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ORIGINAL RESEARCH

Exceptional Cognitive Ability: The Phenotype

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Abstract Characterizing the outcomes related to the phenotype of exceptional cognitive abilities has been feasible in recent years due to the availability of large samples of intellectually precocious adolescents identified by modern talent searches that have been followed-up longitudinally over multiple decades. The level and pattern of cognitive abilities, even among participants within the top 1% of general intellectual ability, are related to differential developmental trajectories and important life accomplishments: The likelihood of earning a doctorate, earning exceptional compensation, publishing novels, securing patents, and earning tenure at a top university (and the academic disciplines within which tenure is most likely to occur) all vary as a function of individual differences in cognitive abilities assessed decades earlier. Individual differences that distinguish the able (top 1 in 100) from the exceptionally able (top 1 in 10,000) during early adolescence matter in life, and, given the heritability of general intelligence, they suggest that understanding the genetic and environmental origins of exceptional abilities should be a high priority for behavior genetic research, especially because the results for extreme groups could differ from the rest of the population. In addition to enhancing our understanding of the etiology of general intelligence at the extreme, such inquiry may also reveal fundamental determinants of specific abilities, like mathematical versus verbal reasoning, and the distinctive phenotypes that contrasting ability patterns are most likely to eventuate in at extraordinary levels.

Keywords Exceptional cognitive abilities · Intellectual talent · Talent searches · Talent development

Introduction

For a special issue of *Behavior Genetics* focused on cognitive abilities, it is perhaps wise to begin by characterizing the phenotype under analysis at the extreme. How do people who possess extraordinary cognitive abilities at an early age look? How do they develop in school and, subsequently, at work? What potential do they harbor for genuine manifestations of creativity? This introduction builds on multiple large-scale analyses of cognitive abilities and the outcomes they forecast over protracted intervals. Given the amount of information that has emerged on the importance of cognitive abilities for learning in educational settings (Corno et al. 2002; Kuncel et al. 2001; Kuncel and Hezlett 2007; Sackett et al. 2009) and work performance in occupational settings (Gottfredson 2003; Schmidt and Hunter 1998), this review focuses on recent findings on the role cognitive abilities play in the development of truly outstanding human accomplishments. Some background is need, however, to set the stage for these longitudinal findings.

First, the nature and organization of cognitive abilities will be described. Second, modern talent searches utilizing measures of these abilities will be reviewed to reveal how thousands of gifted (top 1%) and hundreds of profoundly gifted (top .01%) participants are efficiently identified during early adolescence annually in the US. Third, the findings of follow-up studies that have tracked hundreds of

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these participants over 25 years will be presented. Fourth, how certain populations of talented youth are missed by contemporary talent searches will be documented and solutions offered to forestall this shortcoming. Finally, a concluding statement will be ventured on how identifying contrasting forms of intellectual talent at the extreme, and incorporating these phenotypes into behavior genetic and neuroscience inquiry, holds promise for uncovering the etiology of human intelligence.

Cognitive abilities

Over the past two decades, much clarity has emerged on the nature and organization of human cognitive abilities. There is a clear consensus that cognitive abilities are organized hierarchically (Carroll 1993; Snow and Lohman 1989; Snow et al. 1996). Cognitive abilities are structured around a regnant general factor (general intelligence, or "*g*"), and supported by a number of specific factors (e.g., mathematical, spatial, and verbal abilities). Spearman (1927) defined this general dimension as arraying individuals in terms of their capacity to apprehend experience, and educe relations and correlates. Spearman also depicted *g* as "essentially characterized by the combination of noegenesis with abstraction" (Spearman and Jones, 1950, 72), or the creation of abstract knowledge; and therefore, a chief ingredient in manifestations of creativity, particularly when it is operating at exceptional levels. More concretely, general intelligence, in the words of 52 experts, "is a very general mental capacity that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience. It is not merely book learning, a narrow academic skill, or test—taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings—'catching on,' 'making sense' of things, or 'figuring out' what to do" (Gottfredson 1997, p. 13).

