Psychological Science OnlineFirst, published on May 25, 2016 as doi:10.1177/0956797616644735

Research Article

ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Psychological Science
1–15

DOI: 10.1177/0956797616644735
pss.sagepub.com
SAGE

When Lightning Strikes Twice: Profoundly Gifted, Profoundly Accomplished

Matthew C. Makel[1], Harrison J. Kell[2], David Lubinski[3], Martha Putallaz[1], and Camilla P. Benbow[3]
[1]Talent Identification Program, Duke University; [2]Academic & Workforce Readiness & Success, Research & Development, Educational Testing Service, Princeton, New Jersey; and [3]Department of Psychology and Human Development, Vanderbilt University

Abstract
The educational, occupational, and creative accomplishments of the profoundly gifted participants (IQs ≥ 160) in the Study of Mathematically Precocious Youth (SMPY) are astounding, but are they representative of equally able 12-year-olds? Duke University's Talent Identification Program (TIP) identified 259 young adolescents who were equally gifted. By age 40, their life accomplishments also were extraordinary: Thirty-seven percent had earned doctorates, 7.5% had achieved academic tenure (4.3% at research-intensive universities), and 9% held patents; many were high-level leaders in major organizations. As was the case for the SMPY sample before them, differential ability strengths predicted their contrasting and eventual developmental trajectories—even though essentially all participants possessed both mathematical and verbal reasoning abilities far superior to those of typical Ph.D. recipients. Individuals, even profoundly gifted ones, primarily do what they are best at. Differences in ability patterns, like differences in interests, guide development along different paths, but ability level, coupled with commitment, determines whether and the extent to which noteworthy accomplishments are reached if opportunity presents itself.

Keywords
intelligence, creativity, giftedness, replication, blink comparator

Received 11/19/15; Revision accepted 3/25/16

Extraordinary economies are created by extraordinary minds. More than ever, the strength of countries and their competitiveness depends on exceptional human capital (Friedman, 2007; National Science Board, 2010). This leads to the question: Is it possible to identify those individuals who possess this exceptional human capital early in their lives so that their talents can be fostered for the good of society as well as their own? Recently, as part of the ongoing Study of Mathematically Precocious Youth (SMPY; Lubinski & Benbow, 2006), Kell, Lubinski, and Benbow (2013) tracked the educational, occupational, and creative accomplishments of 320 youths assessed before age 13 as being in the top 1 in 10,000 in mathematical or verbal reasoning ability (or both). They were identified through talent searches using above-level assessments (i.e., mathematical and verbal reasoning measures designed for college-bound high school seniors). By age 38, the magnitude of their creativity, occupational success, and professional stature was astonishing.

Specifically, over the course of 25 years, the individuals who had been identified by SMPY before age 13

Corresponding Authors:
Matthew C. Makel, Talent Identification Program, Duke University, 300 Fuller St., Durham, NC 27701
E-mail: mmakel@tip.duke.edu

Harrison J. Kell, Academic & Workforce Readiness & Success, Research & Development, Educational Testing Service, Princeton, NJ 08541
E-mail: hkell@ets.org

David Lubinski, Vanderbilt University, Department of Psychology and Human Development, Peabody 0552, Nashville, TN 37203
E-mail: david.lubinski@vanderbilt.edu

Martha Putallaz, Talent Identification Program, Duke University, 300 Fuller St., Durham, NC 27701
E-mail: putallaz@duke.edu

Camilla P. Benbow, Vanderbilt University, Department of Psychology and Human Development, Peabody 0552, Nashville, TN 37203
E-mail: camilla.benbow@vanderbilt.edu

accomplished the following: Forty-four percent had obtained doctoral degrees, 7.5% had secured academic tenure at research-intensive universities, and 15% held one or more patents (Kell, Lubinski, & Benbow, 2013). Several were highly successful vice presidents, partners, and department heads in the corporate sector or in the field of law, medicine, or information technology. Yet, even though essentially all participants possessed quantitative and verbal reasoning abilities far superior to those of typical Ph.D. recipients (Wai, Lubinski, & Benbow, 2009), different patterns of profound intellectual talent uncovered in their youth were predictive of qualitatively different educational, occupational, and creative outcomes. To be sure, other things (e.g., commitment, interests, opportunity), clearly mattered (Lubinski & Benbow, 2000, 2006; Simonton, 2014). Nonetheless, participants seemed to prefer to, and did, develop their talents in those areas in which they displayed the highest potential. The policy implications for developing human capital across the life span and for biosocial research are evident and range from calibrating expectations for educational interventions (Subotnik, Olszewski-Kubilius, & Worrell, 2011) to illuminating phenotypes for neuroscientific inquiry into human cognition (Jung & Haier, 2007).

However, there are reasons to exercise caution. These results were based on one sample, and there are no studies in the literature to corroborate the findings. Consequently, replication is essential (Makel & Plucker, 2014; Makel, Plucker, & Hegarty, 2012; Open Science Collaboration, 2015). Would the magnitude of achievement observed by SMPY, and the role that specific abilities appeared to play in structuring qualitatively different accomplishments, be observed in other samples of profoundly gifted young adolescents? Moreover, SMPY's sample was identified by Julian C. Stanley in the early 1980s (Lubinski & Benbow, 2006), and, like Terman before him (Holahan, Sears, & Cronbach, 1995), Stanley worked with many of his participants to develop their talents as adolescents and even as young adults (see the Supplemental Material available online). Did his intervention affect long-term outcomes? Stanley had hoped, of course, that it would.

Answering these questions in a scientifically compelling way presents formidable challenges. Modern talent searches utilizing above-level assessments identify hundreds of profoundly gifted young adolescents annually (Wai, Cacchio, Putallaz, & Makel, 2010), so the opportunity to identify individuals in this population is available, but an extended longitudinal component also is needed. Fortunately, Duke University's Talent Identification Program (TIP; Putallaz, Baldwin, & Selph, 2005) began conducting annual above-level assessments on 10s of thousands of intellectually talented youth in 1981 and, thus, affords the opportunity to satisfy all the methodological requirements to evaluate the generalizability of the SMPY findings (Kell, Lubinski, & Benbow, 2013). The present study, a collaboration between SMPY and Duke TIP, was designed to determine if an independent sample of equally able young adolescents would yield results conceptually equivalent to the two general findings for the SMPY sample: Specifically, we examined whether (a) the magnitude of the educational, occupational, and creative accomplishments of the SMPY sample would be commensurate with that of the TIP sample, and (b) whether patterns of mathematical and verbal abilities would have the same potency in predicting qualitatively different accomplishments over time in the TIP sample as they had in the SMPY sample. Would lightning strike twice?

Method

Participants and selection criteria

Over the past 35 years, Duke TIP has assessed more than 2.5 million of the most intellectually talented young adolescents in the United States (Putallaz et al., 2005). It has done so by inviting young adolescents who score in the top 3 to 5% on achievement tests, routinely administered in their schools, to take college entrance exams such as the SAT. For the current study, SAT data on more than 425,000 Duke TIP participants were examined to identify a sample equivalent to Kell, Lubinski, and Benbow's (2013) in both age and ability level. All participants were enrolled in Duke TIP's talent search prior to 1995 and had earned scores of least 700 on the SAT-Math or at least 630 on the SAT-Verbal (or both) before reaching age 13—which placed them in the top 0.01% of ability for their age group. Our search identified 271 such qualified individuals. Twelve who also had been identified by SMPY and had participated in Kell, Lubinski, and Benbow's study were culled from our final sample which then consisted of 259 individuals (214 males, 45 females), who had taken the SAT between 1981 and 1994 at a mean age of 12.6 years (SD = 0.59). When data on their accomplishments were collected, their mean age was 40 years (SD = 2.4). Their ethnic distribution was as follows: 24% Asian, 65% Caucasian, and 1% other (9% did not report their ethnicity). (See Table S1 in the Supplemental Material for additional demographic information.)

