, N., Chan, T., Chen, Y., Forsell, E., Gampa, A., Heikensten, E., Hummer, L., Imai, T., . . . Wu, H. (2018). Evaluating the replicability of social science experiments in *Nature* and *Science* between 2010 and 2015. *Nature Human Behavior*, *2*(9), 637–644. https://doi.org/10.1038/s41562-018-0399-z

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor analytic studies*. Cambridge University Press.

Cattell, R. B. (1958). A need for alertness to multivariate experimental findings in integrative surveys. *Psychological Bulletin*, *55*(4), 253–256. https://doi.org/10.1037/h0043232

Ceci, S. J., Ginther, D. K., Kahn, S., & Williams, W. M. (2014). Women in academic science: A changing landscape. *Psychological Science in the Public Interest*, *15*(3), 75–141. https://doi.org/10.1177/1529100614541236

Ceci, S. J., & Williams, W. M. (2011). Understanding current causes of women's underrepresentation in science. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(8), 3157–3162. https://doi.org/10.1073/pnas.1014871108

Clynes, T. (2016). How to raise a genius: A long-running study of exceptional children reveals what it takes to produce the scientists who will lead the twenty-first century. *Nature*, *573*(7619), 152–155. https://doi.org/10.1038/537152a

Colangelo, N., Assouline, S. G., & Gross, M. U. M. (Eds.). (2004). *A nation deceived: How schools hold back America's brightest students*. University of Iowa.

Colom, R., & Thompson, P. M. (2011). Understanding human intelligence by imaging the brain. In T. Chamorro-Premuzic, S. von Stumm, & A. Furnham (Eds.), *Handbook of individual differences* (pp. 330–352). Blackwell. https://doi.org/10.1002/9781444343120.ch12

Corno, L., Cronbach, L. J., Kupermintz, H., Lohman, D. F., Mandinach, E. B., Porteus, A. W., & Talbert, J. E. (Eds.). (2002). *Remaking the concept of aptitude: Extending the legacy of Richard E. Snow*. Lawrence Erlbaum. https://doi.org/10.4324/9781410604521

Cronbach, L. J. (1957). The two disciplines of scientific psychology. *American Psychologist*, *12*(11), 671–684. https://doi.org/10.1037/h0043943

Cronbach, L. J. (1989). Construct validity after thirty years. In R. L. Linn (Ed.), *Intelligence: Measurement, theory, and public policy* (pp. 147–171). University of Illinois Press.

Cronbach, L. J., & Snow, R. E. (1981). *Aptitude and instructional methods: A handbook for research on interactions*. Irvington.

Dawis, R. V. (1992). The individual differences tradition in counseling psychology. *Journal of Counseling Psychology*, *39*(1), 7–19. https://doi.org/10.1037/0022-0167.39.1.7

Dawis, R. V. (2005). The Minnesota Theory of Work Adjustment. In S. D. Brown & R. W. Lent (Eds.), *Career development and counseling* (pp. 3–23). John Wiley.

Dawis, R. V., & Lofquist, L. H. (1984). *A psychological theory of work adjustment*. University of Minnesota Press.

Eiduson, B. T., & Beckman, L. (1973). *Science as a career: Theoretical and empirical studies*. Russell Sage Foundation.

Eysenck, H. J. (1995). *Genius: The natural history of creativity*. Cambridge University Press. https://doi.org/10.1017/CBO9780511752247

Ferriman, K., Lubinski, D., & Benbow, C. P. (2009). Work preferences, life values, and personal views of top math/science graduate students and the profoundly gifted: Developmental changes and sex differences during emerging adulthood and parenthood. *Journal of Personality and Social Psychology*, *97*(3), 517–532. https://doi.org/10.1037/a0016030

Flanagan, J. C., Dailey, J. T., Shaycoft, M. F., Gorham, W. A., Orr, D. B., & Goldberg, I. (1962). *Design for a study of American youth*. Houghton Mifflin.

Frey, M. C., & Detterman, D. K. (2004). Scholastic assessment or *g*? The relationship between the scholastic assessment test and general cognitive ability. *Psychological Science*, *15*(6), 373–378. https://doi.org/10.1111/j.0956-7976.2004.00687.x

Gardner, H. (1983). *Frames of mind*. Basic Books.

