

# Introduction to the Special Section on Cognitive Abilities: 100 Years After Spearman's (1904) "General Intelligence, Objectively Determined and Measured"

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The study of individual differences in cognitive abilities is one of the few branches of psychological science to amass a coherent body of empirical knowledge withstanding the test of time. There is wide consensus that cognitive abilities are organized hierarchically, and C. Spearman's (1904) general intelligence occupies the vertex of this hierarchy. In addition, specific abilities beyond general intelligence refine longitudinal forecasts of important social phenomena and paint a rich portrait of this important domain of psychological diversity. This opening article identifies and then reviews 5 major areas concerning the personological significance of cognitive abilities and the methods used to study them. In models of human behavior and important life outcomes, cognitive abilities are critical in more ways than social scientists realize.

As the 100-year marker of Spearman's (1904) "General Intelligence, Objectively Determined and Measured" arrives, the editors of the *Personality Processes and Individual Differences* section of the *Journal of Personality and Social Psychology (JPSP)* thought it would be especially timely to devote a special section to cognitive abilities and their personological significance. At this first century marker, several longitudinal studies have recently issued reports highlighting the significance of cognitive abilities across several important life arenas: Among other phenomena, achieved socioeconomic status (SES), creativity, crime–delinquency, mate selection, health risk behavior, quality of life and longevity, educational–vocational choice (and performance after choice), and positive psychological development more generally all have been causally linked to individual differences in cognitive abilities assessed at an early age (Deary, Leaper, Murray, Staff, & Whalley, 2003; Deary, Whalley, Lemmon, Crawford, & Starr, 2000; Gottfredson, 1997; Lubinski, 2000; Moffitt, Caspi, Harkness, & Silva, 1993; Moffitt, Caspi, Silva, & Stouthamer-Loeber, 1995; Plomin, DeFries, McClearn, & McGuffin, 2001; Shea, Lubinski, & Benbow, 2001). It is interesting that some personality theorists had anticipated the real-world consequences of individual differences in cognitive abilities, and general intelligence in particular, long ago.

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Support for this article was provided by a Templeton Award for Positive Psychology and by National Institute of Child Health and Development Grant P30HD15052 to the John F. Kennedy Center at Vanderbilt University. Earlier versions of this article profited from many excellent suggestions by Camilla P. Benbow, April Bleske-Rechek, Ian J. Deary, Robert A. Gordon, Linda S. Gottfredson, Robert Hogan, David F. Lohman, Julian C. Stanley, James H. Steiger, Auke Tellegen, Mary L. Tenopyr, Jonathan Wai, Niels G. Waller, and Rose Mary Webb.

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Raymond B. Cattell (1950), who one could argue was Spearman's most famous student, for example, stressed that "intelligence is a readily measurable personality factor . . . worthy of consideration for the additional clarification it produces with regard to both the meaning of intelligence and the nature or sources of . . . abnormalities" (pp. 477–478). Starke Hathaway, one of the inventors of the most widely used personality inventory, the Minnesota Multiphasic Personality Inventory (MMPI; Hathaway & McKinley, 1940), thought general intelligence was essential to understanding the whole person. Hathaway's clinical acumen and diagnostic skills were legendary (Nichols & Marks, 1992), and he always stressed to his clinical advisees, "We tend to think of general intelligence as if it only operated in educational and vocational contexts, yet it saturates almost everything we do" (Paul E. Meehl, personal communication, 1993). Gordon Allport (1960), an early protagonist to modern-day positive psychology, also was keenly aware of the need to embrace individual differences in general intelligence for fostering creativity and optimal forms of psychological development.

For reasons beyond the 100-year marker, the focus of this special section is on general intelligence, or Spearman's (1904) *g*. First, a number of distinguished researchers reviewed herein have stressed the importance of this construct for understanding human affairs. And, second, the influence of general intelligence needs to be understood before the psychological import of specific cognitive abilities can reveal themselves, because assessment vehicles designed to measure specific abilities typically carry large components of general intelligence (along with their own uniqueness). It might be useful, therefore, to discuss how modern investigators conceptualize and appraise this construct.

Although as Meehl (1998) has pointed out, verbal definitions are usually problematic because they lack consensus (cf. Sternberg & Detterman, 1986), a group of 52 experts (including Meehl) did develop a consensus on the phenotypic essence of the general intelligence dimension,

a very general mental capability 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)

The scientific significance of measures of general intelligence has been evaluated by these (and other) researchers in the following ways: "The general mental test stands today as the most important technical contribution to the practical guidance of human affairs" (Cronbach, 1970, p. 197), "[A general] intelligence test is the single most important test that can be administered for vocational guidance purposes" (Humphreys, 1985, pp. 210–211), "Almost all human performance (work competence) dispositions, if carefully studied, are saturated to some extent by the general intelligence factor *g*, which for psychodynamic and ideological reasons has been somewhat neglected in recent years but is due for a comeback" (Meehl, 1990, p. 124), and "The great preponderance of the prediction that is possible from any set of cognitive tests is attributable to the general ability that they share. . . . 'empirical *g*' is not merely an interesting psychometric phenomenon, but lies at the heart of the prediction of real-life performances" (Thorndike, 1994). After reviewing 3 decades of research on Aptitude  $\times$  Treatment interactions, R. E. Snow (1989) concluded,

Given new evidence and reconsideration of old evidence, [*g*] can indeed be interpreted as "ability to learn" as long as it is clear that these terms refer to complex processes and skills and that a somewhat different mix of these constituents may be required in different learning tasks and settings. The old view that mental tests and learning tasks measure distinctly different abilities should be discarded. (p. 22)

And, finally, Campbell (1990) has applied this construct to performance in the world of work: "General mental ability is a substantively significant determinant of individual differences in job performance for any job that includes information-processing tasks" (p. 56).

Clearly, there are important cognitive abilities beyond general intelligence, and a number of them are reviewed in subsequent sections. Nevertheless, if personality theorists are to consider the role that cognitive abilities play in structuring important life events, this dimension is where to begin.

In addition, society has now moved out of the industrial revolution and into the information age. With that, "human capital" has become more equated with the abilities of "symbol analysts" (Reich, 1991)—that is, individuals highly skilled at learning, manipulating, and working with abstract material (Hunt, 1995). Thus, especially now, individuals deft at reasoning with symbols (e.g., numbers and words) have an advantage in school and an advantage at work (Drasgow, 2002; Viswesvaran & Ones, 2002). Yet increased complexity is not limited to educational–vocational realms. Everyday functioning in modern society has become more complex as well. Consequently, cognitive abilities are manifesting an ever-increasing importance in everyday life (Gottfredson, 1997, 2002).

These ideas and societal needs set the stage for this special section on cognitive abilities and the milestones reached since Spearman (1904). The series of five articles collected provides an excellent snapshot of the current state of the field. The authors

assembled here have played a key role in documenting the real-world longitudinal significance of cognitive abilities. All have extensive backgrounds in longitudinal research involving cognitive abilities and the development of personally important phenomena that unfold over protracted time frames. Contributions for this special section are arranged on a molarity continuum—from biological to sociological.

Plomin and Spinath (2004) begin with recent advances and methods from molecular biology. Among other things, Plomin's team has (a) contributed empirical support that the heritability of general intelligence increases over the lifespan, (b) devised biometric methods essential for uncovering environmental effects, and (c) produced unanticipated findings regarding the magnitude of genetic variance in familiar environmental measures (Plomin et al., 2001). Next, Deary, Whiteman, and Starr (2004) present the longitudinal stability of general cognitive ability and its biomedical significance. Deary's team has executed a 66-year test–retest (age 11 to age 77) of the Scottish survey (Deary et al., 2000); they are now examining these invaluable data for the role cognitive abilities play in aging, development, and pathology. Kuncel, Hezlett, and Ones's (2004) meta-analytic work documents that general cognitive ability plays a role in determining graduate training and work outcomes even within the top third of the range of general cognitive ability. Their work has revealed how the same source of individual differences cuts across the school to work transition. Schmidt and Hunter (2004) add to their massive amount of work in occupational psychology by explicating the role that general intelligence plays in identification, performance, and self-selection in the world of work. And Gottfredson (2004) extends their argument to health-related behaviors in the context of the complexities encountered in modern life. Gottfredson's work on the sociology of intelligence has revealed the integrative power of the construct of general intelligence for organizing sociological phenomena (cf. Gordon, 1997; Gottfredson, 1997).