Procedure and outcome criteria

The same Web-based search and data-analytic procedures utilized by Kell, Lubinski, and Benbow (2013) were employed to gather information about the TIP sample's educational degrees, occupations, and creative accomplishments. During 2012 through 2014, Web-based search engines were used to collect information about publications, educational credentials, grants, patents, and other creative and occupational accomplishments paralleling those tabulated by Kell, Lubinski, and Benbow. For all statistical results reported here, the first and second authors conducted independent statistical analyses of the educational, occupational, and creative accomplishments of the TIP participants, to confirm the reliability of findings.

First, we examined the extent to which similar ability patterns and life outcomes reliably emerged in the two samples. To highlight the level and range of psychological diversity under analysis, we created scatterplots showing the association between SAT-Math and SAT-Verbal scores in each sample. We then examined the extent to which contrasting ability patterns, as measured by SAT scores, reliably covaried with differential educational (graduate degrees), occupational, and creative accomplishments, viewing these three categories of outcomes as contiguous temporal slices of participants' life trajectories. We looked for clustering of specific accomplishments in a bivariate intellectual space defined by SAT-Math scores (x-axis) and SAT-Verbal scores (y-axis).

Our graphic approach is equivalent to the technique implemented by a *blink comparator* in astronomy (National Air and Space Museum, 2015): Temporally contiguous photographs of the same fields of the night sky are rapidly flashed back and forth on a screen to enable detection of differences in either the brightness of certain objects or, more relevant to the present study, their organizational patterning. Do the celestial objects occupy the same locations in otherwise identical photographs and, if not, in which direction are they headed? Similarly, we sought to characterize the organization and the trajectory of contrasting "constellations" (*criterion classes*) of psychological outcomes emanating from differing patterns of profound intellectual talent. If configurations of profound intellectual talent systematically organize and temporally structure major life outcomes such that different configurations are associated with qualitatively different trajectories from education to occupation to creative accomplishments over 25 years, specific accomplishments should consistently co-occur within distinct regions of intellectual space. We evaluated this idea in two ways: *collaterally*, comparing corresponding criterion classes of the two samples, for the purposes of direct replication (S. Schmidt, 2009), and, *sequentially*, comparing the three criterion classes over time within each sample, for ascertaining the longitudinal potency of early-identified patterns of profound intellectual talent over time. This approach aligns well with other applications employed when form and pattern are more germane than statistical significance, during the early stages of theory development (Meehl, 1978, pp. 824–825, 1990; Wai et al., 2009).

Directed by the achievement categories used by Kell, Lubinski, and Benbow (2013), we computed averaged bivariate points (SAT-Math, SAT-Verbal) representing narrowly defined criterion groups (e.g., engineering degrees). Some participants achieved outcomes that could not be rationally allocated to classes consisting of more than 1 individual, and in these cases, we labeled and plotted single bivariate points in the spirit of Kell, Lubinski, and Benbow's effort to preserve the idiographic character of the findings. Finally, for establishing cross-sample parallels, we assembled three major criterion classes for each superordinate outcome category (educational, occupational, and creative achievements). We surrounded the centroid of each of these three major criterion classes with two tiers of bivariate ellipses in order to assess the extent to which these criterion classes occupied different regions within the intellectual space defined by the axes of mathematical and verbal reasoning abilities. The ellipse closest to each centroid was defined by the standard errors of the mean for that group, having a height and width of ±1 *SEM* for the SAT-Verbal score and SAT-Math score, respectively; the outer ellipse was defined by the standard deviations for that group, having a height and width of ±1 *SD* for the SAT-Verbal score and SAT-Math score, respectively. These rationally developed clusters were designed to capture major classes of qualitatively different ultimate criteria (Thorndike, 1949), which reflect an appreciable degree of latent consistency and thematic unity over time.

The first author developed the narrowly defined criterion groups for the TIP sample independently, as a member of the Duke TIP team, although he consulted with Kell, Lubinski, and Benbow when necessary (e.g., to clarify whether a managing partner of a law firm was considered an attorney and not an administrator-manager in the 2013 SMPY study). Care was taken to avoid investigators from the original SMPY study exerting influence on the Duke TIP categorizations. Naturally, there were some differences between the samples in the disciplines in which individuals earned degrees, as well as in occupations and creative accomplishments. Consequently, we used the narrow categories developed by Kell, Lubinski, and Benbow (2013) as a guide but departed from their coding scheme when necessary to account for the uniqueness of the Duke TIP sample. For example, the Duke TIP sample contained 1 participant with a doctorate in veterinary medicine, whereas the SMPY group did not; the converse was true for acupuncture and Oriental medicine.

Although the analyses described thus far characterized the qualitative nature and pattern of participants' accomplishments through an idiographic-nomothetic, qualitative-quantitative mixed-methods approach, they did not address the magnitude of participants' accomplishments. Therefore, we next assembled five tables that detailed the breadth and intensity of participants' creative accomplishments, impact, and professional stature, such as the number of refereed articles and books they had published, the number of patents they held, the percentage who had earned tenure at a research-intensive university, the amount of grant support they had received from the National Institutes of Health and National Science Foundation, and the prestigious occupational roles they had.

Results

Figure 1 consists of bivariate scatterplots of the SAT-Math and SAT-Verbal data, secured by age 13, for the Duke TIP participants (top panel) and the SMPY participants (bottom panel). Given the selection criteria, every participant was in the top 1 in 10,000 for either the SAT-Math or the SAT-Verbal score—and an appreciable subset were at this level for both subtests. One reason for presenting these plots is to highlight the vast amount of psychological diversity reliably found among young adolescents selected for an extreme specific ability. They vary in psychologically meaningful ways not only on the measure on which they were selected but also on other specific ability measures on which they were *not* selected. For example, consider the participants scoring 700 or above on the SAT-Math. Some have SAT-Verbal scores that are even more impressive, whereas others have SAT-Verbal scores that are "merely" around the cutoff for the top 1% (i.e., just under 400) in verbal reasoning ability. But do these differences matter for important life outcomes? This question is answered empirically and in the affirmative by examining the outcomes organized and graphed in Figures 2 through 4.

Nature of accomplishment

For both samples, distinct configurations of profound intellectual talent were associated with contrasting constellations of ultimate outcomes. Salient clusters reliably emerged within and across time, revealing that individuals with profound intellectual talent tend to gravitate toward domains congruent with their intellectual strengths. At all three time points, impressive and rare outcomes in the arts and humanities were much more likely to emerge in the northwest quadrant within the Cartesian coordinate panel than in the other quadrants; that is, these accomplishments were found primarily among participants whose SAT-Verbal scores were higher than their SAT-Math scores. Conversely, impressive and rare science, technology, engineering, and mathematics (STEM) outcomes were found primarily among participants whose SAT-Math scores were higher than their SAT-Verbal scores. Law degrees, careers in law, and creative accomplishments in this field (i.e., legal publications) occupied an intermediate location within the space defined by these dimensions.

Just as "astronomical blinking" isolates celestial constellations and their respective trajectories, shifting one's visual focus within each figure and across all three figures validates the robustness of the different constellations of psychological outcomes and their organization by distinct patterns of profound intellectual talent, which give rise to qualitatively different developmental paths. In all nine cases across the three figures, the two samples' corresponding major centroids were within 1 standard error of each other. The Pearson's *r*s and Spearman's rhos for the locations of the full set of corresponding x and y values for the major centroids (Figs. 2–4) were both .97. The Pearson's *r*s and Spearman's rhos for the corresponding x values were .96 and 1.0, respectively, and those for the corresponding y centroid values were .96 and .85. Within each temporal frame, these constellations of major outcomes clearly occupied similar regions of intellectual space in the two samples. In addition, the constellations showed similar patterns over time in the two samples.

