ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Current Directions in Psychological Science
19(6) 346-351

DOI: 10.1177/0963721410391442
http://cdps.sagepub.com
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Beyond the Threshold Hypothesis: Even Among the Gifted and Top Math/Science Graduate Students, Cognitive Abilities, Vocational Interests, and Lifestyle Preferences Matter for Career Choice, Performance, and Persistence

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Abstract

The assertion that ability differences no longer matter beyond a certain threshold is inaccurate. Among young adolescents in the top 1% of quantitative reasoning ability, individual differences in general cognitive ability level and in specific cognitive ability pattern (that is, the relationships among an individual's math, verbal, and spatial abilities) lead to differences in educational, occupational, and creative outcomes decades later. Whereas ability level predicts the level of achievement, ability pattern predicts the realm of achievement. Adding information on vocational interests refines prediction of educational and career choices. Finally, lifestyle preferences relevant to career choice, performance, and persistence often change between ages 25 and 35. This change results in sex differences in preferences, which likely have relevance for understanding the underrepresentation of women in careers that demand more than full-time (40 hours per week) commitment.

Keywords

talent development, cognitive abilities, vocational interests, lifestyle preferences, creativity, STEM

Conventional wisdom holds that above a certain threshold of cognitive ability (for example, an ability level in the 90th or 95th percentile), differences in cognitive abilities no longer matter; that is, for all who have cognitive abilities beyond that threshold, individual differences in occupational and creative achievements will be a function of hard work, personality, and opportunity. For example, Malcolm Gladwell writes in his popular book, *Outliers: The Story of Success* (2008, p. 79), "The relationship between success and IQ works only up to a point. Once someone has an IQ of somewhere around 120, having additional IQ points doesn't seem to translate into any measurable real-world advantage." While this *threshold hypothesis* has intuitive appeal, the literature in talent development and other areas does not support it. In this article, we will present recent findings that show that even in the top 1% of cognitive ability, higher levels of cognitive abilities do make a person more likely to make outstanding achievements. In addition, intraindividual differences in abilities predict the domain of those achievements. However, cognitive abilities are not the only variables that contribute to outstanding achievement. We will present evidence that vocational interests and lifestyle preferences also are important factors in career choice, performance, and persistence among those in the highest levels of cognitive ability.

Cognitive Abilities Predict Career Choice and Performance

Ability level and level of achievement

Empirical research fails to substantiate the threshold hypothesis (Park, Lubinski, & Benbow, 2007, 2008; Sackett,

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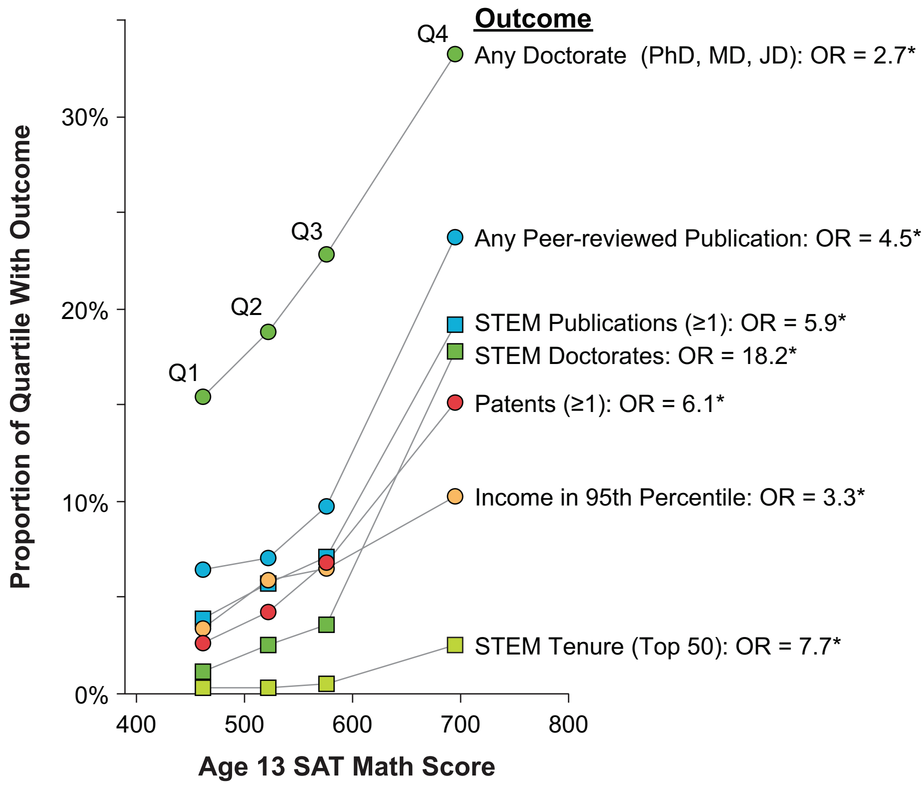