Geary, D. C. (2010). *Male, female: The evolution of human sex differences* (2nd ed.). American Psychological Association. https://doi.org/10.1037/12072-000

Gino, F., Wilmuth, C. A., & Brooks, A. W. (2015). Compared to men, women view professional advancement as equally attainable, but less desirable. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(40), 12354–12359. https://doi.org/10.1073/pnas.1502567112

Gohm, C. L., Humphreys, L. G., & Yao, G. (1998). Underachievement among spatially gifted students. *American Educational Research Journal*, *35*(3), 515–531. https://doi.org/10.3102/00028312035003515

Gottfredson, L. S. (1981). Circumscription and compromise: A developmental theory of occupational aspirations. *Journal of Counseling Psychology*, *28*(6), 545–579. https://doi.org/10.1037/0022-01167.28.6.545

Gottfredson, L. S. (2002). Gottfredson's theory of circumscription, compromise, and self-creation. In D. Brown (Ed.), *Career choice and development* (pp. 85–148). Jossey-Bass.

Gottfredson, L. S. (2003). The challenge and promise of cognitive career assessment. *Journal of Career Assessment*, *11*(2), 115–135. https://doi.org/10.1177/1069

Gottfredson, L. S. (2005). Using Gottfredson's theory of circumscription and compromise in career guidance and counseling. In S. D. Brown & R. W. Lent (Eds.), *Career development and counseling* (pp. 71–100). Wiley.

Gough, H. G., & Heilbrun, A. B. (1983). *The Revised Adjective Checklist manual*. Consulting Psychologists Press.

Grove, W. M., & Meehl, P. E. (1996). Comparative efficiency of formal (mechanical, algorithmic) and informal (subjective, impressionistic) prediction procedures: The clinical/statistical controversy. *Psychology, Public Policy, and Law*, *2*(2), 293–323. https://doi.org/10.1037/1076-8971.2.2.293

Haier, R. J. (2017). *The neuroscience of intelligence*. Cambridge University Press. https://doi.org/10.1017/9781316105771

Hakim, C. (2000). *Work-lifestyle choices in the 21st century: Preference theory*. Oxford University Press.

Hakim, C. (2006). Women, careers, and work-life preferences. *British Journal of Guidance & Counselling*, *34*(3), 279–294. https://doi.org/10.1080/03069880600769118

Harmon, L. R. (1961). High school backgrounds of science doctorates. *Science*, *133*(3454), 679–688. https://doi.org/10.1126/science.133.3454.679

Hobbs, N. (1958). The compleat counselor. *Personnel and Guidance Journal*, *36*(9), 594–602. https://doi.org/10.1002/j.2164-4918.1958.tb01125.x

Holland, J. L. (1996). Exploring careers with a typology: What we have learned and some new directions. *American Psychologist*, *51*(4), 397–406. https://doi.org/10.1037/0003-066X.51.4.397

Hollingworth, L. S., & Cobb, M. V. (1928). Children clustering at 165 IQ and children clustering at 146 IQ compared for three years in achievement. In G. M. Whipple (Ed.), *Twenty-seventh yearbook of the National Society for the Study of Education* (pp. 3–33). University of Chicago Press. https://doi.org/10.1037/11368-001

Humphreys, L. G. (1985). Conceptions of intellectual giftedness. In F. D. Horowitz & M. O'Brian (Eds.), *The gifted and talented: Developmental perspectives* (pp. 331–360). American Psychological Association. https://doi.org/10.1037/10054-011

Humphreys, L. G. (1991). Commentary: What both critics and users of ability tests need to know. *Psychological Science*, *3*(5), 271–274. https://doi.org/10.1111j.1467-9280.1992.tb00670.x

Humphreys, L. G., Lubinski, D., & Yao, G. (1993). Utility of predicting group membership and the role of spatial visualization in becoming an engineer, physical scientist, or artist. *Journal of Applied Psychology*, *78*(2), 250–261. https://doi.org/10.1037/0021-9010.78.2.250

Hunt, E. B. (1999). Multiple views of multiple intelligence [Review of the book *Intelligence reframed: Multiple intelligence in the 21st century*, by H. Gardner]. *Contemporary Psychology*, *46*(1), 5–7. https://doi.org/10.1057/002513

Hunt, E. B. (2008). Applying the theory of successful intelligence to education: The good, the bad, and the ogre. *Perspectives in Psychological Science*, *3*(6), 509–515. https://doi.org/10.1111/j.1745-6924.2008.00094.x

Hunt, E. B. (2010). *Human intelligence*. Cambridge University Press. https://doi.org/10.1017/CBO9780511781308

Intelligence (2003) Volume *31* Issue 4.

Jackson, D. N., & Rushton, J. P. (1985). *Scientific excellence: Origins and assessment*. Sage.

Jensen, A. R. (1998). *The g factor: The science of mental ability*. Praeger.