A finding manifested in both samples—but not emphasized in Kell, Lubinski, and Benbow's (2013) report—is that participants who excelled in the humanities tended to be have more variability in their SAT-Math scores than in their SAT-Verbal scores, whereas the inverse was true among those who excelled in STEM. This underscores that individuals who perform at exceptional levels often vary the least on the attributes most relevant for that performance.

It needs to be noted that there was a ceiling problem with the SAT-Math scores for participants with exceptional STEM outcomes. For example, the mean SAT-Math score for those with creative accomplishments in STEM was 718 (SD = 47) for the Duke TIP participants and 727 (SD = 42) for the SMPY sample. Ceiling effects are evident when a scale's mean is within 2 standard deviations of its ceiling (Lubinski & Humphreys, 1990, p. 334). The mean SAT-Math scores for the Duke TIP and SMPY participants included in the STEM centroids shown in Figures 2 through 4 were all less than 1.75 standard deviations from the highest possible score (800). This suggests that the ellipses surrounding STEM accomplishments would expand in width and move somewhat to the right if assessments capturing the full scope of these participants' mathematical reasoning prowess had been utilized. As impressive as these young adolescents' scores are, the SAT-Math does not capture the full scope of their mathematical reasoning capability; consequently, this specific ability and the general factor that runs through all measures of cognitive functioning (Frey & Detterman, 2004) were not assessed in their full scope. Therefore, within both samples and across all three figures, the psychological distance between the STEM criterion classes and the others is somewhat underestimated.

Magnitude of accomplishment

Table 1 lists a heterogeneous collection of highly valued low-base-rate accomplishments and indicates their

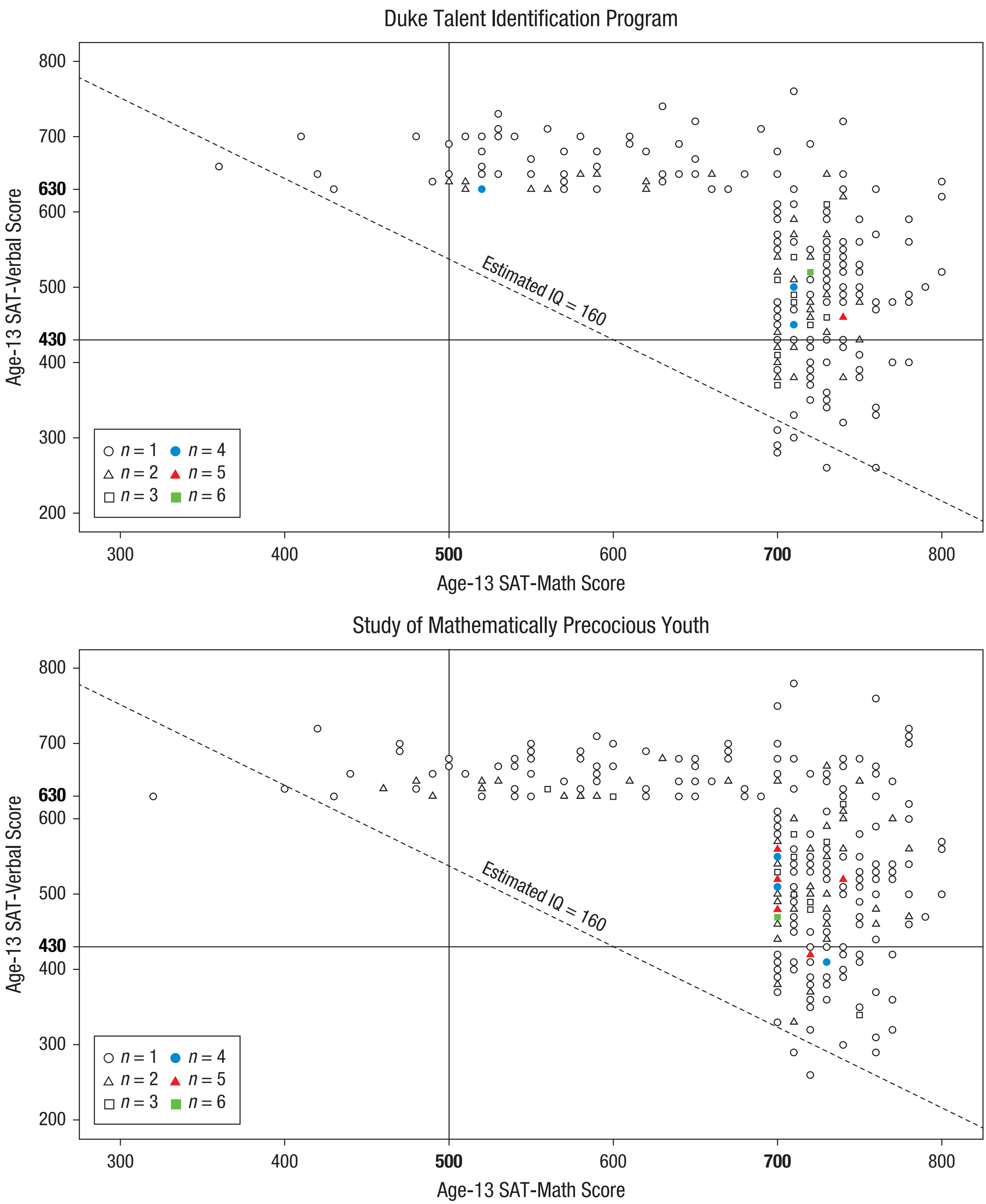

Fig. 1. Scatterplot of age-13 SAT-Math and SAT-Verbal scores for the two samples: Duke University's Talent Identification Program participants (top panel) and the Study of Mathematically Precocious Youth participants (bottom panel). The diagonal line in each scatterplot denotes where an estimated IQ of 160 falls (Frey & Detterman, 2004; Lubinski, Webb, Morelock, & Benbow, 2001, p. 719); bivariate values above these 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.

