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Hans Eysenck's theory of intelligence, and what it reveals about him

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ABSTRACT

Hans Eysenck was a highly analytical, objective, independent-minded experimentalist. He personified the biological perspective of the Galton–Spearman 'London School of Psychology', which he led for many decades. His first (1939) and last publications (1998) were on intelligence. Returning to the topic in the 1960s, he formulated, tested, and promulgated the theory that general intelligence (*g*) is a biological phenomenon with broad social consequences. I examine the status of Eysenck's theory, advances in the field, and social reactions to them during the 1960s–1970s, 1980s–1990s, and since 2000. My perspective is that of a sociologist who, in testing alternative theories of social inequality, was drawn inexorably into the intelligence literature, policy debates over fairness in employee selection, and first-hand observation of the sort of controversies he experienced. Eysenck's 1979 and 1998 textbooks on intelligence mark developments in his theory and supporting evidence during the first two periods. They exhibit considerable knowledge about the philosophy and history of science, and the nature of scientific controversy. Advances in intelligence since 2000, in particular, from neuroimaging and molecular genetics, vindicate his biological perspective. It was controversial during his lifetime because he was so far ahead of his time.

1. Introduction to a remarkable scholar in social context

1.1. Eysenck's approach to intelligence

"*Objective, quantitative, analytical, biological.*" (Jensen, 1986).

Eysenck's scientific approach was a sure-fire recipe for controversy when he began writing again on intelligence in the late 1960s. And so it remains today, especially if one tracks the footprints of human variation in intelligence—objectively, quantitatively, and analytically—from the biological realm into the cultural, as Eysenck did.

But why did Jensen also list 'biological' as if it might be a fourth scientific virtue? After all, we are awash today in brain imaging and molecular genetic studies of intelligence, not to mention behavior genetic research documenting genetic correlations between intelligence and brain physiology, behaviors, life outcomes and events. The older among us will recall, however, that any notion of biological influences on mentation and behavior had been anathema for some time. It was still the age of behaviorism. Eysenck, however, was a persistent and vocal advocate of psychology as a biological science throughout B. F. Skinner's intellectual reign.

Onlookers frequently wonder why any researcher would provoke derision and hostility by seeming to repudiate the consensus in social science and offend public sensibilities. Do they seek or revel in controversy? Are they pushing an ideological agenda? What motivates them?

1.2. Preview

I will offer an answer to the onlookers' question, but first take us back to the tumultuous 1960s and 1970s to examine Eysenck's intelligence work in historical context. Although his first publication (Eysenck, 1939) had been on intelligence, he did not return to the topic until the late 1960s. I focus on his 1979 book, *The Structure and Measurement of Intelligence*, where he outlines a theory of intelligence that integrates prior research. I then move forward to the 1980s and 1990s to examine the last statement of his theory, *Intelligence*: *A New Look* (1998), written just before his death in 1997. Did either his theory or the climate of the times change much, and how? Any evaluation of a scientist's contributions must take into account how well they hold up beyond his own lifetime. I next show that his theoretical paradigm not only holds up, but is even more compelling today. Eysenck spent only a fraction of his multi-faceted career on intelligence, so his leadership in the field is all the more remarkable.

1.3. Personal perspective

My account reflects the perspective of a disciplinary outsider who would became deeply involved in efforts to understand individual differences in general intelligence (*g*) and how societies respond to them. My interest in intelligence theory eventually converged with Eysenck's but from a different direction, his from biology and mine from sociology, which was (and remains) decidedly 'biophobic' (Ellis, 1996). Eysenck had worked for decades in personality, psychopathology, and other domains of individual differences. I came via vocational

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counseling, personnel selection psychology, and other applied fields often embroiled in litigation and disputes over public policy and ethical practice owing to the dilemmas posed by sizeable individual and group differences.

As a new PhD in sociology in 1977, I had no particular interest in intelligence. My work asked a traditional question in the discipline: what creates and sustains social inequality? Because my work simultaneously addressed a neglected question in vocational psychology (what abilities do different occupations require?), I concentrated on occupational inequality (who gets ahead on the occupational hierarchy, and why?). I was skeptical of the prevailing explanation in my field, social class conflict theory, so I set up a contest with its competitor in the field, functional theory: which one better explains the occupational hierarchy itself?

More particularly, why does the hierarchy's ordering of occupations by social status mimic their ordering by average worker IQ? Is it a power hierarchy that the elites disguise as meritocratic to justify their privileges (conflict theory), or does the parallel ordering of status and IQ reflect society's need to recruit more talented workers to perform its most consequential work (functional theory)? In short, does intelligence have a functional value on the job?