## Overview

The domain of individual differences in cognitive abilities has steadily accumulated knowledge important to personality theorists for over 100 years, and these data are among the most impressive in psychological science. It is surprising, however, that many misconceptions and neglected aspects persist about this domain of psychological diversity (cf. Cronbach, 1975; Gottfredson, 1997; Humphreys, 1992; Neisser et al., 1996; Sackett, Schmitt, Kabin, & Ellingson, 2001). Some well-established concepts and findings are not widely assimilated in the psychological community. Therefore, five major topics relevant to understanding cognitive abilities and the methods used to study them are covered in these introductory remarks.

First, evidence of a consensus on the organization of cognitive abilities is presented, and some implications for developing innovative measures and future research are drawn. Second, the concept of general intelligence is discussed in the context of the construct validation process. Third, the psychological import of specific abilities beyond general intelligence is discussed. Fourth, constellations of individual differences attributes defined by affective dimensions that covary with specific abilities are reviewed. Finally, the importance of setting reasonable expectations for the predictive power of cognitive abilities is underscored.

## Cognitive Abilities: Organizing, Labeling, and Aggregating Scales

### Organizing Scales

Although there are exceptions, differential psychologists have reached a consensus that cognitive abilities are organized hierarchically. Carroll's (1993) three stratum model of cognitive abilities, based on his reanalysis of over 460 data sets collected during the past century, is unquestionably the most definitive treatment. This framework was embryonically embedded in the early work of Burt (1940), Guttman (1954), and Vernon (1961), matured through contributions by Gustafsson (1984), Humphreys (1962, 1979), and R. E. Snow (R. E. Snow, Kyllonen, & Marshalek, 1984; R. E. Snow & Lohman, 1989), and entered adulthood a decade ago with Carroll's (1993) *magnum opus*. Carroll's (1993) hierarchical model places general intelligence (or *g*) at its vertex, Stratum III, a number of Stratum II group factors underneath, and, finally, a much larger number of Stratum I first order factors below these. R. E. Snow (1991, 1994, 1996; R. E. Snow & Lohman, 1989) has corroborated this hierarchical structure through multidimensional scaling but put a different lens on the findings. At its core is a complexity dimension (general intelligence, *g*, or the sophistication of the intellectual repertoire). There are three content domains (or more specific abilities): quantitative/numerical, spatial/mechanical, and verbal/linguistic. R. E. Snow and Lohman's (1989) more parsimonious model suffices for our purposes, because the general factor, coupled with its three primary content domains (quantitative, spatial, and verbal), holds most of the personological significance for documented cognitive abilities to date.<sup>1</sup>

### Labeling Scales

Kelley's (1927) jangle fallacy is well known to *JPSP* readers; it was developed because psychologists can name more things than they can measure independently (Gordon, 1997). Less well known is that the jangle fallacy was initially exemplified with cognitive abilities.

Equally contaminating to clear thinking is the use of two separate words or expressions covering in fact the same basic situation, but sounding different, as though they were in truth different. The doing of this . . . the writer would call the "jangle" fallacy. "Achievement" and "intelligence" . . . We can mentally conceive of individuals differing in these two traits, and we can occasionally actually find such by using the best of our instruments of mental measurement, but to classify all members of a single school grade upon the basis of their difference in these two traits is sheer absurdity. (Kelley, 1927, p. 64)

Cronbach (1976) returned to this idea 50 years later: "*In public controversies about tests, disputants have failed to recognize that virtually every bit of evidence obtained with IQs would be approximately duplicated if the same study were carried out with a comprehensive measure of achievement*" (p. 211).

Simultaneously, an American Psychological Association task force similarly concluded that achievement and aptitude or ability tests do not differ in kind, only in degree (Cleary, Humphreys, Kendrick, & Wesman, 1975). Labels are assigned to these instruments as a function of their status on four dimensions: breadth of item sampling, the extent to which they are tied to a specific educational program, recency of learning assessed, and the pur-

pose of assessment (viz., current status, *concurrent* validity, or potential for growth, *predictive* validity).

Indeed, the general intelligence dimension can be measured in multiple ways precisely because it is so general (Gottfredson, 1997, 2002). Fragments of *g* are contained in essentially all problem-solving tasks, such as the acquisition of everyday information, school achievement, highly abstract conditional discriminations (matrix problems), and many different kinds of novel challenges found in occupational settings. Variegated conglomerations of information and problem-solving content, not necessarily tied to an educational program, which may involve fresh as well as old learning (acquired in or out of school), may be used to assess general intelligence. However, if familiar achievement or information items are to be used—rather than relatively content-free reasoning problems (e.g., Raven matrices)—it is important to underscore that sampling should be broad (cf. Roznowski, 1987) to properly assess general intelligence. Although the collections of items formed by this process may look like a "hotchpotch" (Spearman, 1930, p. 325), the communality distilled through their aggregation generates functionally equivalent correlates (Hulin & Humphreys, 1980).

The aggregation of separately administered composites of quantitative, spatial, and verbal reasoning abilities, however, measures general intelligence more efficiently than a test composed only of information items, because reasoning problems typically carry more construct-relevant *g* variance (Gustafsson, 2002; R. E. Snow & Lohman, 1989). In heterogeneous collections of cognitive tests in a wide range of talent, general intelligence accounts for roughly 50% of the common variance (quantitative, spatial, and verbal ability each account for approximately 8%–10% of the remaining common variance). Given the many different item types that may be used to assess general and specific cognitive abilities, a method for determining whether different measures assess the same construct is obviously needed.

Fiske's (1971) formulation of *extrinsic convergent validity* was developed to ascertain when measures could be considered conceptually equivalent and empirically interchangeable. That is, it may be assumed that scales measure the same fundamental construct when they display corresponding correlational profiles across an appreciable range of external criteria. Table 1 illustrates this with three experimentally independent measures that have verbal content: literary information, reading comprehension, and vocabulary. Their intercorrelations are around .75 and, thus, they share approximately half of their variance. Their uniform reliabilities (high .80s) afford each appreciable nonerror uniqueness. Yet one should examine the correspondence across their external correlational profiles, which include criteria ranging from other specific abilities to vocational interests. All three correlational profiles are functionally equivalent. All three measures assess the same

<sup>1</sup> There are other ways to characterize hierarchical organizations of cognitive abilities. For example, Cattell (1971) distinguished between crystallized and fluid abilities, partly on the basis that these two higher order factors appear to differ in their developmental decay. However, measures of these two constructs tend to covary in the mid .70s, and this communality requires an explanation. Gustafsson (2002; Gustafsson & Snow, 1997; Gustafsson & Undheim, 1996) in particular has made a cogent case that fluid intelligence is essentially *g*. Eysenck (1995) preferred *g* followed by a space-verbal bipolar factor.

Table 1  
Extrinsic Convergent Validation Profiles Across Three Measures  
With Verbal Content

Measure	Literature	Vocabulary	Reading comprehension
Aptitude tests			
Mechanical reasoning	.43	.52	.54
2-D visualization	.25	.32	.35
3-D visualization	.35	.43	.47
Abstract reasoning	.45	.53	.61
Arithmetic reasoning	.54	.63	.63
High school math	.57	.59	.57
Advanced math	.42	.43	.39
Information tests			
Music	.67	.68	.62
Social studies	.74	.74	.71
Mathematics	.62	.63	.57
Physical science	.64	.67	.60
Biological science	.57	.61	.56
Interest			
Physical sciences	.24	.25	.22
Biological sciences	.26	.25	.22
Public service	.16	.12	.12
Literary-linguistic	.37	.32	.32
Social service	.07	.06	.07
Art	.32	.30	.29
Music	.23	.20	.20
Sports	.12	.12	.13
Office work	-.35	-.29	-.27
Labor	-.08	-.06	-.06

Note. These correlations were based only on female subjects (male profiles are parallel).  $N = 39,695$ . Intercorrelations for the three measures were the following: literature/vocabulary = .74, literature/reading comprehension = .71, and vocabulary/reading comprehension = .77. Data are from Lubinski and Dawis (1992, p. 22). 2-D = two-dimensional; 3-D = three-dimensional.

underlying construct, even though each possesses a large component of nonerror uniqueness (or room for divergence). Essentially all of the information they afford about individual differences is located in their overlap (or communality); hence, for many research purposes, these three measures may be used interchangeably. To refer to these three measures as assessing distinct constructs just because they have different labels and different items constitutes the jangle fallacy.