Jung, R. E., & Haier, R. J. (2007). The Parieto-frontal integration theory (P-FIT) of intelligence: Converging neuroimaging evidence. *Behavioral and Brain Sciences*, *30*(2), 135–187. https://doi.org/10.1017/S0140525X07001185

Keating, D. P., & Stanley, J. C. (1972). Extreme measures for the exceptionally gifted in mathematics and science. *Educational Researcher*, *1*(9), 3–7. https://doi.org/10.1177/001698629103500105

Kell, H. J., Lubinski, D., & Benbow, C. P. (2013). Who rises to the top? Early indicators. *Psychological Science*, *24*(5), 648–658. https://doi.org/10.1177/0956797612457784

Kell, H. J., Lubinski, D., Benbow, C. P., & Steiger, J. H. (2013). Creativity and technical innovation: Spatial ability's unique role. *Psychological Science*, *24*(9), 1831–1836. https://doi.org/10.1177/0956797613478615

Kelley, T. L. (1927). *Interpretation of educational measurements*. World Book.

Kulik, J. A., & Kulik, C.-L. C. (1984). Effects of acceleration on students. *Review of Educational Research*, *54*(3), 409–425. https://doi.org/10.3102/00346543054003409

Kulik, J. A., & Kulik, C.-L. C. (1992). Meta-analytic findings on grouping programs. *Gifted Child Quarterly*, *36*(2), 73–77. https://doi.org/10.1177.001698629203600204

Kuncel, N. R., & Hezlett, S. A. (2007). Standardized tests predict graduate students' success. *Science*, *315*(5815), 1080–1081. https://doi.org/10.1126/science.1136618

Kuncel, N. R., & Hezlett, S. A. (2010). Fact and fiction in cognitive ability testing for admissions and hiring decisions. *Current Directions in Psychological Science*, *19*(6), 339–345. https://doi.org/10.1177/0963721410389459

Lee, J. J., Wedow, R., Okbay, A., Kong, E., Maghzian, O., Zacher, M., Nguyen-Viet, T. A., Bowers, P., Sidorenko, J., Karlsson Linnér, R., Fontana, M. A., Kundu, T., Lee, C., Li, H., Li, R., Royer, R., Timshel, P. N., Walters, R. K., Willoughby, E. A., . . . Cesarini, D. (2018). Gene discovery and polygenic prediction from a genome-wide association study of educational attainment in 1.1 million individuals. *Nature Genetics*, *50*(8), 1112–1121. https://doi.org/10.1038/s41588-018-0147-3

Lofquist, L. H., & Dawis, R. V. (1991). *Essentials of person-environment correspondence counseling*. University of Minnesota Press.

Lubinski, D. (1996). Applied individual difference research and its quantitative methods. *Psychology, Public Policy, and Law*, *2*(2), 187–203. https://doi.org/10.1037/1076-8971.2.2.187

Lubinski, D. (2000). Scientific and social significance of assessing individual differences: "Sinking shafts at a few critical points." *Annual Review of Psychology*, *51*, 405–444. https://doi.org/10.1146/annurev.psych.51.1.405

Lubinski, D. (2004). Introduction to the special section on cognitive abilities: 100 Years after Spearman's (1904) "'General intelligence,' objectively determined and measured." *Journal of Personality and Social Psychology*, *86*(1), 96–111. https://doi.org/10.1037/00223514.86.1.96

Lubinski, D. (2009a). Exceptional cognitive ability: The phenotype. *Behavior Genetics*, *39*(4), 350–358. https://doi.org/10.1007/s10519-009-9273-0

Lubinski, D. (2009b). Cognitive epidemiology: With emphasis on untangling cognitive ability and socioeconomic status. *Intelligence*, *37*(6), 625–633. https://doi.org/10.1016/j.intell.2009.09.001

Lubinski, D. (2010). Neglected aspects and truncated appraisals in vocational counseling: Interpreting the interest-efficacy association from a broader perspective. *Journal of Counseling Psychology*, *57*(2), 226–238. https://doi.org/10.1037/a0019163

Lubinski, D. (2016). From Terman to today: A century of findings on intellectual precocity. *Review of Educational Research*, *86*(4), 900–944. https://doi.org/10.3102/0034654316675476

Lubinski, D. (2018). Individual differences at the top: Mapping the outer envelope of intelligence. In R. J. Sternberg (Ed.), *The nature of human intelligence* (pp. 230–255). Cambridge University Press. https://doi.org/10.1017/9781316817049.016

Lubinski, D., & Benbow, C. P. (1995). An opportunity for empiricism. [Review of the book *Multiple intelligences: The theory in practice*, by H. Gardner]. *Contemporary Psychology*, *40*(10), 935–938. https://doi.org/10.1037/004016

Lubinski, D., & Benbow, C. P. (2000). States of excellence. *American Psychologist*, *55*(1), 137–150. https://doi.org/10.1037/0003-066X.55.1.137