To test the theories, I examined the work actually performed in different jobs, something sociologists had totally ignored. So, while Eysenck had tested Spearman's vs. Thurstone's claims about a general factor of intelligence (yes vs. no) early in his career, early in mine I tested competing claims about whether the occupational hierarchy orders occupations according to the functional importance of intelligence in performing the work (no vs. yes). He confirmed a *g* factor dominating individual differences in mental ability. Mine (Gottfredson, 1985) identified a parallel cognitive complexity (*g* loading) factor dominating distinctions among jobs. It appears that human variation in *g* might have evolved a *g*-oriented work structure to accommodate population variation in *g*—an extended phenotype of our particularly brainy species.

I draw on other experiences in my non-traditional journey to *g* theory to illustrate meta-themes in Eysenck's work, the evidence on intelligence, and public hostility to it.

2. Intelligence theory and climate of opinion in 1960s and 1970s

2.1. Eysenck's biological theory of intelligence, 1979

Writing about Eysenck's contributions, Jensen (1986, pp. 92) described his 1979 textbook, *The Structure and Measurement of Intelligence*, as the most definitive single source for Eysenck's views on intelligence. In it, Eysenck argued that psychology needs a theory of intelligence and actually already possesses one, which he referred to as its orthodox perspective. He was concerned to redirect the field's attention to the construct of intelligence, away from its preoccupation with measurement technology. Eysenck (1939) had been involved in the debate between Spearman and Thurstone over whether factor analysis supported a single general intelligence, *g*, or multiple primary factors. However, Eysenck now argued that factor analysis, as useful as it had been, could not explain the *g* phenomenon it had revealed. Theory had languished during the intervening decades as testing became a big business. Tests had improved, but it was often unnecessary, impolitic, or financially unwise for developers and users to clarify the construct being measured.

Eysenck's aim in the book was to present the paradigm to which 80 years of research had converged. To this end, he included the very latest advances in the field: Rasch's new measurement model, Maher and Jinks' improvements in the analysis of genetic data, and studies showing a relation between intelligence and strictly biological phenomena such as inbreeding depression and shape of the jaw bone. He also described the first ever study on the heritability of educational attainment (.44), adult occupation (.46), and income (.48), by economist Paul Taubman (1976). He then described another first ever analysis, namely, how David Fulker (1978) used a new technique, multivariate behavior genetic analysis, to calculate the genetic correlations (.44 to .62) among the three outcomes in Taubman's study. They shared most of their genetic variance in common—essentially, a general success factor—which Eysenck interpreted as probably reflecting genes in common with *g*. Later studies would confirm that supposition.

Eysenck conceptualized intelligence as a biological phenomenon that shapes social life, his outlook a legacy from the London School of Psychology's earliest Galtonian days. Eysenck enlarged the legacy with his students and colleagues even during the long dark decades of behaviorism, which rejected mind and genes alike. Fig. 1 summarizes his theory. It links phenomena at different levels of analysis, as good theories do, from genes to life outcomes. It takes into account prior empirical evidence and alternative interpretations too, as any good theory must.

Eysenck substantially expanded the evidentiary base and scope of intelligence theory by hypothesizing and investigating the proximal antecedents and consequences of psychometric *g*. By *g*, he meant Spearman's *g*, which is theoretically and empirically isomorphic with *fluid g*, as distinct from *crystallized g*. Eysenck's theory of intelligence is therefore more precisely a theory of *g*. He knew from prior research that individual differences in *g* have strong genetic roots (distal antecedents) as well as pervasive effects on people's socioeconomic outcomes (distal consequences). Neither *g* nor its impact in human affairs is programmed in the genome, of course, so by what mechanisms would the genome yield a *g*, and *g* exert its apparently considerable influence on people's lives?

To fill these explanatory gaps, Eysenck promoted two lines of research in his lab. Both interrogated some of the brain's more elemental information processing. One focused on aspects of brain function that might influence or reflect the brain's global efficiency and thereby help account, biologically, for a general factor of intelligence. For instance, he and his colleagues used average evoked potentials (AEPs) from EEG studies to probe domain-general mechanisms possibly supporting a highly general intelligence (e.g., mental speed). The other line of research focused on eliciting mental acts so elemental, such as choice reaction time (CRT), that they might explain *g*'s generality of effect in any culture in any era, surely a biological phenomenon in itself. Chancing upon a small CRT study in the German literature, he immediately saw its relevance to intelligence theory. Jensen (2006) would exploit the method in his book *Clocking the Mind* to probe the role of