### Aggregating Scales

It is also important to distinguish between constructs and their measurement vehicles, because construct purity is not guaranteed by content purity. Actually, the contrary frequently holds. Indicators based on homogeneous content often carry large components of more than one construct. Because of this, when measures of specific abilities are used in isolation in psychological research and generate significant results, inferences about the operative construct are typically equivocal. Given this, Gustafsson (2002; Gustafsson & Snow, 1997) has correctly concluded that to determine which component of variance is operating requires measurement operations incorporating both general and specific constructs. That is, measures focused on different tiers of a hierarchy need to compete with one another empirically in the context of relevant

criteria to ascertain their incremental validities (Sechrest, 1963) relative to one another.

Because scales typically measure multiple constructs, it is critical to determine which construct is operating in psychological research before one makes inferences about underlying causal paths. Figure 1 helps flesh this out. Figure 1 contains a scale from each content domain discussed earlier—quantitative, spatial, verbal—and their aggregation. All three scales possess .90 reliabilities (or 10% random error). For each, the preponderance of their variance is restricted to specific (homogeneous) content (55%), namely, quantitative, spatial, or verbal ability, but they also each possess an appreciable general factor component (35%). Aggregation of these three scales results in a composite reflecting predominantly the general factor running through all three indicators (61%). The remaining components of unique variance associated with each indicator shrink to tiny slivers of content homogeneity (11% each) and random error (2% each). By systematically aggregating other distinct indicators that have general and specific components, one can form a composite consisting of 85% of the general factor. Humphreys (Humphreys & Parsons, 1979; Hum-

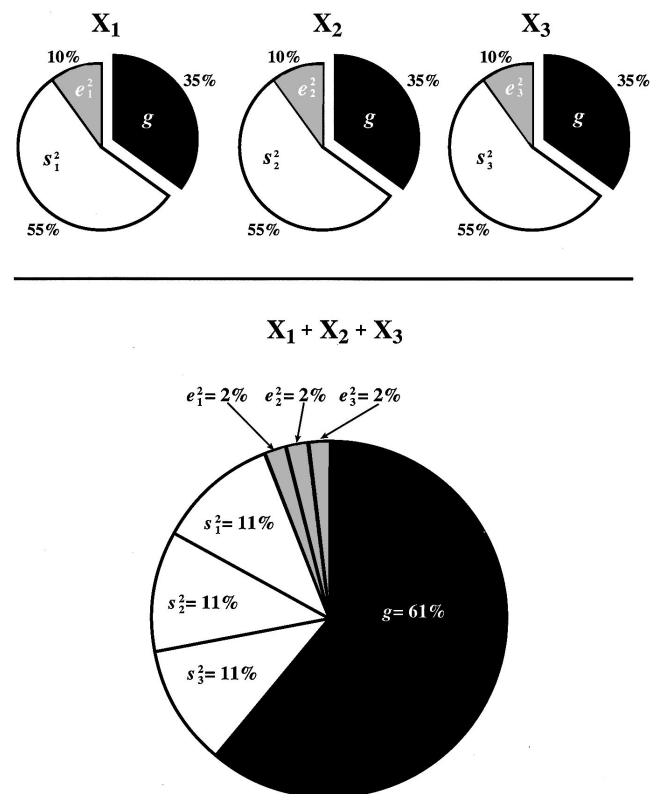


Figure 1. Three scales, each composed of 35% common variance, 55% specific variance, and 10% error variance (top panel). When these three scales are aggregated (bottom panel), the resulting composite consists mostly of the variance they share (61% common variance). Modified and reproduced by special permission of the Publisher, CPP, Inc., Palo Alto, CA 94303, from "Aptitudes, Skills, and Proficiencies," by D. Lubinski & R. V. Dawis, in *Handbook of Industrial and Organizational Psychology* (2nd ed., Vol. 3), by M. D. Dunnette & L. M. Hough (Eds.). Copyright 1992 by CPP, Inc. All rights reserved. Further reproduction is prohibited without the Publisher's written consent.

phreys, Rich, & Davey, 1985) has even illustrated this phenomenon using Piagetian tasks.<sup>2</sup>

These considerations have implications for the development of innovative measures: All cognitive ability measures assess multiple constructs to varying degrees (whether acknowledged or not). Moreover, the major dimensions within the cognitive ability hierarchy account for enough variance in learning, performance, and life outcomes, such that innovative measures of cognitive functioning remain ambiguous until they compete empirically with these conventional dimensions to establish their distinctiveness and unique psychological import. This is how we currently know that specific abilities subordinate to general intelligence are important to life outcomes (e.g., niche selection in educational and occupational settings). They do account for criterion variance beyond general intelligence (Humphreys, Lubinski, & Yao, 1993; Shea et al., 2001). Furthermore, just as multiple measures of verbal ability can all have appreciable uniqueness yet still foster functionally equivalent external correlates (Table 1), novel measures can do the same. Some innovative concepts (e.g., moral reasoning, emotional IQ) make intuitive sense and ostensibly capture unique psychological subtleties, but, when compared with preexisting measures, they frequently fail to add value (e.g., Sanders, Lubinski, & Benbow, 1995).

To be clear, offering a new way of thinking about cognitive abilities is perfectly legitimate in the context of discovery. Establishing verisimilitude, however, occurs within the context of justification (Kordig, 1978; Meehl, 1990). We need to ascertain whether new concepts and the tools purporting to assess them chart new psychological territory (cf. Hunt, 1999; Lubinski & Benbow, 1995), are free of the jangle fallacy (Kelley, 1927), and document incremental validity (Sechrest, 1963). Being vigilant of this set of related ideas will forestall the possibility of dealing with “psychological factors of no importance” (Kelley, 1939, p. 139) as well as the superfluous practice of simply creating “contemporary lyrics [for an] old tune” (Block, 2002, p. 13). In the words of Messick (1992),

Because IQ is merely a way of scaling measures of general intelligence [*g*], the burden of proof in claiming to move beyond IQ is to demonstrate empirically that . . . test scores tap something more than or different from general intelligence by, for example, demonstrating differential correlates with other variables (which is the external aspect of construct validity). (p. 379)

### General Intelligence and Construct Validity

When the large body of research involving general intelligence is viewed from the perspective of the construct validation process, a rich body of empirical and theoretical knowledge emerges. Construct validation research involving general intelligence can be organized around Embretson’s (1983) distinction between *nomothetic span* and *construct representation*. The former, which typically follows the *correlational tradition*, is aimed at establishing the network of correlates surrounding measures of the construct (e.g., academic learning, crime/delinquency, work performance); the latter, which typically follows the *experimental tradition*, is aimed at uncovering the underlying processes or mechanisms responsible for generating these molar behavioral phenomena (e.g., speed of information processing, working memory).

### Nomothetic Span

To the extent that “the best construct is the one around which we can build the most inferences” (Cronbach & Meehl, 1955, p. 288), *g* is clearly the most important dimension of individual differences uncovered in the study of cognitive abilities to date (cf. Brand, 1987; Brody, 1992; Drasgow, 2002; Gottfredson, 1997; Jensen, 1998; Lubinski, 2000; Lubinski & Humphreys, 1997; Moffitt, Gabrielli, Mednick, & Schulsinger, 1981). Measures of *g* covary .70–.80 with academic achievement measures, .70 with military training assignments, .20–.60 with work performance (correlations are moderated by job complexity), .30–.40 with income, and –.20 with unlawfulness. General intelligence covaries .40 with SES of origin and .50–.70 with achieved SES. As well, assortative mating correlations approach .50. These correlations indicate that *g* is among the most important individual differences dimensions for structuring the determinants of Freud’s two-component characterization of life, *lieben* and *arbeiten*, working and loving (or resource acquisition and mating).