Lubinski, D., & Benbow, C. P. (2001). Choosing excellence. *American Psychologist*, *56*(1), 76–77. https://doi.org/10.1037/0003-066X.56.1.76

Lubinski, D., & Benbow, C. P. (2006). Study of Mathematically Precocious Youth after 35 years: Uncovering antecedents for the development of math-science expertise. *Perspectives on Psychological Science*, *1*(4), 316–345. https://doi.org/10.1111/j.1745-6916.2006.00019.x

Lubinski, D., Benbow, C. P., & Kell, H. J. (2014). Life paths and accomplishments of mathematically precocious males and females four decades later. *Psychological Science*, *25*(12), 2217–2232. https://doi.org/10.1177/0956797614551371

Lubinski, D., Benbow, C. P., & Ryan, J. (1995). Stability of vocational interests among the intellectually gifted from adolescence to adulthood: A 15-year longitudinal study. *Journal of Applied Psychology*, *80*(1), 196–200. https://doi.org/10.1037/0021-9010.80.1.196

Lubinski, D., Benbow, C. P., Shea, D. L., Eftekhari-Sanjani, H., & Halvorson, M. B. J. (2001). Men and women at promise for scientific excellence: Similarity not dissimilarity. *Psychological Science*, *12*(4), 309–317. https://doi.org/10.1111/1467-9280.00357

Lubinski, D., Benbow, C. P., Webb, R. M., & Bleske-Rechek, A. (2006). Tracking exceptional human capital over two decades. *Psychological Science*, *17*(3), 194–199. https://doi.org/10.1111/j.1467-9280.2006.01685.x

Lubinski, D., & Dawis, R. V. (1992). Aptitudes, skills, and proficiencies. In M. D. Dunnette & L. M. Hough (Eds.), *Handbook of industrial/organizational psychology* (2nd ed., Vol. *3*, pp. 1–59). Consulting Psychologists Press.

Lubinski, D., & Humphreys, L. G. (1990). A broadly based analysis of mathematical giftedness. *Intelligence*, *14*(3), 327–355. https://doi.org/10.1016/0160-2896(90)90022-L

Lubinski, D., & Humphreys, L. G. (1992). Some bodily and medical correlates of mathematical giftedness and commensurate levels of socioeconomic status. *Intelligence*, *16*(1), 99–115. https://doi.org/10.1016/0160-2896(92)90027-O

Lubinski, D., & Humphreys, L. G. (1997). Incorporating general intelligence into epidemiology and the social sciences. *Intelligence*, *24*(1), 159–201. https://doi.org/10.1016/S0160-2896(97)90016-7

Lubinski, D., & Kell, H. J. (2018). Three crucial dimensions for students with intellectual gifts: It's time to stop talking and start thinking. In S. Pfeiffer, M. Foley-Nicpon, & E. Shaunessy-Dedrick (Eds.), *Handbook of giftedness and talent* (pp. 479–496). American Psychological Association. https://doi.org/10.1037/0000038-031

Lubinski, D., Schmidt, D. B., & Benbow, C. P. (1996). A 20-year stability analysis of the Study of Values for intellectually gifted individuals from adolescence to adulthood. *Journal of Applied Psychology*, *81*(4), 443–451. https://doi.org/10.1037/0021-9010.81.4.443

Lykken, D. T. (1968). Statistical significance in psychological research. *Psychological Bulletin*, *70*(3), 151–159. https://doi.org/10.1037/h0026141

Lykken, D. T. (1991). What's wrong with psychology anyway? In D. Ciccetti & W. Grove (Eds.), *Thinking clearly about psychology* (pp. 3–39). University of Minnesota Press.

Makel, M., Kell, H. J., Lubinski, D., Putallaz, M., & Benbow, C. P. (2016). When lightning strikes twice: Profoundly gifted, profoundly accomplished. *Psychological Science*, *27*(7), 1004–1018. https://doi.org/10.1177/0956797616644735

McCabe, K. O., Lubinski, D., & Benbow, C. P. (2020). Who shines most among the brightest? A 25-year longitudinal study of elite STEM graduate students. *Journal of Personality and Social Psychology*, *119*(2), 390–416. https://doi.org/10.1037/pspp0000239

Meehl, P. E. (1970). Nuisance variables and the ex post facto design. In M. Radner & S. Winokur (Eds.), *Minnesota studies in the philosophy of science* (Vol. 4, pp. 373–402). University of Minnesota Press.