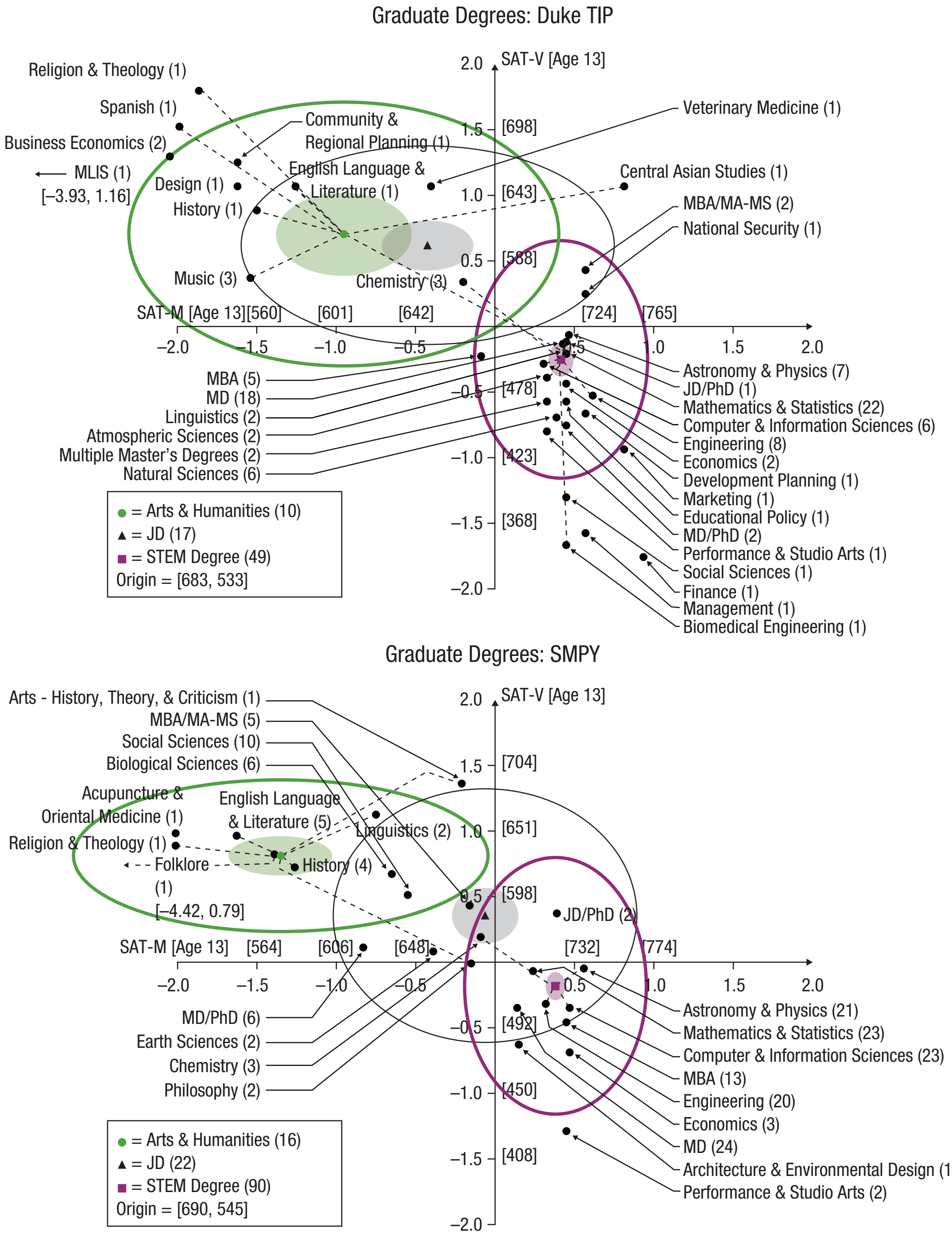

Fig. 2. Bivariate means for age-13 SAT-Math (SAT-M; *x*) and SAT-Verbal (SAT-V; *y*) scores within categories of terminal graduate degrees for Duke University's Talent Identification Program (TIP) participants (top panel) and the Study of Mathematically Precocious Youth (SMPY) participants (bottom panel). Means for individual categories are represented by black circles; the sample sizes for these categories are in parentheses. The green circles, black triangles, and purple squares represent rationally derived major outcome clusters (*n*s are located in the keys). The dashed lines emanating from the centroids 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 length = ±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 length = ±1 *SD* for SAT-M and SAT-V, respectively). Slashes indicate dual degrees. Along the axes, unbracketed values are SAT-M and SAT-V scores in *z*-score units, and bracketed values are raw SAT scores. Two bivariate means are located outside the plotted areas and shown in brackets: in the TIP sample, the bivariate mean for a master's of library information sciences (MLIS), and in the SMPY sample, the bivariate mean for a degree in folklore. The SMPY data for this figure are adapted from Kell, Lubinski, and Benbow (2013). STEM = science, technology, engineering, and mathematics.

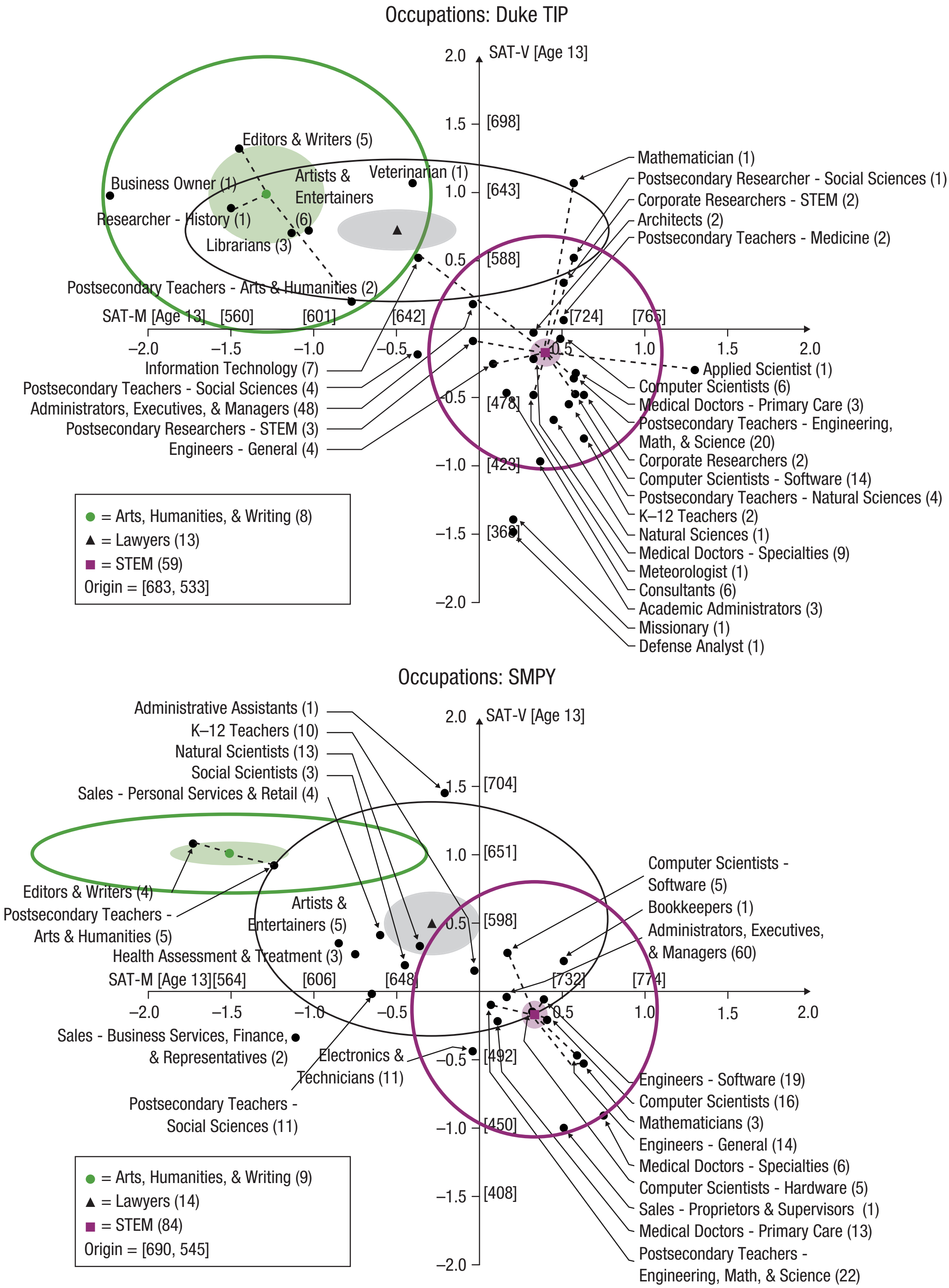

Fig. 3. Bivariate means for age-13 SAT-Math (SAT-M; *x*) and SAT-Verbal (SAT-V; *y*) scores within occupational categories for Duke University's Talent Identification Program (TIP) participants (top panel) and the Study of Mathematically Precocious Youth (SMPY) participants (bottom panel). See Figure 2 for an explanation of the notational scheme. The SMPY data are adapted from Kell, Lubinski, and Benbow (2013), with two label changes: "K-12 Teachers" was "Non-Postsecondary Teachers" in the original figure, and "Administrators, Executives, & Managers" was "Administrative, Executive, & Management" in the original figure. STEM = science, technology, engineering, and mathematics.