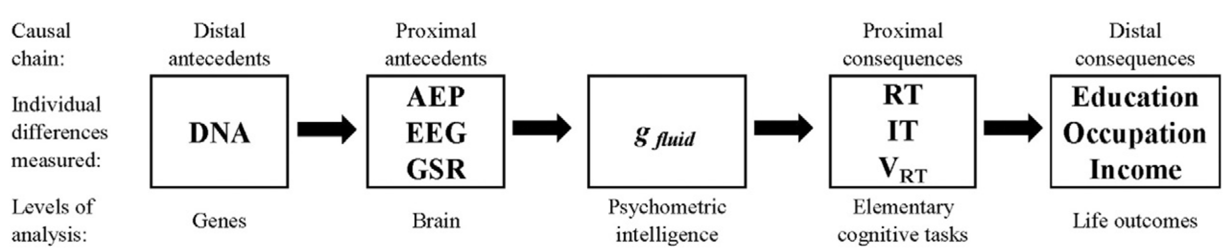

Fig. 1. Eysenck's biological theory of intelligence. Adapted from Eysenck (1998, Fig. 5.6, pp. 75). AEP = average evoked potential, EEG = electroencephalogram, GSR = galvanic skin response, RT = reaction time, IT = inspection time, V_{RT} = variance in reaction time.

mental speed in explaining g. Inspiring Jensen and other talented empiricists to investigate the biology of intelligence was another way in which Eysenck advanced intelligence theory.

Eysenck's writings are notable for his deep knowledge and sophistication in the philosophy of science. Jensen (1986, pp. 91) describes how Eysenck used it, in effect, to provide tutorials in good science: "Readers…can hardly fail to be educated concerning the role of scientific definitions, constructs and paradigms, the interdependence of theory and measurement, and the ways in which the elements, in conjunction with empirical data, are involved in the advancement of scientific knowledge." Eysenck also deployed this knowledge "to counter the amazing accretion of naïve misconceptions and obscurant notions about the nature and measurement of intelligence… [which]… have tended to frustrate the advancement of proper scientific research in this field". Eysenck's writings explain clearly and simply the scientific logic in measuring and interpreting latent constructs like intelligence. They are timeless in this regard. They also clarify basic phenomena that most people misunderstand, for example, how the high heritability of intelligence actually guarantees, not precludes, intergenerational social mobility. And some of his most technical examples are utterly fascinating. I never imagined that the history of the thermometer could be so interesting and informative!

2.2. Climate of opinion toward intelligence research in the 1960s and 1970s

Back in the 1960s, American social scientists generally accepted that individual and group differences in intelligence are real and influence life chances. They presumed, however, that intelligence is malleable and could be raised by redressing educational and economic disadvantage. On these assumptions, the U.S. government enacted far-reaching policies to equalize achievement by equalizing education, for example, with compensatory education, free or reduced-price meals for poor students, Head Start programs for poor pre-schoolers, and intensive early intervention programs to raise low IQs among poor black children. But none eradicated the racial gaps as hoped. It also commissioned a national study of thousands of schools and their students—*Equality of Educational Opportunity* (Coleman et al., 1966)—to determine how school attributes affects student test scores. The Coleman report revealed that the test score gaps between black, white, Hispanic, and Asian students were associated primarily with characteristics of their families, not their schools. Public policy had now drawn an indelible line between race and intelligence. Attempts to erase it soon followed.

Social scientists began to turn against tests and intelligence when the U.S. government's War on Poverty in the 1960s failed to narrow racial differences in IQ and standardized achievement and when the Coleman report indicated that schooling was neither their cause nor solution. Mental tests are biased, they said. Intelligence isn't important anyway. It doesn't differ by race, and even if it did, the gap would not be genetic. The hostility crystallized when Jensen's (1969) monograph, *How Much Can We Boost IQ and Scholastic Achievement?*, made a case that remedial education had failed to raise low IQs because IQ differences are highly heritable. Indeed, it ignited an explosion of public vitriol by suggesting that education would not eliminate the racial IQ gap if it too is partly genetic. Herrnstein (1971) amplified Jensen's message by tying the heritability of IQ to social inequality in general: social inequality is inevitable when IQ is heritable and merit matters. It was an old idea, but now off-limits, so it reignited the storm. This was the ideological buzz-saw into which Eysenck knowingly stepped with his biological theory of intelligence and social inequality.

Psychometricians and test publishers continued to defend the validity and fairness of professionally-developed intelligence tests, but distanced themselves from genetics. For instance, the eminent psychometrician Anne Anastasi (1970, pp. 900) saw no need to hypothesize any innate properties. In her view, psychometrically-identified ability factors (e.g., g, verbal, numerical, and spatial) are formed by co-occurring experiences that cultures provide individuals at different ages: "It follows that different traits may be formed in different cultures." This would become a common argument among other luminaries in later decades to dispute the already proved biological basis of g.

2.3. Extreme environmentalism of sociology's standard path model of status attainment

Retrieving Eysenck's 1979 book recently, I was struck by its cover (see Fig. 3). Stamped into the hardback's front was the sort of analysis I had been taught in graduate school to trace the effects of family background on socioeconomic success in adulthood. Sociologists routinely mis-specified IQ's role in status attainment, however, so Eysenck had slightly altered their standard path model. His tweak symbolizes why his work ignited public controversy. It implied that Mother Nature has a hand in creating social inequality.