An overwhelming amount of evidence suggests that the preponderance of criterion variance predictable by cognitive abilities in educational, occupational, and even more common everyday life settings is attributable to the general factor (Gottfredson 1997, 2004; Jensen 1998; Schmidt and Hunter 1998).[1] This general factor accounts for approximately 50% of the common variance in cognitive tests (Carroll 1993); however, specific abilities add value to forecasts based on general cognitive ability in multiple real-world settings (Corno et al. 2002; Gottfredson 2003; Lubinski 2004; Snow et al. 1996).

This article details some developmental outcomes among young adolescents who manifest exceptional cognitive abilities at an early age. After all, for an attribute to be considered a priority for molecular behavior genetic inquiry, the implications of individual differences in the attribute should be impressive and firmly established. It is certain that cognitive abilities in general hold water with regard to this issue (Corno et al. 2002; Kuncel and Hezlett 2007; Jensen 1998; Sackett et al. 2009; Schmidt and Hunter 1998). The question is, Do differences within the top 1% of ability eventuate in important differences in life? Or, is there a threshold beyond which more ability doesn't seem to matter? To get a purchase on this question, it is useful to use the IQ scale for judging the variability in intelligence. The cutting score for IQs in the top 1% of ability is around 137, but IQs go beyond 200 (i.e., over one-third of the range in intelligence is beyond the cutting score for the top 1%). Do ability differences within this range among young adolescents relate to meaningful differences in ultimate educational outcomes, occupational level and performance, and genuine manifestations of creative expression later in life? To determine with confidence whether they do requires a mechanism for securing large samples of these rare individuals.

Talent searches: identifying exceptional cognitive abilities

Prior to the advent of modern talent searches (Keating and Stanley 1972; Stanley 1996), securing an appreciable number of exceptionally talented individuals in either general or specific cognitive abilities was arduous if not prohibitive. In Terman's classic study of 1,528 California students in the top 1% on IQ (Terman 1925, 1954), for example, each participant was required to take an individually administered Stanford-Binet. The process was costly and time consuming. Nowadays, modern talent searches routinely administer college entrance exams like the SAT to intellectually talented youth in large numbers (Benbow and Stanley 1996; Colangelo et al. 2004; Putallaz et al. 2005; Stanley 1996, 2000). Seventh and eighth grade students qualify for talent searches by scoring in the top few percentage points on any number of standardized achievement tests given by their schools. Talent searches were invented to identify students whose needs were not being met well by the standard educational curriculum designed for typically developing adolescents. For example, when measures like the SAT are administered to 12-year-olds, who, in the seventh grade, score in the top few percentage points on conventional achievement tests,

[1] Given the number of reports that suggest socioeconomic status (SES) influences cognitive ability measures in unknown ways, readers are referred to articles that have revealed the importance of cognitive abilities in predicting educational, occupational, and medical phenomena while controlling for SES (Gottfredson 2004; Lubinski and Humphreys 1992; Murray 1998; Sackett et al. 2009).

they reproduce the same score distribution as college-bound high school seniors. Those young adolescents who score 500 on an SAT subscale by age 13 have cognitive abilities in the top 0.5 percent, and those scoring 700 constitute the top 1 in 10,000 (Lubinski and Benbow 2006). Talent search participants scoring at the mean of college-bound high school seniors (SAT-M or SAT-V = 500) are invited to summer residential programs for talented youth where they frequently assimilate a full high school course in 3 weeks of full-time study; those scoring 700 or more on an SAT subscale can assimilate at least twice this amount within this time frame.[2]

Above-level assessments, that is, administering instruments designed for much older students to younger students, like the SAT in this case, are needed to differentiate the able from the exceptionally able. As talent search participants typically hit the ceiling on assessment tools designed for people of their chronological age, measures with high ceilings are needed to capture the full scope of their learning-potential. Students with SAT scores around 500 versus 700 by age 13 have different educational needs, because they learn abstract-symbolic material at different rates (they acquire knowledge at different rates), and the SAT has been one of many useful tools for indexing these differential rates of growth. The success that the first talent searches achieved resulted in a kind of paradigm shift in educational practice. When Julian C. Stanley (1996; Keating and Stanley 1972) conducted the first talent search back in 1972 just over 450 students participated; today, around 200,000 seventh and eighth graders take college entrance exams annually for summer residential programs for talented youth, conducted at universities like Duke, Johns Hopkins, Northwestern, University of Iowa, University of Denver, and Vanderbilt (Benbow and Stanley 1996; Colangelo et al. 2004; Stanley 2000). Recent longitudinal research has provided useful information on how these intellectually precocious rapid-learners look later in life.