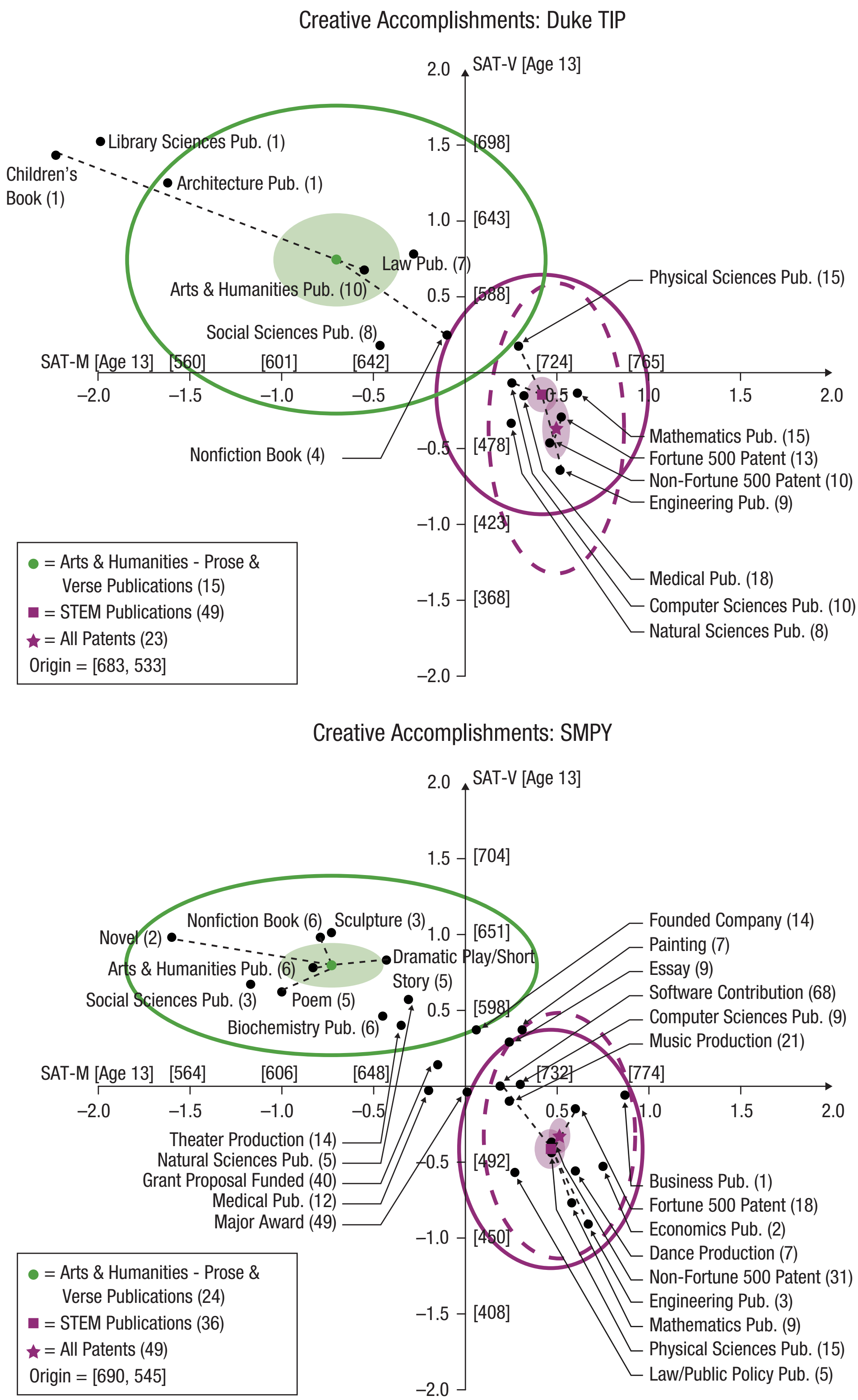

Fig. 4. Bivariate means for age-13 SAT-Math (SAT-M; *x*) and SAT-Verbal (SAT-V; *y*) scores within creative-accomplishment categories for Duke University's Talent Identification Program (TIP) participants (top panel) and the Study of Mathematically Precocious Youth (SMPY) participants (bottom panel). See Figure 2 for an explanation of the notational scheme; in this figure, however, purple stars are used instead of black triangles, to indicate that two of the major categories (represented by purple squares and stars) are science, technology, engineering, and mathematics (STEM) outcomes. Note that the outer ellipses for patents are dashed, so that they can be distinguished from the outer ellipses for STEM publications. The SMPY data are adapted from Kell, Lubinski, and Benbow (2013).

Table 1. Selected Educational, Occupational, and Creative Accomplishments of the Talent Identification Program (TIP) and 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%. 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.

frequency in both the Duke TIP and the SMPY samples, providing an additional point of comparison for the samples. Intellectually talented populations are known to differ significantly in the frequency of these accomplishments relative to the norm (Lubinski, Benbow, & Kell, 2014). To put these data into perspective, consider the following base rates: In the United States, the base rates for earning a doctorate, publishing a book, and securing a patent are 2%, less than 1%, and 1%, respectively (see the Supplemental Material).

In addition to being markedly beyond base-rate expectations, the values in this table, reflecting the participants' achievement at around age 38 to 40, essentially meet or exceed those of more typical talent-search participants (top 1%) at age 50 (Lubinski et al., 2014), which suggests that these more-select top-0.01% samples are on a different developmental trajectory. However, it is difficult to make precise comparisons between the profoundly gifted participants in the current study and top-1% adolescents who are now much older. One quantitative comparison that can be made concerns their advanced degrees. Essentially, our two profoundly gifted groups have completed their terminal educational degrees (and even if not, this comparison would underestimate the difference these groups and the top 1%). Whereas 37% of the Duke TIP sample had earned a doctorate by age 40 and 44% of the SMPY sample had earned a doctorate by age 38, 31.7% of the top-1% participants studied by Lubinski et al. (2014) had earned a doctorate by age 50. Although the difference from the top-1% sample is significant for the SMPY sample, it only approaches statistical significance for the TIP sample. However, this contrast fails to capture the differential trajectories of the gifted and the profoundly gifted: For example, 16.3% of the TIP sample and 22.5% of the SMPY sample had secured their doctorates from the top 10 U.S. graduate training institutions (see Table S2 in the Supplemental Material), whereas "only" 6.1% of the top 1% identified at age 13 and recently tracked by Lubinski et al. to age 50 had done so (both contrasts between the top 1% and the top 0.01% were significant, zs = 5.74 and 9.74, ps < .01).

Further context for interpreting these results is provided by previous studies of the profoundly gifted SMPY participants in Kell, Lubinski, and Benbow's (2013) study. Those earlier studies revealed that their age-33 accomplishments typically met or surpassed those of top math and science graduate students identified in their 1st or 2nd year of graduate work and then tracked until their mid-30s (Lubinski, Benbow, Webb, & Bleske-Rechek, 2006). Further, another study of the first three SMPY cohorts, who were all in the top 1% in quantitative reasoning ability (N > 1,500), revealed that their ability differences assessed at age 13 continued to predict their numbers of publications and patents even when analyses controlled for terminal educational degree and caliber of participants' graduate institution (Park, Lubinski, & Benbow, 2008). Although it is often difficult to provide precise quantitative measurement of differences between the profoundly gifted and pertinent comparison samples, such quasi-experimental evidence can be compelling. It suggests that there are differences between the profoundly gifted (top 0.01%) and the gifted (top 1%) beyond that those that are afforded by opportunity.