Meehl, P. E. (1999). *Thoughts on construct validity*. http://meehl.umn.edu

Messick, S. (1992). Multiple intelligences or multilevel intelligence? Selective emphasis on distinctive properties of hierarchy: An essay review of Gardner's Frames of Mind and Sternberg's Beyond IQ in the context of theory and research on the structure of human abilities. *Psychological Inquiry*, *3*(1), 365–384. https://doi.org/10.1207/s15327965pli0304_20

Muratori, M. C., Stanley, J. C., Gross, M. U. M., Ng, L., Tao, T., Ng, J., & Tao, B. (2006). Insights from SMPY's greatest former prodigies: Drs. Terence ("Terry") Tao and Lenhard ("Lenny") Ng reflect on their talent development. *Gifted Child Quarterly*, *50*(4), 307–324. https://doi.org/10.1177/001698620605000404

Murray, C. (1998). *Income, inequity, and IQ*. American Enterprise Institute.

Murray, C. (2003). *Human accomplishment: The pursuit of excellence in the arts and sciences, 800 B.C. to 1950*. HarperCollins.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*. U.S. Department of Education. https://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

National Research Council. (1995). *Research-doctorate programs in the United States: Continuity and change*. Washington, DC: National Academies Press.

Okahana, H., & Zhou, E. (2018). *Graduate enrollment and degrees: 2007 to 2017*. Council of Graduate Schools. https://cgsnet.org/ckfinder/userfiles/files/CGS_GED17_Report.pdf

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science*, *349*(6251), Article aac4716. https://doi.org/10.1126/science.aac4716

Oyama, S. (2000). Causal democracy and causal contributions in developmental systems theory. *Philosophy of Science*, *67*(Suppl.), S332–S347. https://doi.org/10.1086/392830

Ozer, D. J., & Benet-Martinez, V. (2006). Personality and the prediction of consequential outcomes. *Annual Review of Psychology*, *57*, 401–421. https://doi.org/10.1146/annurev.psych.57.102904.190127

Park, G., Lubinski, D., & Benbow, C. P. (2007). Contrasting intellectual patterns for creativity in the arts and sciences: Tracking intellectually precocious youth over 25 years. *Psychological Science*, *18*(11), 948–952. https://doi.org/10.1111/j.1467-9280.2007.02007.x

Park, G., Lubinski, D., & Benbow, C. P. (2008). Ability differences among people who have commensurate degrees matter for scientific creativity. *Psychological Science*, *19*(10), 957–961. https://doi.org/10.1111/j.1467-9280.2008.02182.x

Park, G., Lubinski, D., & Benbow, C. P. (2013). When less is more: Effects of grade skipping on adult STEM accomplishments among mathematically precocious youth. *Journal of Educational Psychology*, *105*(1), 176–198. https://doi.org/10.1037/a0029481

Pinker, S. (2008). *The sexual paradox: Men, women, and the real gender gap*. Scribner.

Plomin, R. (2018). *Blueprint: How DNA makes us who we are*. Penguin.

Plomin, R., DeFries, J. C., Knopik, V. S., & Neiderhiser, J. M. (2016). Top 10 replicated findings from behavioral genetics. *Perspectives on Psychological Science*, *11*(1), 3–23. https://doi.org/10.1177/1745691615617439

Pressey, S. L. (1949). *Educational acceleration: Appraisals and basic problems*. The Ohio State University.

Pressey, S. L. (1955). Concerning the nature and nurture of genius. *Scientific Monthly*, *81*(3), 123–129.

Putallaz, M., Baldwin, J., & Selph, H. (2005). The Duke University Talent Identification Program. *High Ability Studies*, *16*(1), 41–54. https://doi.org/10.1080/13598130500115221

Reich, R. (1991). *The work of nations: Preparing ourselves for 21st century capitalism*. Knopf.

Rhodes, S. E. (2004). *Taking sex differences seriously*. Encounter Books.

Roe, A. (1951). A psychological study of physical scientists. *Genetic Psychology Monographs*, *43*, 121–235.

Roe, A. (1953). *The making of a scientist*. Dodd Mead.

Roe, A. (1961). The psychology of the scientist. *Science*, *134*(3477), 456–459. https://doi.org/10.1126/science.134.3477.456

Roe, A. (1965). Changes in scientific activities with age. *Science*, *150*(3694), 313–318. https://doi.org/10.1126/science.150.3694.313

Rogers, K. B. (2004). The academic effects of acceleration. In N. Colangelo, S. G. Assouline, & M. U. M. Gross (Eds.), *A nation deceived: How schools hold back America's brightest students* (pp. 47–57). University of Iowa. https://doi.org/10.1126/science.150.3694.313

Rounds, J. B., & Tracey, T. J. (1990). From trait-and-factor to person–environment fit counseling: Theory and process. In W. B. Walsh & S. H. Osipow (Eds.), *Career counseling* (pp. 1–44). Erlbaum.