Fig. 1. Accomplishments across individual differences within the top 1% of mathematical reasoning ability 25+ years after identification at age 13. Participants from Study of Mathematically Precocious Youth (SMPY) Cohorts 1, 2, and 3 ($N = 2{,}385$) are separated into quartiles based on their age-13 SAT-M score. The quartiles are plotted along the *x*-axis by their mean SAT-M score. The cutoff for a score in the top 1% of cognitive ability was 390, and the maximum possible score was 800. Odds ratios (OR) comparing the odds of each outcome in the *top* (*Q4*) and *bottom* (*Q1*) SAT-M quartiles are displayed at the end of every respective criterion line. An asterisk indicates that the odds of the outcome in *Q4* was significantly greater than in *Q1*. STEM = science, technology, engineering, or mathematics. STEM Tenure (Top 50) = tenure in a STEM field at a U.S. university ranked in the top 50 by *U.S. News and World Report's* "America's Best Colleges 2007." Adapted in part from Park, Lubinski, and Benbow (2007, 2008).

Borneman, & Connelly, 2008). Studies cited in support of the threshold hypothesis typically suffer from at least one of several methodological weaknesses that reduce statistical power and artificially attenuate the relationship between ability and accomplishment at exceptional levels. When a study lacks sufficient statistical power to detect a real relationship between cognitive ability and outcome variables above this threshold, some researchers mistakenly interpret their inability to find a significant relationship between cognitive ability and outcome variables as evidence supporting the threshold hypothesis.

Figure 1 is based on data from Park et al. (2007, 2008) that falsifies the threshold hypothesis. In this study, nearly 2,500 participants took the SAT-Math by age 13 as part of a talent search. Figure 1 presents outcomes they achieved over the following 25 years. It shows that ability differences matter among participants in the top 1% in mathematical ability. For example, in the bottom quartile (Q1) of the top 1% in Figure 1, 15.4% have earned a doctorate (a PhD, JD, or MD). But the corresponding proportion for the top quartile (Q4) is 33.2%: more than twice as many people in the top quartile have earned a doctorate as in the bottom quartile!

Certain methodological features are required for a study to test the threshold hypothesis effectively. First, a study must use measures of cognitive ability that do not mask individual differences in ability beyond the threshold in question.[1] One remedy for this masking problem is the use of above-level assessments, in which difficult tests are given at ages younger than typical. For example, the participants in Figure 1 were initially invited to participate based on having grade-level standardized achievement scores in the top 3%, and then they took the SAT-Math 4 to 5 years earlier than normal—by 13 years of age. The threshold score for mathematical reasoning ability in the top 1% of their age group was 390, and the maximum score was 800, leaving ample room for observation of individual differences in mathematical reasoning ability among the top 1% (Fig. 1).

In addition, a study must also use outcomes that are difficult to achieve. One indicator of such difficulty is the proportion of the general population that achieves an outcome, or its *base rate*. For example, an outcome such as being employed has a high base rate; most adults in the general population and most adults in the top 1% of cognitive ability are employed. Having authored at least one peer-reviewed publication (Fig. 1), on the other hand, has a low base rate. It is a rare accomplishment in the general population, and even within the top 1% the majority of individuals do not have such a publication.

Finally, to allow reliable observation of how the many different kinds of life outcomes vary as a function of cognitive ability, a study must have a large sample and span a considerable time interval between initial assessment and final outcomes. Choosing to pursue one of the outcomes presented in Figure 1 may preclude achievement of another, because of the time required to develop sufficient expertise to do so. Nevertheless, the proportions of participants achieving each outcome can be observed reliably, because in this sample there are almost 600 participants in each quartile of cognitive ability.