Other compelling evidence consists of the idiographic data on the particulars of our samples' occupational roles and creative expression. Such data are found in Tables 2 through 5. Unfortunately, however, unlike qualitatively different outcomes that may be aggregated into meaningful

Table 2. Outlying Accomplishments of the Talent Identification Program (TIP) and 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 the 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."

clusters, with the distance between clusters meaningfully interpreted quantitatively (Figs. 2–4), the unique idiographic accomplishments listed in Tables 2 through 5 cannot easily be scaled to allow precise quantitative comparisons. Yet the idiographic achievements in the tables are clearly indicative of exceptional creativity and occupational impact that cannot be lightly dismissed. They speak to the extent to which this population, and the full scope of its members' individuality, is worthy of future study.

Table 2 sheds further light on the magnitude of the TIP and SMPY samples' outcomes by listing accomplishments of individual outliers. These examples illustrate how commensurate these impressive and rare accomplishments are across the two samples. For the Duke TIP participants specifically, individual accomplishments range from being named one of "America's Top Physicians," to having argued more than 10 cases before the U.S. Supreme Court, to being the president of a major city's chamber of commerce, to holding 43 patents. Included among the noteworthy accomplishments for the SMPY participants are being the codirector of a major organ-transplant center, being a vice president of a Fortune 500 company, being a national policy advisor to a president of the United States, and having produced more than 500 musical productions. We need to be somewhat cryptic in describing these accomplishments in order to protect identities, but sufficient detail is given to paint an adequate picture of the samples' achievements. Individually, any one of these outstanding accomplishments could be dismissed as simply an interesting anecdote, but, collectively, the list coalesces into solid documentation of the potential and versatility found among adolescents with profound intellectual talent.

Tables 3 through 5 (which parallel Tables 1–3 in Kell, Lubinski, & Benbow, 2013) provide more extensive and fine-grained details on the magnitude of the TIP participants' creativity and impact, and the prestige of their work-related accomplishments, which appear to be commensurate with those of the SMPY sample. The TIP participants have published widely in refereed outlets (Table 3), in fields ranging from the highly holistic and organic (e.g., arts and humanities, biology, medicine) to the highly technical and inorganic (e.g., computer science, engineering, mathematics). Moreover, they occupy an inordinate number of positions of great responsibility and trust, in many different kinds of organizations, which exert substantial influence on society at large and are vital for maintaining and advancing modern cultures (Tables 4 and 5). Moreover, it is important to note that they largely are still in the early part of their professional careers.

Discussion

Accomplishments of a profoundly gifted sample of 259 individuals identified by Duke TIP at age 13 and tracked over three decades (Tables 1–5) are consistent with the extraordinary occupational and creative outcomes observed earlier in an independent sample of 320 of their intellectual peers identified at a similar age and followed up through age 38 by SMPY (see Tables 1–3 in Kell, Lubinski, & Benbow, 2013). In addition, we observed coherent cross-sample qualitative differences in graduate degrees, occupations, and creative accomplishments as a function of distinct ability patterns identified by age 13 (Figs. 2–4). In short, the SMPY results were replicated,

Table 3. Details on Duke Talent Identification Program Participants' Creative Accomplishments (*N* = 259)

- Arts and humanities
  - Children's book (1, 1)[a]
  - Refereed publication (10, 1, 1–47, 63)
- STEM refereed publications (49, 8, 1–62, 695)
  - Astronomy and physics (9, 12, 1–37, 126)
  - Chemistry (5, 2, 1–60, 68)
  - Computer and information sciences (10, 2.5, 1–20, 75)
  - Earth sciences (1, 11)[b]
  - Engineering (9, 36, 1–62, 259)
  - Mathematics and statistics (15, 8, 2–34, 156)
- Other publications
  - Nonfiction books (4, 1, 1–2, 5)[c]
  - Refereed publications
    - Biology, genomics, and neuroscience (8, 10, 1–68, 133)
    - Law (7, 3, 1–13, 28)
    - Medicine (18, 5.5, 1–24, 125)[d]
    - Social sciences (9, 4, 1–43, 109)
- Patents (23, 3, 1–43, 142)[e]
  - Fortune 500 patents (13, 2, 1–43, 86)
- National Institutes of Health grants
  - Grants received (3, 5, 3–6, 14)
  - Funding received (3, $852K, $413K–$1.5M, $2.8M)[f]
- National Science Foundation grants
  - Grants received (10, 4, 1–10, 46)
  - Funding received (10, $650K, $90K–$6.6M, $16.5M)[f]

Note: Except where noted otherwise, the values in parentheses indicate the number of participants who achieved the accomplishment, the median number of accomplishments, the range of the number of accomplishments, and the total number of accomplishments aggregated across individuals. STEM = science, technology, engineering, and mathematics.
[a]One participant wrote one children's book. [b]One participant produced 11 refereed publications in the earth sciences. [c]The base rate for nonfiction books in the United States is 0.46% (see the Supplemental Material). [d]In Table 1 of Kell, Lubinski, and Benbow (2013), refereed publications in organic sciences were incorrectly listed as STEM referred publications. In fact, the analyses and figures in that article (as in the present one) included only inorganic disciplines as STEM disciplines. [e]The base rate for patents in the United States is approximately 1%. [f]Values in parentheses indicate the number of individuals who received grant funding and the median amount, range, and total amount of funding aggregated across individuals. K = thousands; M = millions.

and thus, these findings have important implications for the biosocial sciences and policy. It is possible to identify, at an early age, rare human capital that is needed to move society forward in multiple ways, which are differentially predictable.

The graphic approach utilized—conceptually equivalent to that of a blink comparator in astronomy—made visible to the naked eye contrasting constellations of psychological outcomes that emanated from different patterns of profound intellectual talent. Through sequencing educational, occupational, and then creative accomplishments over multiple decades, we demonstrated that qualitatively different psychological outcomes consistently occupy distinct regions of intellectual space. This approach complements other applications utilized when uncovering form and pattern is of focal significance (Meehl, 1978, 1990).

Ability level

Selecting the top 0.01% in ability identified an inordinate number of future innovators, corporate leaders, and builders of modern economies. They were "discovered" because above-level (developmentally appropriate) and sufficiently challenging intellectual assessments were used for these 13-year-olds. Specifically, these assessments identified future vice presidents of major corporations, lawyers at prestigious firms, financiers, tenured faculty at research-intensive universities, and STEM leaders—all socially valued outcomes. To assess competing explanations for the effect of extraordinary ability in SMPY participants, earlier SMPY studies formed quasi-experimental comparison groups: (a) top STEM graduate students identified in their early 20s and tracked into their mid-30s (Lubinski et al., 2006) and (b) talent-search participants throughout the top 1% in ability (not just the top 0.01%).

The SMPY sample appeared a bit more accomplished than the Duke TIP sample on some indicators (Table 1), even though they were equally able. Why? Was there, perhaps, an opportunity differential? To our knowledge, the only opportunity separating the two groups is Stanley's intervention, as described earlier. Did it have the impact for which he had hoped? We cannot definitively answer this question. However, our findings are consistent with such a conclusion.