Sackett, P. R., Borneman, M. J., & Connelly, B. S. (2008). High-stakes testing in higher education and employment: Appraising the evidence for validity and fairness. *American Psychologist*, *63*(4), 215–227. https://doi.org/10.1037/0003-066X.63.4.215

Sackett, P. R., Hardison, C. M., & Cullen, M. J. (2004). On interpreting stereotypic threat as accounting for African American-White difference in cognitive tests. *American Psychologist*, *59*(1), 7–13. https://doi.org/10.1037/0003-066X.59.1.7

Sackett, P. R., Kuncel, N. R., Arneson, J. J., Cooper, S. R., & Waters, S. D. (2009). Does socioeconomic status explain the relationship between admissions tests and post-secondary academic performance. *Psychological Bulletin*, *135*(1), 1–22. https://doi.org/10.1037/a0013978

Sackett, P. R., Lievens, F., Van Iddekinge, C. H., & Kuncel, N. R. (2017). Individual differences and their measurement: A review of 100 years of research. *Journal of Applied Psychology*, *102*(3), 254–273. https://doi.org/10.1037/apl0000151

Sackett, P. R., Schmitt, N., Ellingson, J. E., & Kabin, M. B. (2001). High-stakes testing in employment, credentialing, and higher education. *American Psychologist*, *56*(4), 302–318. https://doi.org/10.1037/0003-066X.56.4.302

Sanders, C. E., Lubinski, D., & Benbow, C. P. (1995). Does the Defining Issues Test measure psychological phenomena distinct from verbal ability: An examination of Lykken's query. *Journal of Personality and Social Psychology*, *69*(3), 498–504. https://doi.org/10.1037/0022-3514.69.3.498

Scarr, S. (1996). How people make their own environments: Implications for parents and policy makers. *Psychology, Public Policy, and Law*, *2*(2), 204–228. https://doi.org/10.1037/1076-8971.2.2.204

Scarr, S., & McCartney, K. (1983). How people make their own environments: A theory of genotype → environment effects. *Child Development*, *54*(2), 424–435.

Schmidt, D. B., Lubinski, D., & Benbow, C. P. (1998). Validity of assessing educational-vocational preference dimensions among intellectually talented 13-year olds. *Journal of Counseling Psychology*, *45*(4), 436–453. https://doi.org/10.1037/0022-0167.45.4.436

Schmidt, F. L., & Hunter, J. E. (1996). Measurement error in psychological research: Lessons from 26 research scenarios. *Psychological Methods*, *1*(2), 199–223. https://doi.org/10.1037/1082-989X.1.2.199

Schmidt, F. L., & Hunter, J. E. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin*, *124*(2), 262–274. https://doi.org/10.1037/0033-2909.124.2.262

Seashore, C. E. (1922). The gifted student and research. *Science*, *56*(1458), 641–648. https://doi.org/10.1126/science.56.1458.641

Seligman, M. E. (1970). On the generality of the laws of learning. *Psychological Review*, *77*(5), 406–418. https://doi.org/10.1037/h0029790

Shea, D. L., Lubinski, D., & Benbow, C. P. (2001). Importance of assessing spatial ability in intellectually talented young adolescents: A 20-year longitudinal study. *Journal of Educational Psychology*, *93*(3), 604–614. https://doi.org/10.1037/0022-0663.93.3.604

Simonton, D. K. (1988). *Scientific genius*. Cambridge University Press.

Simonton, D. K. (1994). *Greatness: Who makes history and why*. Guilford Press.

Simonton, D. K. (Ed.). (2014). *Handbook of genius*. Wiley. https://doi.org/10.1002/9781118367377

Snow, R. E. (1991). The concept of aptitude. In R. E. Snow & D. E. Wiley (Eds.), *Improving inquiry in the social sciences* (pp. 249–284). Lawrence Erlbaum.

Snow, R. E. (1999). Commentary: Expanding the breadth and depth of admissions testing. In S. Messick (Ed.), *Assessment in higher education: Issues of access, quality, student development, and public policy* (pp. 133–140). Lawrence Erlbaum.

Snow, R. E., Corno, L., & Jackson, D., III. (1996). Individual differences in affective and conative functions. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 243–310). Macmillan.

Snyder, T. D., de Brey, C., & Dillow, S. A. (2019). *Digest of Education Statistics 2017* (NCES 2018-070). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. https://nces.ed.gov/pubs2018/2018070.pdf

Southern, W. T., & Jones, E. D. (2004). Types of acceleration: Dimensions and issues. In N. Colangelo, S. G. Assouline, & M. U. M. Gross (Eds.), *A nation deceived: How schools* *hold back America's brightest students* (pp. 5–12). University of Iowa.