F. H. Allport’s (1974; Nicholson, 2000) suggestion that all important aspects of personality are correlated with social class may be a bit exaggerated, but it is clear that social class phenomena are personally relevant and many covary with *g*. Although the breadth and depth of *g*’s nomothetic span is well documented and widely accepted (Gottfredson, 1997; Snyderman & Rothman, 1987), the causal force of this construct remains opaque. Is *g* causal, or do privilege and social status beget privilege and social status?

Given that measures of general intelligence and SES are correlated, justifiable cautions have been issued against making causal inferences about general intelligence and social phenomena. For example, Terman’s (1954) gifted participants were found to be physically and psychologically healthier than their average ability age mates. However, in addition to being gifted, they also were raised in home environments averaging one standard deviation above the normative mean in SES. Such confounding tempers causal speculation: Was their superior health directly linked to their exceptional ability, or was it merely due to their privileged rearing environment (cf. Lubinski & Humphreys, 1992)? Indeed, of all the variables thought to compromise causal inferences based on general intelligence, SES is by far the most conspicuous competitor. Is there a way to cleanly untangle the ability/privilege confound to estimate the relative contribution of these two pur-

<sup>2</sup> Figure 1 also illuminates a problem involving the generalizability of classical test theory to intermediate dimensions within all individual differences domains that are hierarchically organized. When Spearman (1904, 1910) developed true and error score theory, he had general intelligence in mind, and, for this construct, the reliable variance of a heterogeneous measure is close to its *g* variance. Therefore, when the index of reliability—namely,  $(r_{xx})^{1/2}$ —is theoretically interpreted as the correlation between the measure and a perfect measure of the attribute it assesses, this interpretation is not far off. However, for specific abilities that have multiple components of variance (e.g., 35% general and 55% specific variance), this interpretation is highly distorted. The classic theory Spearman invented was not bad for the construct he was after, although we now know that there is much more to cognitive abilities than general cognitive ability. Formulas for estimating common, specific, and error variance components of composites are found in Lubinski and Dawis (1992).

ported causal sources on outcomes of interest to personality theorists?

Murray (1998) provided a way to isolate the relative influences of ability and SES of origin on a variety of outcomes that would interest F. H. Allport (1974). This design combines a sibling control longitudinal follow-up with a variety of social status indicators. It is deceptively simple but conceptually powerful: Pairs of biologically related siblings are chosen for longitudinal tracking if they meet two selection criteria: One sibling must fall within an arbitrarily selected normal IQ range (e.g., normal = 25%–74%), whereas the other sibling must fall outside of this range and is placed in one of four arbitrary classes (e.g., very dull < 10%, dull = 10%–24%, bright = 75%–89%, or very bright > 90%). This controls for SES in a way that forestalls methodological concerns expressed by Kahneman (1965) and Meehl (1970), because the SES of the sibling pairs is essentially perfectly matched in that the siblings were raised in the same household for at least the first 7 years of the younger sibling's life. Tracking differential outcomes along these IQ gradations reflects the influence of general intelligence while implementing a powerful quasi-experimental SES control. Tables 2 and 3 illustrate some results gleaned through the use of this design on 1,074 sibling pairs taken from the National Longitudinal Survey of Youth (NLSY; Gottfredson, 1997; Murray, 1998). They were assessed as young adults on the Armed Forces Qualifying Test (AFQT; Gottfredson, 1997; Murray, 1998), and scores were converted to general intelligence equivalents corresponding to the aforementioned arbitrary categories. Outcome data were collected 15 years later.

Table 2 contains only some of the outcomes examined by Murray (1998): years of education, occupational prestige, and earned income. Across these cognitive groups, social class outcomes mirror those seen in the general population across corresponding general ability gradients. The powerful influence of general cognitive ability is readily apparent. Table 3 blocks on those participants in the norm reference group who did not earn a 4-year college degree and those who did. On adjacent sides, percentages for the participants' siblings in the other four classes are given. The advantages of more cognitive ability, again, are

readily revealed by this analysis. Another way to look at these data is the following: Two-hundred twenty-eight sibling pairs were discordant for a 4-year college degree; of these, 88% went to the higher ability sibling (i.e., only 12% of lower ability siblings earned college degrees). Cognitive differences make real life differences.

Finally, Table 4 does not use a sibling control; it uses a different kind of control. Here, a variety of outcomes are examined for the full NLSY sample ( $N = 12,686$ ) across the same five general ability gradations. These benchmarks are then compared with the outcomes of a utopian subsample of the NLSY. Culled from this subsample were all NLSY participants who were raised in a single parent home or in homes located within the bottom quartile of earned income. Comparing the full NLSY sample to the utopian subsample provides an opportunity to see how social outcomes might change as a function of the elimination of extreme conditions of single-parent homes and poverty. There are differences, to be sure, but the outcome congruencies are strikingly similar between the full NLSY sample and the utopian subsample.

One particularly interesting finding from this analysis is the relatively small number of participants in lower cognitive classes married to spouses with earned incomes. In lower cognitive classes, there are fewer combined incomes; in higher cognitive classes, not only are there more combined incomes, but these incomes are higher. This brings to light a corollary to the well-established finding of assortative mating based on general cognitive ability (Bouchard & McGue, 1981). Namely, assortative mating based on general cognitive ability appears to augment social mobility in both directions. The two components of life stressed by Freud (and now by evolutionary psychologists), resource acquisition and mating, not only covary but also appear to share a common antecedent, general cognitive ability.

### Construct Representation

Over the past 2 decades, research aimed at fundamental underlying processes driving individual differences in  $g$  has grown tremendously. Experimental paradigms are now routinely com-

Table 2  
*Paired Sibling Sample Comparisons: IQ, Education, Occupation, and Income*

Variable	Very dull siblings (<10th percentile)	Dull siblings (10th–24th)	Normal reference group (25th–74th)	Bright siblings (75th–89th)	Very bright siblings (≥90th)
IQ characteristics					
<i>M</i> IQ ( <i>SD</i> )	74.5 (5.4)	85.9 (2.5)	99.1 (5.9)	114.0 (2.7)	125.1 (5.6)
<i>M</i> difference	–21.1	–11.2		11.8	21.8
<i>n</i>	199	421	1,074	326	128
Years of education					
<i>M</i> difference ( <i>SD</i> )	–1.6	–0.8	13.5 (2.0)	1.3	1.9
<i>n</i>	149	326	850	266	109
Occupational prestige					
<i>M</i> difference ( <i>SD</i> )	–18.0	–10.4	42.7 (21.5)	4.1	10.9
<i>n</i>	102	261	691	234	94
Earned income (\$)					
<i>M</i> difference ( <i>SD</i> )	–9,462	–5,792	23,703 (18,606)	4,407	17,786
<i>Mdn</i> difference	–9,750	–5,000	22,000	4,000	11,500
<i>n</i>	128	295	779	257	99

Note. Data are from Murray (1998).

Table 3  
Paired Sibling Sample Comparison: BA Degree

Variable	Very dull siblings (<10th percentile)	Dull siblings (10th–24th)	Normal reference group (25th–74th)	Bright siblings (75th–89th)	Very bright siblings (≥90th)
For reference siblings without a BA					
Comparison siblings with a BA (%)	1	1	0	42	59
<i>n</i>	177	339	811	220	75
For reference siblings with a BA					
Comparison siblings with a BA (%)	0	18	100	76	91
<i>n</i>	19	55	198	78	46

Note. Data are from Murray (1998).

bined with psychometric assessments of general intelligence (Deary, 2000; Hale, 1997; Jensen, 1998; Kail, 1991; Myerson, Hale, Zheng, Jenkins, & Widaman, 2003; Salthouse, 1996; Newcomb, 2002). A number of these orchestrations have eventuated in some intriguing conjectures about underlying mechanisms: “Reasoning ability is (little more than) working memory?!” (Kyllonen & Christal, 1990), and “the causal factor underlying the correlation between psychometric *g* and scholastic performance” (Luo, Thompson, & Detterman, 2003a).