Of course, ability, commitment, interests, and opportunity are all needed for extraordinary accomplishments to result (Lubinski & Benbow, 2000, 2006; Simonton, 1999, 2014), so how is it that the SMPY and the Duke TIP samples achieved so much given that they were selected exclusively on the basis of their extraordinary ability? The answer is that the selection process used measures that effectively capture the outer envelope of the primary personal characteristics needed for rare outcomes to eventuate.

David Epstein (2011), in *The Sports Gene*, reached the same conclusion. Just as there is not an ability threshold for intellectually demanding performances, neither is there a threshold beyond which more height does not matter for competing at the most elite level in basketball (i.e., the National Basketball Association, or NBA):

> For a man between six feet and 6'2" [between ages 20 and 40], the chance of his currently being in the NBA is five in a million. At 6'2" to 6'4", that increases to twenty in a million . . . between 6'10" and seven

Table 4. Job Titles of the Duke Talent Identification Program Participants and Descriptions of Their Employing Organizations

Corporate sector	Law	Medicine
Vice president: global investment firm with more than $32 billion in capital	Associate chief counsel: U.S. federal agency	Associate program director of ambulatory care: internal-medicine residency program at top-25 U.S. medical school
Vice president: Web site with more than $200 million in venture capital invested	Managing partner: law firm dealing with billion-dollar biotechnology deals	Chief of hematology: U.S. medical school
Managing partner: hedge fund managing nearly $83 million in assets	Partner: top-20 law firm according to the *Vault Guide to the Top 100 Law Firms*	Deputy director: office of the assistant secretary at a U.S. federal agency
Partner: global management consulting firm with more than 5,000 employees	Assistant director: criminal-justice project receiving thousands of requests annually from convicted felons seeking retrial	Nephrologist: top-100 "best company to work for" according to *Fortune*
Principal: global consulting firm with more than 15,000 employees		Neurological surgeon: private practice
Principal: global financial services company with more than $25 billion in annual revenue		Neurologist: vice president, board of directors of large medical organization
Senior director of corporate development: pharmaceutical company with nearly $1 billion in annual revenue		Orthopedic surgeon: private practice
Senior consulting actuary: consulting agency with more than $3 billion in annual revenue		Otolaryngologist: private practice
Senior developer: international human-resources organization with more than $400 million in annual revenue and more than 10,000 employees		Pediatric anesthesiologist: top-25 U.S. children's hospital
Senior development lead: Fortune 500 company		Pediatric cardiologist (assistant professor of pediatrics): top-25 U.S. medical school
Director of strategic planning: major Hollywood motion-picture studio		Pediatric endocrinology research fellow: member institution of the U.S. National Institutes of Health
		Vice president of finance: infectious-disease research organization with annual budget of more than $20 million

Information technology	Other
Cofounder and CEO: software company with multiple Fortune 500 clients	Provost: top-50 U.S. liberal-arts college
Director of operations: Fortune 500 company	Senior editor: U.S. national magazine with circulation of more than 150,000
Director of information-technology operations: Fortune 500 company	
Senior software engineer: GPS manufacturer with more than $2 billion in annual revenue	
Senior software-development engineer: Fortune 500 company	
Senior research software-development engineer: Fortune 500 company	
Principal research scientist: Fortune 500 company	

Note: Jobs are grouped rationally by occupational category. Organizational descriptions are sufficiently general to preserve participants' anonymity.

> feet tall, it rises to thirty-two thousand in a million [3.2%]. [Among] American men ages twenty to forty who stand seven feet tall, a startling 17 percent of them are in the NBA *right now*. Find six honest seven footers, and one will be in the NBA. (Epstein, 2011, pp. 131–132)

Thus, the lack of a threshold is a general principle that applies across multiple talent domains. Seven-foot-tall intellectual giants who also demonstrate reasonable commitment and drive, provided they have been given appropriate opportunity, are readily capable of distinguishing themselves in their learning- and work-related endeavors. However, exceptional ability, in combination with extraordinary commitment, *is* better, if true eminence is the goal.

To avoid giving the impression that only ability matters, we want to emphasize the importance of opportunity and its role in creating excellence. Not only is opportunity critical, but if routinely seized (i.e., commitment), it leads to more and even rarer opportunities for sharpening expertise (Simonton, 2014; Zuckerman, 1977)—an iterative process leading to further opportunities to develop and distinguish oneself. Accomplishment builds on and further enables accomplishment, technical innovation, and advances in the frontiers of knowledge.

Table 5. Institutions at Which Talent Identification Program Participants Had Been Granted Academic Tenure and Refereed Publications in Which Their Work Had Appeared

Tenure-granting institution	Selected refereed publication outlets
Bard College	Arts, humanities, and law
California State University, Long Beach	*Church History*
Colorado Mesa University	*Journal of the Early Republic*
Duke University	*Library Trends*
Michigan State University	*University of Pennsylvania Journal of Constitutional Law*
Naval Postgraduate School	*Washington University Law Review*
Pennsylvania State University	*Wisconsin Law Review*
Princeton University	General sciences
Purdue University	*Nature*
Sewanee: The University of the South	*Proceedings of the National Academy of Sciences, USA*
Southeast Community College	*Science*
University of Arizona (2)	Natural sciences and medicine
University of California, Davis	*The Annals of Thoracic Surgery*
University of Colorado, Boulder	*Annual Review of Genomics and Human Genetics*
University of Illinois, Urbana–Champaign	*Annual Review of Neuroscience*
University of Michigan	*Cell*
University of Tokyo	*The Lancet*
	Nature Neuroscience
	Neuron
	The New England Journal of Medicine
	Social sciences
	The American Economic Review
	American Journal of Public Health
	Annual Review of Resource Economics
	Journal of Health Economics
	Labour Economics
	Science, technology, engineering, and mathematics (STEM)
	Algebraic and Geometric Topology
	Astronomy & Astrophysics
	The Astrophysical Review
	Discrete Mathematics
	Journal of the Atmospheric Sciences
	The Journal of Chemical Physics
	Journal of Geophysical Research: Atmospheres
	Journal of Molecular Spectroscopy
	Journal of Number Theory
	Nuclear Physics B
	Physical Review Letters

Note: Institutions that the Carnegie Foundation (2010) classified as having "very high research productivity" are in boldface. If more than 1 participant was at an institution, the number is indicated in parentheses.

Ability pattern

Opportunity and initial ability level are important, but so is ability pattern. Ability level structures the magnitude, or degree, of accomplishment, whereas ability pattern guides the path of development into a particular domain, as shown by this study. We could detect this effect of pattern because the samples were identified by sufficiently challenging multidimensional assessments and because multiple rare (low-base-rate) criteria were used to assess ultimate life paths over protracted intervals (Corno et al., 2002; Thorndike, 1949). This approach revealed that ability differences within profoundly gifted samples are vast and multidimensional, and are important to assess in their full scope when modeling exceptional promise for differential learning, occupational outcomes, and creativity.

Well-documented auxiliary findings have revealed, however, that educational and occupational interests covary in different ways with measures of mathematical, spatial, and verbal reasoning. Therefore, appreciable intraindividual differences in cognitive abilities relate to motivational differences in gravitating toward (as well as away from) contrasting subject matters in educational and occupational settings (Ackerman, 1996; Ackerman & Heggestad, 1997; D. B. Schmidt, Lubinski, & Benbow, 1998; Webb, Lubinski, & Benbow, 2007). Different patterns of specific abilities are important, but so too is how they align with interests. Whether interests and specific abilities have common or distinct causal antecedents has yet to be determined (Lubinski, 2010). What is known is that each contributes incremental validity relative to the other in predicting the types of outcomes examined here (Lubinski & Benbow, 2006). Interests and abilities jointly drive development down different paths.