Spain, S. L., Pedroso, I., Kadeva, N., Miller, M. B., Iacono, W. G., McGue, M., Stergiakouli, E., Smith, G. D., Putallaz, M., Lubinski, D., Meaburn, E. L., Plomin, R., & Simpson, M. A. (2016). A genome-wide analysis of putative functional and exonic variation associated with extremely high intelligence. *Molecular Psychiatry*, *21*(8), 1145–1151. https://doi.org/10.1038/mp.2015.108

Stanley, J. C. (1977). Rationale of the Study of Mathematically Precocious Youth (SMPY) during its first five years of promoting educational acceleration. In J. C. Stanley, W. C. George, & C. H. Solano (Eds.), *The gifted and the creative: A fifty-year perspective* (pp. 75–112). Johns Hopkins University Press.

Stanley, J. C. (1996). SMPY in the beginning. In C. P. Benbow & D. Lubinski (Eds.), *Intellectual talent: Psychometric and social issues* (pp. 225–235). Johns Hopkins University Press.

Stanley, J. C. (2000). Helping students learn only what they don't already know. *Psychology, Public Policy, and Law*, *6*(1), 216–222. https://doi.org/10.1037/1076-8971.6.1.216

Steenbergen-Hu, S., Makel, M. C., & Olszewski-Kubilius, P. (2016). What one hundred years of research says about the effects of ability grouping and acceleration on K–12 students' academic achievement: Findings of two second-order meta-analyses. *Review of Educational Research*, *86*(4), 849–899. https://doi.org/10.3102/0034654316675417

Steenbergen-Hu, S., & Moon, S. (2011). The effects of acceleration on high-ability learners: A meta-analysis. *Gifted Child Quarterly*, *55*(1), 39–53. https://doi.org/10.1177/0016986210383155

Stoet, G., & Geary, D. C. (2015). Sex differences in academic achievement are not related to political, economic, or social equality. *Intelligence*, *48*, 137–151. https://doi.org/10.1016/j.intell.2014.11.006

Stoet, G., & Geary, D. C. (2018). The gender-equality paradox in science, technology, engineering, and mathematics education. *Psychological Science*, *29*(4), 581–593. https://doi.org/10.1177/0956797617741719

Su, R., Rounds, J., & Armstrong, P. I. (2009). Men and things, women and people: A meta-analysis of sex differences in interests. *Psychological Bulletin*, *135*(6), 859–884. https://doi.org/10.1037/a0017364

Super, D. E., & Bachrach, P. B. (1957). *Scientific careers and vocational development theory*. Teachers College Press.

Terman, L. M. (1931). Introduction. In D. Fryer (Ed.), *The measurement of interests: In relation to human adjustment* (pp. xvii–xix). Holt.

Terman, L. M. (1954a). Scientists and nonscientists in a group of 800 gifted men. *Psychological Monographs*, *68*(7), 1–44. https://doi.org/10.1037/h0093672

Terman, L. M. (1954b). The discovery and encouragement of exceptional talent. *American Psychologist*, *9*(6), 221–230. https://doi.org/10.1037/h0060516

Terman, L. M. (1955). Are scientists different? *Scientific American*, *192*(1), 25–29. https://doi.org/10.1038/scientificamerican0155-25

Thorndike, R. L. (1949). *Personnel selection: Test and measurement techniques*. John Wiley.

Tyler, L. E. (1974). *Individual differences*. Prentice Hall.

Tyler, L. E. (1992). Counseling psychology—Why? *Professional Psychology*, *23*(5), 342–344. https://doi.org/10.1037/0735-7028.23.5.342

von Strumm, S., & Ackerman, P. L. (2013). Investment and intelligence: A review and meta-analysis. *Psychological Bulletin*, *139*(4), 841–869. https://doi.org/10.1037/a0030746

Wai, J., Lubinski, D., & Benbow, C. P. (2005). Creativity and occupational accomplishments among intellectually precocious youth: An age 13 to age 33 longitudinal study. *Journal of Educational Psychology*, *97*(3), 484–492. https://doi.org/10.1037/00220663.97.3.484

Wai, J., Lubinski, D., & Benbow, C. P. (2009). Spatial ability for STEM domains: Aligning over fifty years of cumulative psychological knowledge solidifies its importance. *Journal of Educational Psychology*, *101*(4), 817–835. https://doi.org/10.1037/a0016127

Wai, J., Lubinski, D., Benbow, C. P., & Steiger, J. H. (2010). Accomplishment in science, technology, engineering, and mathematics (STEM) and its relation to STEM educational dose: A 25-year longitudinal study. *Journal of Educational Psychology*, *102*(4), 860–871. https://doi.org/10.1037/a0019454

Wai, J., & Worrell, F. C. (2016). Helping disadvantaged and spatially talented students fulfill their potential: Related and neglected national resources. *Policy Insights from the Behavioral and Brain Sciences*, *3*(1), 122–128. https://doi.org/10.1177/2372732215621310