In these experiments, chronometric assessments of elementary cognitive tasks (ECTs; viz., sensation, perception, and memory) are used. There are two main classes: *inspection time* (the minimum length of time required to discriminate between two or more stimuli) and *response time* (the length of time it takes to respond to an experimental stimulus). The power derived from these experimental procedures accrued slowly, however, because experimentalists typically used ECTs in isolation. Individually, these experimental tasks typically manifested small correlations with one another and correlations between .30–.40 with psychometric *g* (within the general population). So their connection with psychometric *g* was initially deemed too loose and frail to contribute to a better understanding of a construct with broad referent generality. Once it became apparent that individual ECTs aggregate like psychometric items (Green, 1978;

Spearman, 1910), things changed rapidly. Like specific psychometric items, experimental tasks contain mostly unique variance (method- or process-specific variance). Aggregation is required to distill what they have in common and enhance their construct validity (Rushton, Brainerd, & Pressley, 1983). When families of ECTs are aggregated across different *modalities* (auditory, visual), *content domains* (figures, numbers, words), and *tasks* (reaction time, stimulus discrimination, and inspection time), general properties emerge: processing speed and working memory. These two general factors may define *g* experimentally, such that *g* reflects some product of these two major dimensions (Jensen, in press).

Experimentation is far from sorting out definitively the functional properties of these concepts and measures (cf. Lohman, 2000). What we do know, however, is that aggregating processing speed and working memory composites creates a super aggregate that overlaps highly with psychometric *g* (Luo et al., 2003a, 2003b). Moreover, this finding has recently been subjected to a critical replication involving external validation (Luo et al., 2003b): In this study, a conventional IQ measure and a chronometric composite manifested comparable correlations with academic achievement, and each composite added incremental validity relative to the other. Because of the comprehensiveness of the experimental and psychometric measures and the large sample

Table 4  
Utopian Sample Comparisons

Variable	Very dull (<10th percentile)		Dull (10th–24th)		Normal (25th–74th)		Bright (75th–89th)		Very bright (≥90th)	
	Utopian	Full NLSY	Utopian	Full NLSY	Utopian	Full NLSY	Utopian	Full NLSY	Utopian	Full NLSY
Educational attainment										
<i>M</i> years of education	11.4	10.9	12.3	11.9	13.4	13.2	15.2	15.0	16.5	16.5
% obtaining BA	1	1	4	3	19	16	57	50	80	77
Employment and earned income										
<i>M</i> no. weeks worked	36	31	39	37	43	42	45	45	46	45
<i>Mdn</i> earned income (\$)	11,000	7,500	16,000	13,000	23,000	21,000	27,000	27,000	38,000	36,000
% w/ spouse w/ earned income	30	27	38	39	53	54	61	59	58	58
<i>Mdn</i> earned family income (\$)	17,000	12,000	25,000	23,400	37,750	37,000	47,200	45,000	53,700	53,000
Female childbearing characteristics										
Fertility to date (no. of children)	2.1	2.3	1.7	1.9	1.4	1.6	1.3	1.4	1.0	1.0
Mother's mean age at birth (years)	24.4	22.8	24.5	23.7	26.0	25.2	27.4	27.1	29.0	28.5
% children born out of wedlock	49	50	33	32	14	14	6	6	3	5

Note. Data are from Murray (1998). NLSY = National Longitudinal Survey of Youth; w/ = with.

size, this investigation provides especially compelling evidence for how these two procedures complement each other.

If valid chronometric methods for assessing individual differences in general cognitive ability can be standardized and more widely used, researchers stand a better chance of making connections with well-known phenomena in behavioral pharmacology, endocrinology, genetics, and neurology or the underlying subsystems supporting growth, development, and cognitive aging (Deary, 2000; Jensen, 1998; Myerson et al., 2003; Plomin et al., 2001; Vernon, 1993). These measures not only possess ratio scale properties and, hence, a greater sensitivity for uncovering the kinds of exponential and logarithmic relationships so typical in psychophysics but also forestall concerns about construct irrelevancies found in many psychometric measures because of experiential differences associated with culture, learning, and language.

Finally, Hale's (1997) special issue of *Aging, Neuropsychology, and Cognition* highlights the importance of chronometric procedures for comparative adult cognition (e.g., Alzheimer's, depression, head injuries, and other special populations) and supports Cattell's (1950) prediction about cognitive abilities contributing to the study of abnormalities (cf. Gottesman & Gould, 2003). Perhaps, however, these measures furnish even more opportunities for comparative psychological inquiry: Just as vocal verbal behavior for teaching language to nonhuman primates was abandoned in favor of a more appropriate medium (American Sign Language), perhaps the precision and power of chronometric procedures afford a more appropriate medium for studying the well-known between- and within-species differences in cognitive capabilities among nonhuman primates. In his target article pertaining to individual differences in language- versus nonlanguage-trained groups of chimpanzees, Premack (1983) noted that

although chimpanzees vary in intelligence, we have unfortunately never had any control over this factor, having to accept all animals that are sent to us. We have, therefore, had both gifted and nongifted animals in each group. Sarah is a bright animal by any standards, but so is Jessie, one of the non-language trained animals. The groups are also comparable at the other end of the continuum, Peony's negative gifts being well matched by those of Luvy. (p. 125)

Using chronometric procedures with nonhuman primates is not far-fetched (cf. Washburn & Rumbaugh, 1997).

### Specific Abilities

Beginning with Terman (see Burks, Jensen, & Terman, 1930; Cox, 1926; Terman, 1925; Terman & Oden, 1947, 1959), longitudinal researchers have documented educational-vocational outcomes associated with high general intelligence (Holahan & Sears, 1995). The findings from the classic Terman (1954) studies are well known. Individuals with high general intelligence do extremely well educationally, vocationally, and personally. Since 1972, when annual talent searches began, similar findings accumulated for specific cognitive abilities (Stanley, 1996). Talent searches identify young adolescents scoring around the top 3% on conventional achievement tests administered in their schools and provide these students with opportunities to take college entrance exams for further differentiating their strengths and relative weaknesses. Longitudinal findings on the special populations defined by their extreme standing on specific abilities reveal the developmen-

tal significance of cognitive abilities beyond general intelligence. Simultaneously, these findings also underscore the importance of opportunity.

For example, whereas Terman's (1925; Terman & Oden, 1959; see also Holahan & Sears, 1995) male-female participants differed markedly in their achievements, findings on more contemporary samples reveal that the sexes are earning educational credentials commensurate with their abilities (Benbow, Lubinski, Shea, & Eftekhari-Sanjani, 2000; Lubinski, Webb, Morelock, & Benbow, 2001). Across both sexes, 25% of young adolescents with general, quantitative, and verbal abilities in the top 1 in 100 secure doctorates (25 times base rate expectations), whereas 50% of those scoring among the top 1 in 10,000 secure doctorates (50 times base rate expectations). Moreover, the caliber of the universities attended and the creative products generated by this latter (profoundly gifted) group reveal a much steeper, much more impressive developmental trajectory. Furthermore, the specific nature of these students' educational development is, in part, a function of ability pattern: Individuals who are more verbally than mathematically talented tend to develop in different but predictable ways from those with the inverse pattern (see below). These findings fit with theoretical discussions in developmental psychology about the personal attributes that factor into niche building and selection.