Longitudinal data on talent search participants

The data presented here will focus on the life outcomes of over 2,300 talent search participants in the top 1% of ability who were tracked into young adulthood and middle age. Over the past decade in particular, the Study of Mathematically Precocious Youth (SMPY), a planned 50-year longitudinal study of over 5,000 intellectually precocious youth, which began in 1971 (Lubinski and Benbow 2006), has published a number of 10-, 20-, and 25+ year longitudinal follow-ups (Benbow 1992; Benbow et al. 2000; Bleske-Rechek et al. 2004; Lubinski et al. 2001a, 2001b, 2006; Park et al. 2007, 2008; Shea et al. 2001; Wai et al. 2005; Webb et al. 2002). And indeed, later in life, talent search age 12 SAT assessments are related to a variety of educational and occupational outcomes. But like measuring academic growth of precocious youth, criteria with high ceilings (or low base rates) are required to capture the magnitude of their psychological development.

For example, the base rate for earning a doctorate (i.e., JD, MD, or PhD) in the U.S. is approximately 1%. Yet, 30% of the top 1 in 200 achieve this degree, and over 50% of top 1 in 10,000 participants do so, furthermore, the more able tend to earn their doctorates at more highly ranked institutions (Lubinski and Benbow 2006; Lubinski et al. 2001a, 2001b, 2006). Indeed, when the top 1 in 10,000 talent search participants are compared to same-aged first- and second-year graduate students attending top math-science training programs, the talent search participants, even though they were identified by a 2 h test administered at age 12, earn comparable—and arguably more impressive—outcomes in regard to income and secured tenure-track positions by their mid-30 s (cf. Lubinski et al. 2006, p. 196). The following will detail some additional outcomes as a function of the range of individual differences within the top 1% of in general ability.

General ability level

Figure 1 contains data from 2,329 participants taken from the first three SMPY cohorts (Lubinski and Benbow 2006); they all met the cutting score for the top 1% on either the SAT-M or SAT-V for their age group (and only a small percentage did not meet both). Frey and Detterman 2004 have shown how the SAT-M plus SAT-V composite

[2] This illustrates a common finding. Namely, educational interventions that work increase the mean level of achievement and expand the variance (Ceci and Papierno 2005; Gagne 2005; Jensen, 1991, p. 178; Kenny 1975; Robinson et al. 1996; Robinson et al. 1997). When all students are provided with opportunities to learn at their desired rate, those who begin with more ability typically learn more from such opportunities. This nonlinearity between learning-*potential* ("ability") and learning-*achievements* ("knowledge") is brought into sharper focus by considering the full range of ability: Students with developmental delays assimilate much less than typically developing students even in the best of conditions, yet this fanning out in achievement is observed throughout the ability spectrum and within these populations as well (Fuchs et al. 1999; Fuchs et al. 2001). That opportunities for optimal growth expand individual differences in achievement has been periodically discussed for decades (Seashore 1922; Pressey 1946, 1955; Thorndike 1911; Thurstone 1948; among others), yet it is conspicuously absent in many modern treatments [two excellent exceptions, however, are Ceci and Papierno (2005) and Gagne (2005)]. Ceci and Papierno (2005, p.149) nicely depict this phenomenon by subtitling their treatment: "When the 'have nots' gain but the 'haves' gain even more." Stanford University's distinguished educational psychologist Elliot Eisner (1999, p.660), drew on this principle as a metric for evaluating schools: "The good school, as I have suggested, does not diminish individual differences; it increases them. It raises the mean and increases the variance."