This leads to an important limitation of this study. The past 25 years have witnessed a growing realization that examining spatial ability sheds light on developmental phenomena in education, the world of work, and creativity. Yet spatial ability was not assessed in our samples early in their adolescence, some 30 years ago. Empirical evidence firmly reveals that for both typically developing college students and intellectually talented top-1% students, spatial ability adds value (incremental validity) to measures of mathematical and verbal reasoning ability in predicting the criteria examined here (Kell, Lubinski, Benbow, & Steiger, 2013; Lubinski, 2010; Wai et al., 2009). We suspect that our findings on ability patterns would have been even more compelling if spatial ability had been assessed.

Conclusion

Profound intellectual talent, and its patterning, has cross-disciplinary and policy implications. Just as identifying clear phenotypes indicative of developmental delays and psychopathology has informed neuroscience and behavioral genetic inquiry (Colom & Thompson, 2011; Plomin & Deary, 2014), characterizing phenotypes indicative of truly outstanding intellectual capability will likely lead to basic scientific advances. By studying intellectual continua in their full scope (Spain et al., 2015), a deeper psychological understanding of human accomplishment is attained. What also likely awaits is insight into the structures, systems, and subsystems underlying general and specific aspects of human intelligence and cognition.

Action Editor

Steven W. Gangestad served as action editor for this article.

Author Contributions

All five authors developed the study concept. Age-13 data collection for the Study of Mathematically Precocious Youth participants was conducted by C. P. Benbow, and data collection for the Duke Talent Identification Program sample was conducted by M. Putallaz. M. C. Makel, H. J. Kell, and D. Lubinski conducted the Web-based criterion searches. All the authors contributed to designing the particulars of the current study and writing the manuscript. The execution of the statistical analyses was conducted independently by M. C. Makel and H. J. Kell.

Acknowledgments

Invaluable recommendations and suggestions for this article were provided by Wystan Benbow, Frank Miele, William Revelle, and James H. Steiger.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Funding

Support for this study was provided by a research and training grant from the Templeton Foundation (Grant 55996) and by the Vanderbilt Kennedy Center for Research on Human Development.

Supplemental Material

Additional supporting information can be found at http://pss.sagepub.com/content/by/supplemental-data

References

Ackerman, P. L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence*, *22*, 227–257.

Ackerman, P. L., & Heggestad, E. D. (1997). Intelligence, personality, and interests: Evidence for overlapping traits. *Psychological Bulletin*, *121*, 218–245.

Carnegie Foundation. (2010). *The Carnegie classification of institutions of higher education*. Retrieved from http://classifications.carnegiefoundation.org/

Colom, R., & Thompson, P. M. (2011). Understanding human intelligence by imaging the brain. In T. Chamorro-Premuzic, S. von Stumm, & A. Furnham (Eds.), *The Wiley-Blackwell handbook of individual differences* (1st ed., pp. 330–352). Malden, MA: Blackwell.

Corno, L., Cronbach, L. J., Kupermintz, H., Lohman, D. F., Mandinach, E. B., Porteus, A. W., & Talbert, J. E., for the Stanford Aptitude Seminar. (2002). *Remaking the concept of aptitude: Extending the legacy of Richard E. Snow* (L. J. Cronbach, Ed.). Mahwah, NJ: Erlbaum.

Epstein, D. (2011). *The sports gene: Inside the science of extraordinary athletic performance.* New York, NY: Current.

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*, 373–378.

Friedman, T. L. (2007). *The world is flat: A brief history of the twenty-first century* (3rd ed.). New York, NY: Farrar, Straus and Giroux.

Holahan, C. K., Sears, R. R., & Cronbach, L. J. (1995). *The gifted group in later maturity.* Stanford, CA: Stanford University Press.

Jung, R. E., & Haier, R. J. (2007). The parieto-frontal integration theory (P-FIT) of intelligence: Converging neuroimaging evidence. *Behavioral & Brain Sciences*, *30*, 135–187.

Kell, H. J., Lubinski, D., & Benbow, C. P. (2013). Who rises to the top? Early indicators. *Psychological Science*, *24*, 648–659.

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

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*, 226–238.

Lubinski, D., & Benbow, C. P. (2000). States of excellence. *American Psychologist*, *55*, 137–150.

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*, 316–345.

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*, 2217–2232.

Lubinski, D., Benbow, C. P., Webb, R. M., & Bleske-Rechek, A. (2006). Tracking exceptional human capital over two decades. *Psychological Science*, *17*, 194–199.

Lubinski, D., & Humphreys, L. G. (1990). A broadly based analysis of mathematical giftedness. *Intelligence*, *14*, 327–355.

Lubinski, D., Webb, R. M., Morelock, M. J., & Benbow, C. P. (2001). Top 1 in 10,000: A 10-year follow-up of the profoundly gifted. *Journal of Applied Psychology*, *86*, 718–729.

Makel, M. C., & Plucker, J. A. (2014). Facts are more important than novelty: Replication in the educational sciences. *Educational Researcher*, *43*, 304–316.

Makel, M. C., Plucker, J. A., & Hegarty, B. (2012). Replications in psychology research: How often do they really occur? *Perspectives on Psychological Science*, *7*, 537–542.

Meehl, P. E. (1978). Theoretical risks and tabular asterisks: Sir Karl, Sir Ronald, and the slow progress of soft psychology. *Journal of Consulting and Clinical Psychology*, *46*, 806–834.

Meehl, P. E. (1990). Appraising and amending theories: The strategy of Lakatosian defense and two principles that warrant it. *Psychological Inquiry*, *1*, 108–141.

National Air and Space Museum. (2015, May 14). Finding Pluto with the blink comparator [Web log post]. Retrieved from http://blog.nasm.si.edu/planetary-science/blink-comparator/

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

National Science Board. (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital*. Arlington, VA: National Science Foundation.

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science*, *349*, Article 4716. doi:10.1126/science.aac4716

Park, G., Lubinski, D., & Benbow, C. P. (2008). Ability differences among people who have commensurate degrees matter for scientific creativity. *Psychological Science*, *19*, 957–961.

Plomin, R., & Deary, I. J. (2014). Genetics and intelligence differences: Five special findings. *Molecular Psychiatry*, *20*, 98–108.

Putallaz, M., Baldwin, J., & Selph, H. (2005). The Duke University Talent Identification Program. *High Ability Studies*, *16*, 41–54.

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*, 436–453.

Schmidt, S. (2009). Shall we really do it again? The powerful concept of replication is neglected in the social sciences. *Review of General Psychology*, *13*, 90–100.

Simonton, D. K. (1999). Talent and its development: An emergenic and epigenetic model. *Psychological Review*, *106*, 435–457.

Simonton, D. K. (2014). *Handbook of genius*. New York, NY: Wiley.

Spain, S. L., Pedroso, I., Kadeva, N., Miller, M. B., Iacono, W. G., McGue, M., . . . Simpson, M. A. (2015). A genome-wide analysis of putative functional and exonic variation associated with extremely high intelligence. *Molecular Psychiatry*. Advance online publication. doi:10.1038/mp.2015.108

Subotnik, R. F., Olszewski-Kubilius, P., & Worrell, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science in the Public Interest*, *12*, 3–54.

Thorndike, R. L. (1949). *Personnel selection: Test and measurement techniques*. New York, NY: John Wiley & Sons.

Wai, J., Cacchio, M., Putallaz, M., & Makel, M. C. (2010). Sex differences in the right tail of cognitive abilities: A 30 year examination. *Intelligence*, *38*, 412–423.

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*, 817–835.

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*, 397–420.

Zuckerman, H. (1977). *Scientific elite*. New York, NY: Free Press.