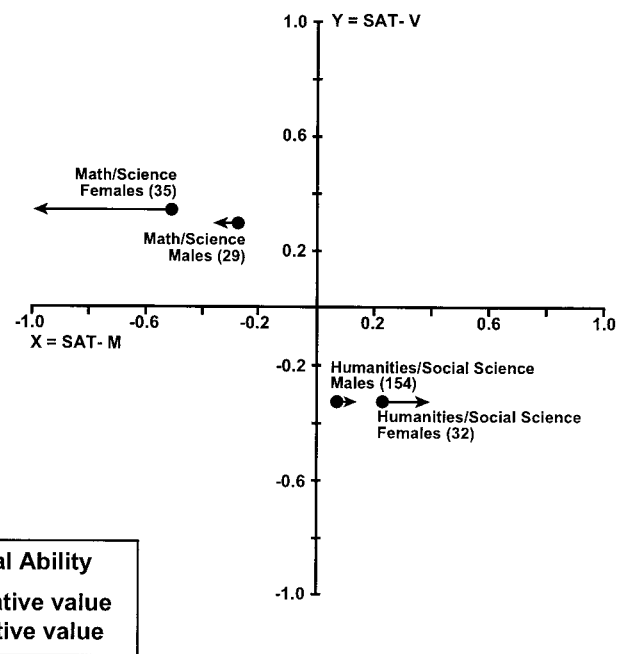
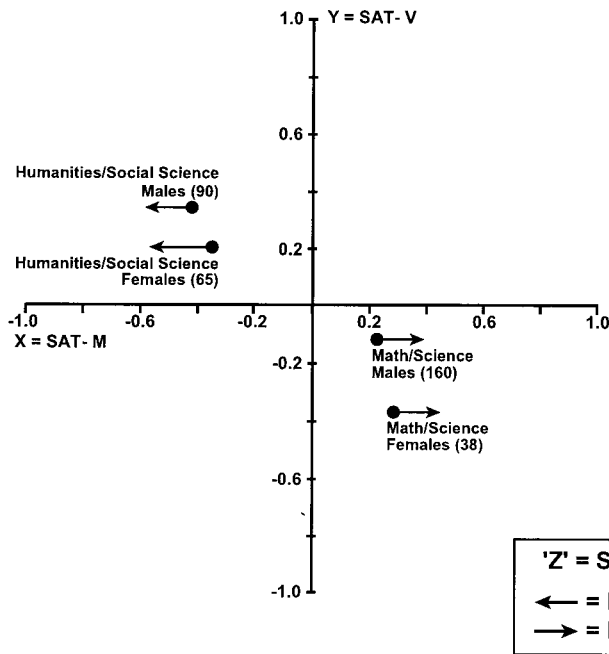
Niche building and selection are especially important topics in developmental psychology (Scarr, 1996). People do not select educational tracks and occupations randomly. They do so, at least in part, on the basis of stable features of their personality, which include their specific abilities. One reason specific abilities are so important is that at exceptional levels of general intellectual talent, specific abilities vary widely, and the distinct profiles they form reflect different developmental potentialities (Achter, Lubinski, Benbow, & Eftekhari-Sanjani, 1999; Gottfredson, 2003). For example, the four panels of Figure 2 track a group of intellectually precocious participants at three time points over a 20-year interval. At age 13, participants were in the top 1% of their age mates in general intellectual ability; at this time, they were assessed on quantitative, spatial, and verbal reasoning measures (Shea et al., 2001). At ages 18, 23, and 33, individual differences in their mathematical, spatial, and verbal abilities assessed in early adolescence were related in distinct ways to subsequent preferences for contrasting disciplines and ultimate educational and occupational group membership. Specifically, Panels A and B, respectively, show whether participants' favorite and least favorite high school course was in math/science or the humanities/social sciences. Panels C and D, respectively, reflect college major at age 23 and occupation at age 33.

All four panels represent a three-dimensional view of how mathematical ( $X$ ), verbal ( $Y$ ), and spatial ( $Z$ ) ability factor into educational-vocational preferences and choice. For all four panels, all three abilities are standardized in  $z$ -score units (A and B are within sex, C and D are combined across sex). For each labeled group within each panel, the direction of the arrows represents whether spatial ability ( $Z$  axis) was above (right) or below (left) the grand mean for spatial ability. These arrows were scaled in the same units of measurement as the SAT (math and verbal) scores, so one can envision how far apart these groups are in three-dimensional space in standard deviation units as a function of these three abilities. Across these developmentally sequenced panels, exceptional verbal ability, relative to mathematical and spatial



**A. Favorite High School Course (Age 18)**

**B. Least Favorite High School Courses (Age 18)**



'Z' = Spatial Ability  
 ← = Negative value  
 → = Positive value

**C. College Majors (Age 23)**

**D. Occupation (Age 33)**

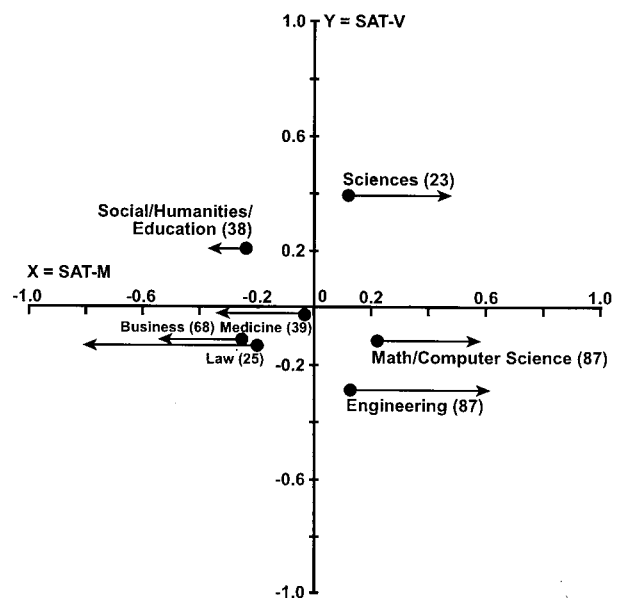
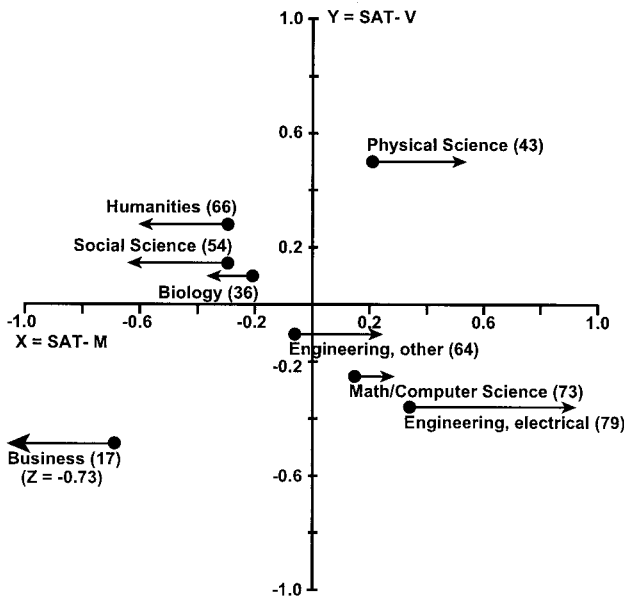


Figure 2. Trivariate means for (A) favorite high school class and (B) least favorite class at age 18, (C) conferred bachelor's degree at age 23, and (D) occupation at age 33. Group sample sizes are in parentheses. SAT-V = Verbal subtest of the SAT; SAT-M = Mathematical subtest of the SAT; Spatial Ability = a composite of two subtests of the Differential Aptitude Test (space relations and mechanical reasoning). Panels A and B are standardized within sexes; Panels C and D are standardized between sexes. The large arrowhead in Panel C indicates that this group's relative weakness in spatial ability is actually twice as great as that indicated by the displayed length. Adapted from "Importance of Assessing Spatial Ability in Intellectually Talented Young Adolescents: A 20-Year Longitudinal Study," by D. L. Shea, D. Lubinski, and C. P. Benbow, 2001, *Journal of Educational Psychology*, 93, Figures 1-3 and Figure 5, pp. 607-610. Copyright 2001 by the American Psychological Association.

ability, is characteristic of group membership in the social sciences and humanities, whereas higher levels of math and spatial abilities, relative to verbal abilities, characterize group membership in engineering and math/computer science. For example, engineering is relatively high spatial, high math, and relatively low verbal. Other sciences appeared to require appreciable amounts of all three abilities. These findings were highly consistent for other outcome criteria as well, such as graduate field of study (Shea et al., 2001). Across all time points, all three abilities achieved incremental validity relative to the other two in predicting group membership. This amount of differentiation could not have been achieved with one dimension or what these measures have in common; rather, their specific variance (illustrated for an artificial example in Figure 1) is responsible for distinguishing these groups psychologically.