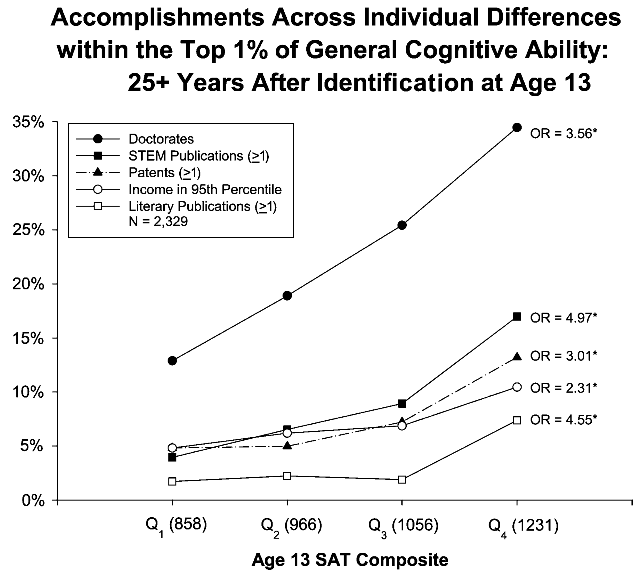

Fig. 1 Participants are separated into quartiles based on their age 13 SAT-M + SAT-V Composite. The mean age 13 SAT composite scores for each quartile are displayed in parentheses along the *x*-axis. Odds ratios comparing the likelihood of each outcome in the *top* (Q_4) and *bottom* (Q_1) SAT quartiles 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 Q_4 was significantly greater than in Q_1. These SAT assessments by age 13 were conducted before the re-centering of the SAT in the mid-1990 s (i.e., during the 1970 s and early 1980 s); 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. This figure contains a quartile graphing of some of the data plotted in Park et al. 2007 using a different approach. The fresh data added here were "doctorates" and "income" (in the 95th percentile)

constitutes an excellent measure of general intelligence; so here, an age 12 SAT composite was formed and parsed into quartiles to array talent search participants on general intelligence. Then, a variety of longitudinal criteria secured 20–25 years later, which reflect extraordinary accomplishments in education, the world of work, and creative expression (securing a patent, publishing a novel or major literary work, or publishing a refereed scientific article) were regressed onto these four quartiles. Odds ratios ("ORs") reflect the comparison between the top and the bottom quartiles, and all are statistically significant at the .05 level. The way in which these outcome data were secured through mail, web based surveys, and internet search engines is detailed in Lubinski and Benbow (2006) and Park et al. (2007, 2008). What is important to assess here is the overall general trend.

Moving along the gradient of individual differences within the top 1% of general intellectual ability, even when this ability is assessed at age 12, ultimately results in a family of achievement functions indicating that more ability enhances the likelihood of a host of impressive accomplishments decades later. For example, the base rate for patents in the U.S. is 1%, each quartile is around five times this rate, but there is a statistically significant difference between the top and bottom quartiles, 13.2 versus 4.8%, respectively. There is also a significant difference between the top and bottom quartiles in the incomes in the top 95th percentile, 10.5 versus 4.8%, respectively; and these participants are in their mid-30 s, typically such incomes are earned much later in life. Overall, there does not seem to be an ability threshold within the top1%. While other personal attributes such as energy and commitment certainly matter (Ericsson et al. 2006; Eysenck 1995; Jensen 1996; Simonton 1994), and opportunity clearly always matters—more ability still imparts an advantage. It is also important to state explicitly the design features that are needed to uncover relationships such as those illustrated in Fig. 1, because studies that do not meet certain methodological requirements are unlikely to reveal these functional relationships.

What is needed to evaluate the psychological significance of individual differences in ability within the top 1% is the following. Empirical studies need to employ ability measures with high ceilings (capable of differentiating the able from the exceptionally able), rare accomplishment criteria (with high ceilings and low base rates), and longitudinal time frames over protracted intervals (to allow sufficient time for expertise to develop). By definition, precocious youth are rare, and so are exceptional achievements, so assessments that reliably index each are needed to ascertain the extent to which these two rare events covary. In addition, because there are so many ways for exceptional abilities to operate, multiple criteria and large samples are needed. Multiple criteria are needed because investing in one rare form of achievement often precludes others, and large samples are needed to establish that robust statistical trends have been uncovered for all of the criteria under analysis. Finally, as epidemiologists have shown (Gottfredson 2004; Lubinski and Humphreys 1997), odds ratios are a more sensitive approach in contrast to conventional correlational analyses for illustrating "relative risk" relationships between a variable and low base rate outcomes. All of these critical design features are met in Fig. 1. But many other criteria could be added to flesh out the multifaceted construct of exceptional human accomplishment and the extent to which general intellectually ability is related to such functional arrays. The modest number criteria displayed in Fig. 1 nevertheless make the point. Recent findings have shown that these relationships hold even within advanced educational degrees earned at institutions of comparable quality (Park et al. 2008).