Waller, J. H. (1971). Achievement and social mobility: Relationships among IQ score, education, and occupation in two generations. *Social Biology*, *18*(3), 252–259. https://doi.org/10.1080/19485565.1971.9987927

Warne, R. T. (2012). History and development of above-level testing of the gifted. *Roeper Review*, *34*(3), 183–193. https://doi.org/10.1080/02783193.2012.686425

Warne, R. T. (2015). Five reasons to put the *g* back into giftedness: An argument for applying the Cattell–Horn–Carroll Theory of intelligence to gifted education research and practice. *Gifted Child Quarterly*, *60*(1), 3–15. https://doi.org/10.1177/0016986215605360

Warne, R. T., Sonnert, G., & Sadler, P. M. (2019). The relationship between advanced placement mathematics courses and students' STEM career interest. *Educational Researcher*, *48*(2), 101–111. https://doi.org/10.3102/0013189X19825811

Webb, R. M., Lubinski, D., & Benbow, C. P. (2002). Mathematically facile adolescents with math-science aspirations: New perspectives on their educational and vocational development. *Journal of Educational Psychology*, *94*(4), 785–794. https://doi.org/10.1037/0022-0663.94.4.785

Webb, R. M., Lubinski, D., & Benbow, C. P. (2007). Spatial ability: A neglected dimension in talent searches for intellectually precocious youth. *Journal of Educational Psychology*, *99*(2), 397–420. https://doi.org/10.1037/0022-0663.99.2.397

Williamson, E. G. (1965). *Vocational counseling: Some historical, philosophical, and theoretical perspectives*. McGraw-Hill.

Wilson, E. O. (1998). *Consilience: The unity of knowledge*. Knopf.

Wise, L. L., McLaughlin, D. H., & Steel, L. (1979). *The Project TALENT data bank*. American Institutes for Research. https://www.projecttalent.org/wp-content/uploads/2017/02/Data_Bank_Handbook_(1979).pdf

Worrell, F. C., Subotnik, R. F., Olszewski-Kubilius, P., & Dixson, D. D. (2019). Gifted students. *Annual Review of Psychology*, *70*, 551–576. https://doi.org/10.1146/annurev-psych-010418-102846

Zabaneh, D., Krapohl, E., Gasper, H., Curtis, C., Lee, S., Patel, H., Newhouse, S., Wu, H. M., Simpson, M., Putallaz, M., Lubinski, D., Plomin, R., & Breen, G. (2018). A genome-wide association study of extremely high intelligence. *Molecular Psychiatry*, *23*(5), 1226–1232. https://doi.org/10.1038/mp.2017.121

Zuckerman, H. (1977). *Scientific elite*. Free Press.

Author Biographies

David Lubinski is Cornelius Vanderbilt professor of Psychology at Vanderbilt University, where he co-directs the Study of Mathematically Precocious Youth. His research interests are in modeling the development of exceptional intellectual talent over the life span to uncover factors that enhance and attenuate learning and work accomplishments as well as creativity and eminence. He has served as President for the International Society for Intelligence Research, a trustee for the Society for Multivariate Experimental Psychology, and Associate Editor for the *Journal of Personality and Social Psychology*. He received APA's 1996 Early Career Award (psychometrics/applied individual differences), and APA's George A. Miller Outstanding article in General Psychology Award (twice 1996, 2016), the Distinguished Scholar Award (National Association for Gifted Children. 2006), the MENSA Research Foundation's Lifetime Achievement Award (2015), and the Lifetime Achievement Award: For Outstanding Contributions to the Field of Intelligence (2018) from the International Society for Intelligence Research.

Camilla P. Benbow is Patricia and Rodes Hart Dean of Education and Human Development at Vanderbilt University's Peabody College. She has led Peabody, one of the nation's leading colleges of education and human development, since 1998. She also codirects the Study of Mathematically Precocious Youth. She has served on the National Science Board, vice-chair of the National Mathematics Advisory Panel, and is on the board of the American Psychological Foundation. She has received the David Imig Award from the American Association of Colleges for Teacher Education, the President's and Distinguished Scholar Awards from the National Association for Gifted Children, the Distinguished Alumna Award from Johns Hopkins University, and the Lifetime Achievement Award from the MENSA Education and Research Foundation. The International Society for Intelligence Research awarded her its highest honor: the Lifetime Achievement Award: For Outstanding Contributions to the Field of Intelligence. And, in 2019, received the World Council for Gifted and Talented Children: International Award for Research.

Manuscript received: October 4, 2019; Final revision received: January 15, 2020; Accepted: February 20, 2020