Just as contrasting body builds differentially tailor athletes with exceptional physical potential for excellence in different Olympic events (Tanner, 1965), contrasting specific ability profiles differentially tailor adolescents with exceptional intellectual potential for developing contrasting expertise (Humphreys et al., 1993; Shea et al., 2001). What is especially intriguing about these findings is that spatial abilities are seldom measured and used in educational–vocational counseling. Yet they play a critical role in determining important niches students routinely self-select themselves into and out of (whether they are measured or not). These measures behave the same way across the sexes; note especially the potential usefulness of spatial abilities for identifying women with genuine talent for and interest in math/science careers (Figure 2, Panels A and B). Spatial abilities should be used more in the study of positive psychological development and in educational practice. For example, it is not well known, but Terman (1925; Terman & Oden, 1959) actually measured but failed to include two Nobel laureates in his famous longitudinal study of gifted youth (cf. Shurkin, 1992). Luis Alvarez and William Shockley both fell a bit short on the highly verbal Stanford Binet! Modern talent search procedures have begun to correct for this by using both quantitative and verbal reasoning instruments, but spatial ability continues to be neglected. Although not many modern-day Alvarizes and Shockleys are missed with contemporary procedures (Lubinski, Benbow, Shea, Eftekhari-Sanjani, & Halvorson, 2001), this does not generalize to the personalities of inventors such as Thomas Edison and Henry Ford. By focusing exclusively on mathematical and verbal reasoning, modern talent search procedures currently miss approximately 50% of the top 1% in three-dimensional spatial visualization (Shea et al., 2001). A comprehensive picture of positive psychological development will remain incomplete until this special population talented at nonverbal ideation is more completely characterized and better understood.

### Constellations

General and specific abilities are essential for understanding why certain learning and work environments are found attractive as well as aversive. General intellectual ability is critical for predicting migration up and down niches that differ in complexity (Wilk, Desmarais, & Sackett 1995; Wilk & Sackett, 1996), whereas specific abilities refine predictions about content or the nature of learning and work wherein cognitive abilities are expressed (Gottfredson, 2003). Nevertheless, other dimensions of

psychological diversity are needed to refine predictions and explain the breadth of human variation found within these and other niches (cf. Dawis, 1992; Tyler, 1974; Williamson, 1965). Some additional dimensions to consider are the affective and conative covariates of specific cognitive abilities—for example, Holland's (1996) six dimensions of educational–vocational interests (realistic, investigative, artistic, social, enterprising, and conventional; Day & Rounds, 1998) and the well-known Big Five dimensions of personality (Extraversion, Neuroticism, Agreeableness, Conscientiousness, and Openness; Goldberg, 1993). When teamed, specific abilities and these noncognitive attributes add incremental validity, relative to each other, in the prediction of longitudinally remote educational–occupational outcomes (Achter et al., 1999; Austin & Hanisch, 1990). They also afford psychological insight, especially for coming to terms with contrasting educational–occupational outcomes among groups similar in general intelligence (Lubinski, Benbow et al., 2001; Webb, Lubinski, & Benbow, 2002).

Several of these dimensions form unique patterns with specific abilities. Moreover, small correlations across ability, interest, and personality dimensions have been used to define affective–cognitive trait clusters (Ackerman, 1996; Ackerman & Heggestad, 1997), taxons (Dawis & Lofquist, 1984), and aptitude complexes (Corno, Cronbach et al., 2002; R. E. Snow, Corno, & Jackson, 1996). These amalgams denote constellations of individual-differences attributes that, among other things, are important for determining what people are likely to invest in (Cattell, 1971). They also refine the personological understanding of exceptional intellectual talent by highlighting its multifaceted character. For example, two of Ackerman's (1996) trait clusters, *intellectual/cultural* and *science/math*, provide empirical support for C. P. Snow's (1967) two cultures. The intellectual/cultural dimension consists of small correlations between measures of verbal ability and aesthetic and investigative interests, whereas the science/math dimension consists of small correlations between math/spatial abilities and working with things/gadgets, scientific activities, and (in reverse) social interests. Although defined by small positive and negative correlations, these trait complexes nevertheless generate ostensibly different types when selection focuses on specific abilities and cutting scores are stringent.

The selection of two groups at the extremes on any pair of the major markers of general intelligence (math/verbal, math/space, verbal/space) eventuates in multiple group differences on other major individual differences dimensions (Ackerman, 1996; Ackerman & Heggestad, 1997; D. B. Schmidt, Lubinski, & Benbow, 1998). Moreover, such group differences are often sufficiently pronounced to stimulate reasonable observers to speculate about discontinuities, multiple intelligences, and qualitatively different types. Yet these speculations could simply stem from continuous gradations within an underlying multivariate space of systematic sources of individual differences with no discrete boundaries. Special populations of mathematically versus spatially versus verbally talented participants are likely to appear to be qualitatively different, just as Olympic athletes do, unless they are analyzed in the context of the full range of humanity.

For example, in a study of intellectually talented adolescents (D. B. Schmidt et al., 1998), spatial ability covaried approximately .25 with realistic interests (working with things) and  $-.25$  with social interests (working with people). If spatially talented students are selected, with a cutting score of merely

two standard deviations above the mean, a sample averaging one half ( $2 \times .25 = .50$ ) standard deviation above the mean in interests in working with things and one half ( $2 \times -.25 = -.50$ ) standard deviation below the mean in interests in working with people would be anticipated. On the other hand, using the same cutting score on verbal ability would generate the inverse pattern. Collectively, these two selection procedures would engender group differences in interests for people versus things conspicuous enough to motivate the categorical distinctions of scientists and humanists (Lubinski & Benbow, 2000), which would, in turn, generate stereotypic impressions of different types. This discussion aligns well with observations by other investigators about different personality types being found in distinctly different psychological specialties (Boring, 1950; Cronbach, 1957; Kimble, 1984) and psychology's history and systems more generally (Lubinski, 2000, pp. 433–436).

From a broader perspective, individual differences in *g* seem to reflect the overall sophistication of the intellectual repertoire, a general capacity for acquiring new knowledge, information processing, and reasoning through abstract relationships; individual differences in specific cognitive abilities reflect differential proclivities and proficiencies for contrasting content (or symbol systems: figures, numbers, words). Even among people with comparable general ability, those with sharp specific ability differences have distinct preferences for processing and working with different mediums; these, in turn, characterize contrasting learning and work environments. At the extremes, people with markedly different cognitive profiles live in, and process information in, a somewhat different intellectual design space. That is, contrasting cognitive strengths reflect differential plasticity for assimilating knowledge and processing information within different niches. Contrasting cognitive strengths also reflect preferences for and selective attention toward different niches—different subcultures—different aspects of modern culture. This has implications for how people see the world (Dawis, 2001; Lubinski, 1996, 2000).

### Empirical Expectations for Cognitive Abilities

How much criterion variance should general intelligence account for? How much should specific (mathematical, spatial, and verbal) abilities account for? How much should all cognitive abilities account for? Because personologists are interested in complex life outcomes and broad, longitudinally stable behavior patterns, they are interested in phenomena that are multiply determined. No one variable or class of variables is expected to tell the full story. Yet seldom do researchers explicitly state their empirical expectations regarding what to anticipate from a measure or class of measures in the context of relevant criteria. Doing so, however, is important (Lubinski & Dawis, 1992; Meehl, 1990). Consider the following.

General intelligence typically accounts for 30% of criterion variance in work performance in professional occupations (F. L. Schmidt & Hunter, 1998) and approximately twice this amount in academic learning in educational settings in the general population (Corno, Cronbach et al., 2002; Cronbach & Snow, 1977; Jensen, 1980, 1998). Figure 3 illustrates a common finding on cognitive abilities. Even when one uses all four dimensions of cognitive ability covered here, over half of the criterion variance remains

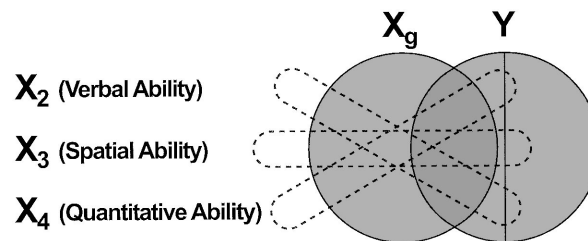


Figure 3. Overlap between general intelligence and three specific abilities in the prediction of a criterion variable. General intelligence accounts for the preponderance of variance, but each specific ability manifests incremental validity relative to general intelligence and relative to the others.

unexplained. This is a common finding: When multiple cognitive abilities are teamed to predict real-world criteria,  $R^2$  increments often begin to asymptote before the total multiple  $R^2$  reaches .50.