Specific ability pattern

Although Fig. 1 highlights the importance of overall general ability level, what about ability pattern? Some intellectually precocious youth possess commensurate talent in mathematical and verbal reasoning, whereas others have a clear strength in one and an accompanying relative weakness in the other. Do distinctive patterns of specific abilities relate to differential development and the kinds of exceptional accomplishments that intellectually precocious youth go on to achieve? Figure 2 offers an empirical answer to this question.

Figure 2 is taken from a recently published study that involved the same participants characterized in Fig. 1 (Park et al. 2007). This study utilized the SAT to ascertain the relative importance of the SAT-M versus SAT-V pattern as it relates to accomplishments in the sciences and the humanities. Two SAT composites were placed on *X* and *Y* co-ordinates. Plotted on the *Y*-axis were the SAT composite scores utilized in Fig. 1 (general ability level, SAT-M plus SAT-V) in SD *z*-score units. On the *X*-axis, however, Park et al. 2007 plotted composite scores reflecting ability "tilt" (i.e., SAT-M minus SAT-V): High scores on this composite reflect an intellectual profile distinguished by mathematical reasoning ability, relative to verbal reasoning ability, whereas low scores on this composite reflected the inverse, namely salient verbal reasoning ability relative to mathematical reasoning ability. Scores on this composite were also transformed into *z*-scores, and the two composites were relatively independent ($r = .02$). The four panels reveal how these two ability composites relate to differential outcomes in the sciences and humanities over 25 years later.

For criterion measures, accomplishments in the humanities and STEM (i.e., science, technology, engineering, & mathematics) were classified into four broad groups: those who had secured terminal Bachelor's or Master's degrees (Fig. 2a), those who had secured doctorates (Ph.D.; Fig. 2b), those who had secured a tenure-track position at a U.S. university (Fig. 2c), and those who had secured a patent or authored a noteworthy literary publication (Fig. 2d). STEM degrees included the physical sciences, mathematics, computer science, and engineering. Humanities degrees included art, history, literature, languages, drama, and related fields. (Other fields such as the social sciences, biological sciences, health sciences, architecture, business and management were not analyzed for the purposes of this study.)