A study that possesses all of these methodological characteristics is the Study of Mathematically Precocious Youth (SMPY). The data presented in Figure 1 are drawn from the first three of five SMPY cohorts. SMPY began in 1971; it is an ongoing longitudinal study of intellectual talent with follow-ups still to be completed. SMPY's five cohorts were selected between 1972 and 1997 and total more than 5,000 participants. The first four cohorts were identified through talent searches. A fifth SMPY cohort consists of students selected from top math/science graduate programs in 1992 (Lubinski, Benbow, Shea, Eftekhari-Sanjani, & Halvorson, 2001), who were followed up 10 years later (Lubinski, Benbow, Webb, & Bleske-Rechek, 2006).

Ability pattern and domain of achievement

Further findings from SMPY have revealed the importance of assessing verbal and spatial ability in addition to quantitative reasoning ability. All three of these specific abilities add incremental validity in the prediction of important educational, occupational, and creative outcomes relative to each other (Park et al., 2007, 2008; Wai, Lubinski, & Benbow, 2009). Whereas ability level predicts the level of achievement, ability pattern predicts the nature of achievement: Patterns of math, spatial, and verbal abilities among mathematically gifted adolescents influence which educational and occupational domains they choose.

For example, even among mathematically precocious youth with sufficient quantitative acumen for a distinguished career in STEM (science, technology, engineering, or mathematics), possessing verbal ability that is much more distinguished than their quantitative ability will make them more likely to pursue a non-STEM track (Lubinski, Webb, Morelock, & Benbow, 2001). Furthermore, in addition to an exceptional level of mathematical ability, higher spatial ability than verbal ability seems to be characteristic of participants who go on to secure advanced degrees in STEM. The opposite has been found for the humanities. Recently this pattern was replicated using data from Project TALENT, a study launched in 1960 consisting of a stratified sample of 400,000 U.S. high-school students in grades 9 through 12, with longitudinal data collected 11 years after their high-school graduations (Wai et al., 2009).[2]

Vocational Interests Predict Career Choice

Cognitive abilities are important for career choice and performance, but educational-vocational interests have incremental validity beyond cognitive abilities in the prediction of educational-occupational choices (Lubinski & Benbow, 2006). Indeed, interests appear to behave in the same way for intellectually talented adolescents as they do for high-school seniors and young adults. Because of this, models of educational-vocational development designed for older adolescents and young adults, in which abilities and interests are teamed, have been generalized to intellectually precocious youth for conceptualizing their development (Lubinski & Benbow, 2000, 2006). For example, according to the theory of work adjustment (TWA; Dawis, 2005; Dawis & Lofquist, 1984), which SMPY has used to inform its longitudinal research, correspondence between an individual's abilities and the ability requirements of an educational or career track constitutes *satisfactoriness* ("can do"), whereas correspondence between an individual's needs, interests, and values and the rewards and content offered by an educational or career track constitutes *satisfaction* ("will do"). According to TWA, the co-occurrence of satisfaction and satisfactoriness is required for optimal educational-occupational choice, performance, and persistence.

One of the most well-known findings in the measurement of educational-vocational interests is the conspicuous gender difference in interest in people versus things (Su, Rounds, & Armstrong, 2009), which we have called interest in "organic" versus "inorganic" domains (Lubinski & Benbow, 2006). For decades, the sex difference in interest in people versus things has been approximately one standard deviation. Overall, boys and men are much more interested in working with things, gadgets, and inorganic material than girls and women are, whereas the inverse is true for working with people and organic content. (For instance, more than 70% of students in schools of veterinary medicine nowadays are women; around 80% of developmental psychology students are women.) SMPY follow-ups have found that among mathematically precocious youth, men and women ultimately earn commensurate proportions of advanced degrees, but the male/female ratio varies across disciplines: Men are more likely than women to take advanced degrees in engineering and the physical sciences, whereas women are more likely to earn degrees in law, medicine, or the social sciences. SMPY's 20-year longitudinal follow-ups reveal that these men and women are equally satisfied with their choices and equally successful on objective and subjective indicators. This is precisely what would be anticipated from a gender difference in vocational interest in people versus things (Su et al., 2009).