Is this a problem? Some have suggested that it is. Clark Hull (1928) was among the first, and he referred to this problem as “the .50 barrier” (p. 193). Regardless of the ability measures investigators assembled, it was difficult to cross this barrier. Because most of the criterion variance remains unexplained—after traditional cognitive ability assessments are fully used—some have called for new models of intelligence to account for more criterion variance. Yet, in the world of work and elsewhere, other things matter besides ability. Ambition, conscientiousness, energy, interests, health, and physical attractiveness all make a difference, and these determinants factor into performance, as do individual differences among teachers and supervisors who structure learning and work environments (Benbow & Stanley, 1996; Bleske-Rechek, Lubinski, & Benbow, in press; Cronbach, 1996; Lubinski & Dawis, 1992; Stanley, 2000). Furthermore, and probably more than psychologists like to acknowledge (cf. Meehl, 1978), chance factors also operate in life to attenuate the accuracy of predictions about human behavior.

Thus, what is a reasonable expectation for variance accounted for by cognitive abilities in work performance? Reasonable minds differ, but estimates well under 100% are certain. Hull (1928, p. 193) ended up concluding that work performance was 50% ability, 35% industriousness, and 15% chance.

Hull's (1928) emphasis on industriousness is useful for calibrating expectations for the ultimate psychological yield from cognitive variables (and new models of intelligence). Cognitive variables are underappreciated but harbor profound and wide-ranging psychological implications by, among other things, adding incremental validity to several important life outcomes that cognitive abilities predict (Benbow et al., 2000, p. 476). Figure 4 is based on two questions from a 20-year follow-up of nearly 2,000 intellectually precocious youth (at age 13, their cognitive abilities were in the top 1% of their age mates). At age 33, they were asked how much they actually *do work* (Panel A) and, second, how much they would be *willing to work* in their ideal job (Panel B). These figures reveal huge *noncognitive* individual differences. One only needs to imagine the ticking of a tenure clock and the differences likely to accrue over a 5-year interval between two faculty members working 45-versus 65-hr weeks (other things being equal). Making partner in a prestigious law firm is no different, nor is achieving genuine

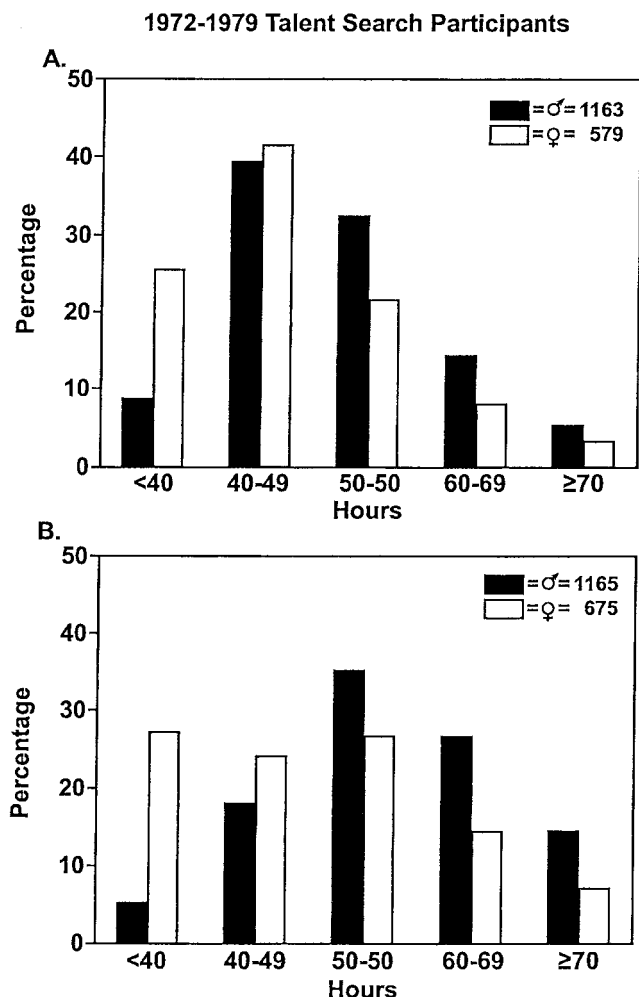


Figure 4. In the 1970s, participants were identified as having quantitative reasoning abilities in the top 1% of their age group. At age 33, they were asked (Panel A) how many hours per week they typically work, by sex (excluding homemakers), and (Panel B) how many hours per week they were willing to work, given their job of first choice, by sex. (Adapted from Lubinski & Benbow, 2000.) ♂ = male participants; ♀ = female participants.

excellence in other intellectually demanding areas (Eysenck, 1995; Gardner, 1995; Simonton, 1999; Zuckerman, 1977). In the words of Dean Simonton (1994), a leading authority on the development of eminence,

Making it big [becoming a star] is a career. People who wish to do so must organize their whole lives around a single enterprise. They must be monomaniacs, even megalomaniacs, about their pursuits. They must start early, labor continuously, and never give up the cause. Success is not for the lazy, procrastinating, or mercurial. (p. 181)

In addition, the distinguished biologist, E. O. Wilson (1998), noted that

I have been presumptuous enough to counsel new Ph.D.'s in biology as follows: If you choose an academic career you will need forty hours a week to perform teaching and administrative duties, another twenty

hours on top of that to conduct respectable research, and still another twenty hours to accomplish really important research. This formula is not boot-camp rhetoric. (pp. 55–56)

Individual differences in conative factors surely engender dramatic differences in performance and work-related outcomes. They also engender different professional opportunities. Accounting for much more than 50% of work performance variance with all cognitive abilities may not be a cogent expectation.

### Conclusion

As modern societies move to create more information and to make this information readily available, more opportunities become available for differential development. In addition, tasks important at school, at work, and in life are becoming less concrete and less well defined. The dimensions of educational, occupational, and social niches are becoming more abstract and fluid. An examination of phrases used to characterize skills needed in today's most complex learning and work environments quickly reveals that the current need is for abilities for "coping with change," "dealing with novelty," "quickly grasping" the relevance of innovative ideas for staying "ahead of the curve" and "anticipating change." The skills needed in modern society require dealing with complexity and with change, and, more than ever before, these changes are relatively content free. At work as in life in general, people are required to respond to situations for which they have not practiced. Modern environments underscore the importance of Spearman's (1923, 1927) three principles of cognition: apprehension of experience, eduction of relations, and the eduction of correlates. And perhaps, here, links may be drawn from Spearman to Freud's (1925) fundamental task of the nervous system: "The task of the nervous system is—broadly speaking—to *master stimuli*" (p. 63). The specific content is not fundamental, because the specific content of life is ever changing. Coping with life requires the continuous development of new skills, so abilities useful for mastering new content—and new relationships—are what are needed.

Assessment designed to index individual differences in prespecified domains (e.g., mastery of prescribed content in educational and occupational contexts) will always be important, but, increasingly, skills in coping with novelty, generalizing and discriminating dynamic relationships, and making inferences that anticipate distal events are what modern society demands. In her synthesis of widely diverse literatures, for example, Gottfredson (2004) presents a compelling case that, as information accrues about diet, health, and preventive medicine, we become our own primary health care providers. Preventive health care is the most effective kind of health care, but health-related information is often highly complex, and knowing when to act and when to consult becomes critical. The same can be said for financial planning, educational and vocational decision making, parenting, and world travel. All of these contexts are taking on more dimensions, and how we respond to these complexities has implications for personal development and interpersonal relationships, because they determine how free we are to choose among multiple short- and long-term life options. To the extent that social scientists embrace cognitive abilities for modeling important human behaviors and outcomes, they will be better positioned to explain and understand—from a scientific point of view—those aspects of life that capture the exigencies, interests, and opportunities in modern cultures.

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Received December 30, 2002

Revision received June 13, 2003

Accepted June 16, 2003 ■



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