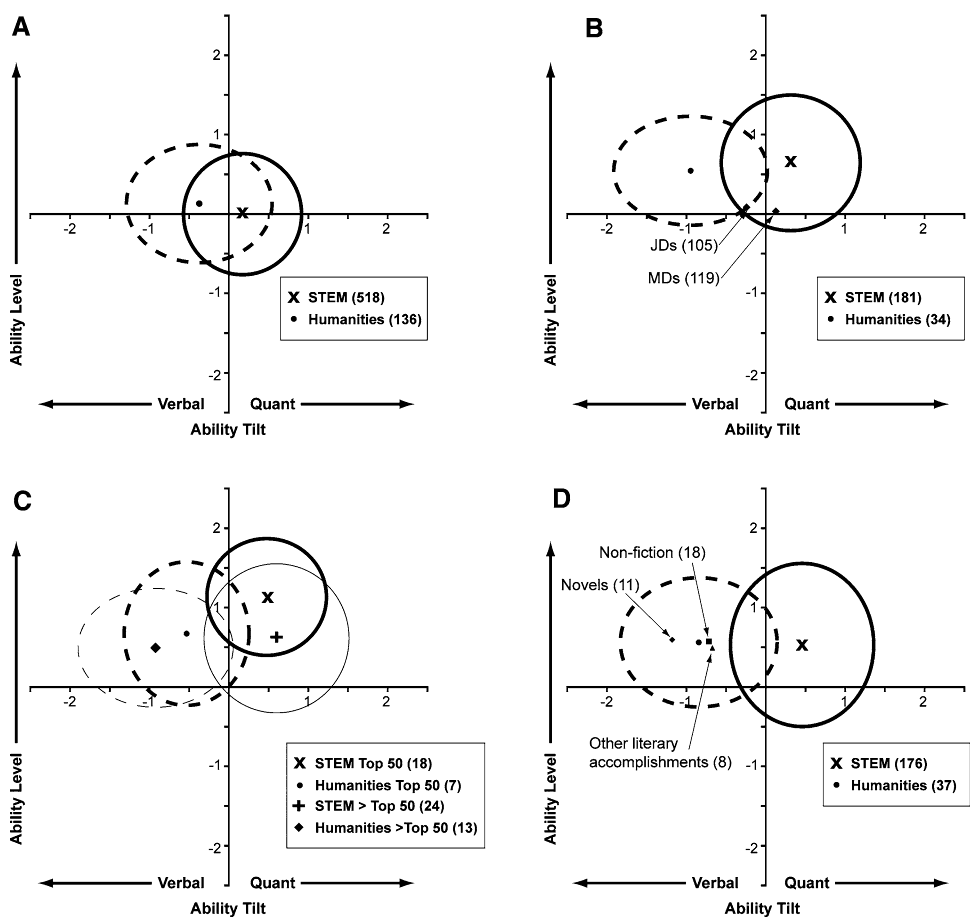

Fig. 2 The *x*-axis represents ability pattern (SAT-M − SAT-V) and the *y*-axis ability level (SAT-M + SAT-V) in SD units. *Ellipses* were formed around each bivariate mean using ±1 SD on each dimension. Sample sizes are given in *parentheses*. Mean SAT scores (SAT-M, SAT-V) for STEM and Humanities (Hum) groups in each *panel* are: *1a*, STEM (575, 450), Hum (551, 497); *1b*, STEM (642, 499), Hum (553, 572); *1c*, STEM Top 50 (697, 534), Hum Top 50 (591, 557), STEM > Top 50 (659, 478), Hum > Top 50 (550, 566); *1d*, STEM (648, 493), Hum (561, 567). Taken from Park et al. 2007, p. 950

Figures 2a through 2d represent the two-dimensional space defined by ability pattern (*x*-axis) and ability level (*y*-axis). Within each panel, bivariate means for the humanities and STEM groups were plotted, and ellipses were formed around each using ±1 SD on each dimension. An additional pair of ellipses was constructed in Fig. 2c to distinguish those participants who secured tenure-track positions at top 50 U.S. universities from participants with tenure-track positions at other U.S. universities. Units on each axis represent SD units of the entire sample. Additionally, we plotted more specific criterion groups, such as novelists, non-fiction authors, and those who secured an M.D. or J.D., simply as bivariate means without SD ellipses for a more complete portrait of the accomplishments of this sample.

Examination of these four panels confirms that the humanities and STEM groups occupy different regions in the space defined by these dimensions. Like most powerful findings, these are readily seen by the naked eye. Yet, statistical analyses were performed to quantify the degree of separation between the humanities and STEM groups and to test for significance (cf. Park et al. 2007). In a nutshell, all of the contrasted groups differed significantly in tilt (from each other and the total sample), and all but panel A differed from the total sample in ability level.

Panel C provides an especially interesting contrast for the tenure-track positions in the top 50 versus lower ranked schools, notice, for example, how the ellipses for the top schools converge. This is due to a number of participants earning ceiling-level scores on the SAT-M at age 12. For example, of the 18 participants who later earned tenure-track positions in STEM fields at top 50 U.S. universities, their mean SAT-M score was 696, and the lowest score among them was 580 (a score greater than over 60% of all participants). About 2 of these 18 individuals earned 800, the top possible SAT-M score, which illustrates that for profoundly gifted participants, college entrance exams such as the SAT can manifest ceiling effects as early as age 12 (cf. Benbow and Stanley 1996; Muratori et al. 2006; Stanley 2000).

Discussion

In the popular book, *Outliers: The Story of Success*, Malcolm Gladwell 2008, p.79 writes: "The relationship between success and IQ works only up to a point. Once someone has reached an IQ of somewhere around 120, having additional IQ points doesn't seem to translate into any measurable real-world advantage." These are the kinds of quotes pulled from *Outliers* that minimize the importance of ability. Yet, to be fair, Gladwell (2008) notes the importance of ability in a number of places: he notes Bill Joy's SAT-M = 800, that Bill Gates was a precocious youth, and there are other examples. But in a number of places *Outliers* minimizes ability and stresses special opportunities and hard work. Yet, with respect to the latter nothing is really new here. I am unaware of any scientist in the talent development area who does not stress hard work and opportunity in addition to ability. And, to be sure, there are huge individual differences among the intellectually gifted in terms of how much they invest in developing their careers and expertise (Lubinski and Benbow 2006); and opportunity differences are well known (Benbow and Stanley 1996; Colangelo et al. 2004; Stanley 2000) Indeed, many individuals had opportunities commensurate with those available to Gates and Joy, but few are likely to have also had their exceptional ability coupled with their intense ambition; collectively, these personal attributes formed an exceptional constellation of promise for when opportunity presented itself (at an early age) to these two world-class leaders in technical innovation. The vast majority of scientists in talent development would say that it takes at least ability, ambition, and opportunity; there is no need to minimize the importance of any of these when it takes all three.