Lifestyle Preferences May Predict Career Persistence

Finally, recent findings have shed light on another important set of determinants of career development beyond abilities and

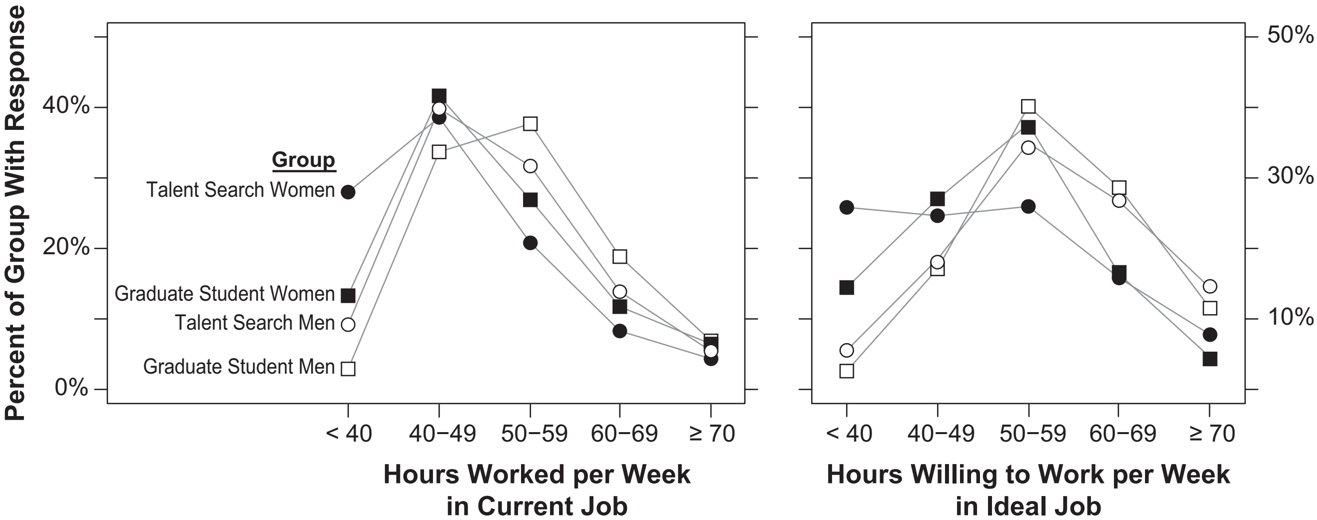

Fig. 2. Number of hours talent search participants (from SMPY Cohorts 1, 2, and 3; male $n \geq 1{,}425$ and female $n \geq 736$) and graduate student participants (SMPY Cohort 5; male $n \geq 269$ and female $n \geq 263$) worked per week and were willing to work per week in their ideal job, by sex. Participants were surveyed when they were in their mid-30s; they were asked how many hours per week they typically worked (left panel; homemakers were excluded from this question) and how many hours per week they were willing to work, given their job of first choice (right panel). Adapted from Lubinski and Benbow (2006).

interests. While abilities and interests play a central role in educational-vocational choice, performance, and persistence, individual differences in lifestyle preferences affect vocational decisions as well. Lifestyle preferences involve how people perceive and prefer to structure their lives in the broader context of family, personal development, career, social relationships, and community. Like vocational interests, lifestyle preferences manifest notable sex differences. The available evidence suggests that men and women gravitate to different career environments and career demands, on average, and that bias against women plays at most a minor role in sex differences in career outcomes (Ceci, Williams, & Barnett, 2009; National Academy of Sciences, 2010; Pinker, 2008).

At the time of their mid-30s follow-ups, we examined the number of hours per week that participants in SMPY Cohorts 1, 2, 3 (talent search participants), and 5 (top STEM graduate students) allocated to their jobs and would be willing to allocate to their ideal jobs. The results are summarized in Figure 2. There is substantial variation among their responses, with approximately 25% of talent search women preferring to work fewer than 40 hours per week; overall, women worked and were willing to work fewer hours per week than men were (Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000; Lubinski & Benbow, 2000; Lubinski et al., 2006).

Possible explanations for this observation are that women prefer or feel obliged to spend more time than men do in life pursuits other than work. In the same mid-30s follow-ups of 2 SMPY cohorts (Cohorts 3 and 5), we observed that women in their mid-30s preferred more balance among different areas of life: Across both cohorts, the women appeared to see life more communally and holistically than the men did, placing more importance on family, friendships, and community and less importance on their careers, while the men seemed more focused on their careers, emphasizing agency, compensation, risk taking, and recognition in their fields (Ferriman, Lubinski, & Benbow, 2009). For Cohort 5 only, we had work preferences data at age 25 also, which enabled us to examine changes in some work preferences between age 25 and age 35, especially among women who became mothers during that time. While these men and women had been very similar on multiple psychological dimensions and in their educational experiences up to age 25 (Lubinski, Benbow, et al., 2001), the changing responsibilities among the mothers (whether by choice or not) resulted in salient sex differences in work preferences 10 years later. These findings highlight the need for models of career development to incorporate individual-differences variables beyond abilities and interests that may begin to surface during young and mid-adulthood. Priorities can and do change over time, which is one of many reasons it is important to assess individual differences periodically over the life span.

The underrepresentation of women in STEM domains engenders different degrees of concern among social observers (Ceci & Williams, 2007). From an educational-vocational counseling perspective (Dawis, 1992), whether mathematically talented individuals invest their intellectual acumen in saving forests as environmental lawyers or in understanding the physical world as scientists is immaterial. What is important is that they have the opportunity to choose. Furthermore, it may be worth considering that, given the ever-increasing importance of quantitative and scientific reasoning skills in contemporary society, a talented individual's choice to pursue a discipline or an occupation outside of STEM is not necessarily a loss or underutilization of talent. Rather, it can be seen as exactly what is needed for disciplines and organizations to meet the challenges posed by rapidly developing cultures, globalization, changes in technology, and the war for STEM talent.

Conclusions and Questions for Subsequent Research

The science of talent development has revealed the importance of assessing individual differences in cognitive abilities within the top 1%. Ability level and pattern are both critical for modeling the many different kinds of developmental trajectories that intellectually precocious young adolescents display. Moreover, measures of educational-vocational interests and lifestyle preferences add value in forecasting the likelihood of educational, occupational, and creative outcomes over the life span.

Ongoing studies and future SMPY longitudinal research will examine what interventions, opportunities, and social supports facilitate the development of the necessary attitudes, knowledge, and skills needed to reach high levels of performance. In addition, because longitudinal research has touched only the surface of the importance of lifestyle preferences for subsequent achievements, we will explore if and how these changes continue over the life span, as well as the relative influence that cultural values and personality have on lifestyle preferences. Lifestyle preferences can and do change over time, and those changes that occur within the decade between a person's mid-20s and mid-30s have implications for developing expertise in and advancement in multiple domains.

These and other areas of talent development will be examined as we collect data in our next phase of longitudinal research through a series of age 50 follow-ups—the first being scheduled for launch in 2011. While the particulars of future discoveries only can be speculated upon, we do anticipate confirmation of one generalization: Taking a multidimensional approach—incorporating human abilities, interests, and lifestyle preferences—will continue to be the most productive strategy for understanding educational, career, and life span development.

Notes

1. Consider the top 1% in cognitive ability. IQ tests measure cognitive ability on a scale from near 0 to more than 200. Given a mean score of 100 and a standard deviation of 16, normal distribution theory tells us that any score above 137 is within the top 1%, which means that more than one third of the range of this measure of cognitive ability lies within the top 1%. However, the typical measure of cognitive ability that is scaled for the general population will not distinguish between the able and the exceptionally able because it is too easy—individuals within the top 1% will all obtain near-perfect scores.
2. Over the past three decades, modern talent searches have revealed the importance of assessing specific abilities beyond general intelligence for the prediction of group membership (e.g., conferred educational degrees in specific majors, occupations, and creativity in the humanities versus STEM; Lubinski & Benbow, 2006; Park et al., 2007). But contemporary talent searches typically restrict their selection devices to measures of quantitative and verbal reasoning ability. A recent review of more than 50 years of research on spatial ability, which included large normative longitudinal studies containing measures of spatial ability, and modern talent searches experimenting with measures of spatial ability, makes a compelling case for spatial ability being added to selection measures (Wai, Lubinski, & Benbow, 2009). Indeed, modern talent searches miss more than half of young adolescents in the top 1% on spatial ability, because they miss the cut on both quantitative and verbal selection measures. Spatial ability is critical for disciplines and careers in architecture, STEM, and many of the creative arts (Snow, 1999; Wai et al., 2009, and references therein).

Recommended Reading

Ceci, S.J., Williams, W.M., & Barnett, S.M. (2009). (See References). A comprehensive review of the issue of women's underrepresentation in science.

Lubinski, D., & Benbow, C.P. (2006). (See References). A recent review of research from SMPY that discusses the study in more detail.

Acknowledgments

Earlier versions of this article benefited from comments from Gregory Park.

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 article was provided by a Research and Training Grant from the Templeton Foundation and National Institute of Child Health and Development Grant P30 HD 15051 to the Vanderbilt Kennedy Center for Research on Human Development.

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