It is clear by the level and pattern of relationships revealed in Figs. 1 and 2 that individual differences in cognitive abilities among young adolescents within the top 1% of ability matter in important ways later in life. The likelihood of exceptional achievement is markedly enhanced as a function of general ability. There does not appear to be an "ability threshold" (i.e., a point at which, say, beyond an IQ of 115 or 120, more ability does not matter). Although other things like ambition and opportunity clearly matter, more ability is better. The data also suggest the importance of going beyond general ability level when characterizing exceptional phenotypes, because specific abilities add nuance to predictions across different domains of talent development. Differential ability pattern, in this case verbal relative to mathematical ability and vice versa, are differentially related to accomplishments that draw on different intellectual strengths. Exceptional cognitive abilities do appear to be involved in creative expression, or "abstract noegenesis" (Spearman and Jones, 1950). That these abilities are readily detectable at age 12 is especially noteworthy.

One important limitation of modern talent searches needs to be stressed, however. The refined nuances observed in Fig. 2 due to taking into account ability pattern would be enhanced by including spatial ability assessments along with those for mathematical and verbal reasoning abilities (Lubinski 2004; Wai et al. 2009). There is excellent evidence suggesting that spatial ability would add value to forecasts based on mathematical and verbal reasoning abilities; utilizing spatial ability more fully would also identify an under-served special population of intellectually talented youth. Talent searches have yet to add systematic assessments of spatial ability to their selection criteria, although there is good reason to do so (Gohm et al. 1998; Shea et al. 2001; Webb et al. 2007). For a review of this topic covering longitudinal findings over a 50-year period with multiple large-scale data sets, see Wai et al. (2009).

Another especially important thing to keep in mind in viewing the figures presented here is that many of the individual differences revealed would be suppressed or masked by SAT assessments conducted when age 12 talent search participants are high school seniors (age 17 or 18). By high school, most of these participants will be scoring at the ceiling of SAT subtests (800). But ceiling problems are largely forestalled by using above-level assessment tools at age 12. But not completely, for example, many of the 18 participants who had secured tenure-track position in STEM at top U.S. universities were located at the ceiling on the SAT-M at age 12 (cf. Fig. 2, Panel C); and so were many others (cf. Fig. 1, Q_4).

Moreover, in addition to modeling outstanding human accomplishments psychologically, the phenotypic patterns formed by exceptional mathematical, spatial, and verbal ability may have the potential to inform multidisciplinary inquiry. For example, given the heritability of cognitive abilities (Plomin 2003), uncovering the biological and environmental antecedents to these phenotypes is a particularly attractive scientific pursuit. Such inquiry is not only likely to provide a more complete understanding of the development of exceptional abilities; it may also afford insight into the manifestation of developmental delays (Plomin and Kovas 2005). The unanswered empirical questions swirling around these important phenotypes are numerous, because the level and pattern of exceptional cognitive abilities not only holds promise for biometrically informed designs and molecular behavior genetics, but they also may provide critical parameters for informing and structuring research designs in the neurosciences (Haier 2009; Jung and Haier 2007).

Regardless of the multidisciplinary connections researchers are interested in establishing, the findings reported here illustrate the importance of taking advantage of the full range of human individuality when identifying psychological phenotypes. When the variance in psychological indicators is constrained by ceiling effects, the covariance between such measures and external phenomena becomes markedly reduced. And identifying truly exceptional phenotypes becomes compromised. There are huge individual differences in human cognitive abilities, and the relationships highlighted here illustrate the importance of utilizing measures that capture their full scope. Uncovering the etiology pathways of underlying systems giving rise to exceptional general and specific ability patterns warrants intensive scientific efforts. This work requires special measures to identify extreme populations capable of producing rare accomplishments.

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