Blau and Duncan (1967) had recently transformed the study of social mobility by demonstrating a more systematic, quantitative way—path analysis—to model how family background and schooling might generate socioeconomic inequality in adulthood. Path analysis quickly replaced the field's cumbersome cross-tabular analyses of mobility across social classes, which Eysenck (1973a) had reviewed in his 1973 book, *The Inequality of Man*. I was impressed with how familiar he was with the relevant studies in my native discipline.

Blau and Duncan's (1967) book was the first to be assigned in my graduate program at the Johns Hopkins University. Path modeling was an exciting new tool for the statistically minded and set the standard for technically sophisticated sociology. It left behind sociology's rich conceptualization of social classes as cultural entities, which are distinctive not just socioeconomically but in norms, mores, and behavior too. Status attainment models focused instead on individual-level differences in socioeconomic origins and outcomes by using readily available indicators of parental status to predict parallel attainments among offspring, principally years of formal education, prestige level of occupation, and annual income, if available. The correlational and other descriptive data from these large national studies were highly informative, but I considered the modeling mechanical and theoretically mindless.

Blau and Duncan did not have IQ data, but later status attainment studies did. Perhaps the most important was Sewell and Hauser's (1975) book *Education, Occupation, and Earnings: Achievement in Early Career*. Fig. 2 reproduces the path diagram guiding their statistical analyses. It was the standard causal model of status attainment at that time. Socioeconomic inequality among parents begets a cascade of inequalities among children: first in IQ, then years of education, then occupational status, then income.

Sewell and Hauser assumed, as many social scientists still do, that parents' socioeconomic status determines offspring IQ. A child's IQ also correlates with their adult accomplishments, so the authors concluded that IQ *transmits*, serves as a conduit for, the parents' social privileges to the child in adulthood. Even when adherents to the standard model concede that people might differ genetically at birth, they brush that fact aside. As they see it, powerful social forces damage some people while enhancing others and soon overwhelm any genetic influences. The result is to generate in offspring generations the same inequality seen in parent generations. Under the standard model, social inheritance is wholly responsible for individual differences in mental ability. Absent this unfairness, parent–child correlations for intelligence, education, occupation, and income would approach zero. Promoting intergenerational social mobility therefore requires equalizing rearing environments.

Fig. 3 shows the path model imprinted on Eysenck's book. (Ignore the numbers and differences in terminology.) He positions intelligence as an exogenous (unexplained) variable, meaning that differences in children's intelligence are not caused by differences in parents' socioeconomic resources (here, fathers' attainments). He appropriately rejects Sewell and Hauser's extreme environmentalism because it was

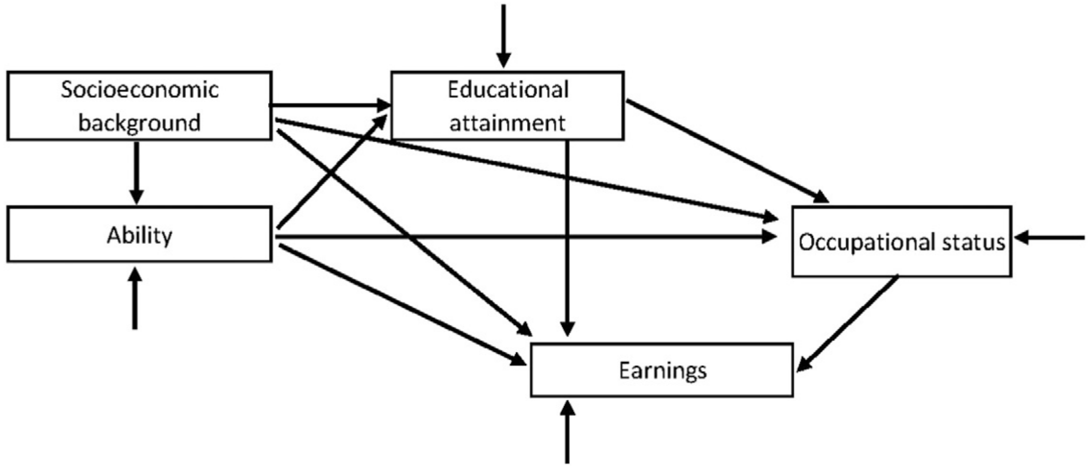

Fig. 2. Standard status attainment path model in sociology (Sewell & Hauser, 1975, pp. 49). Note: The short arrows coming in from outside the model denote residual factors unexplained by the specified variables.

clear by the 1970s that individual differences in intelligence are substantially heritable.

Once IQ was added to the field's standard path model, I realized that, far from being atheoretical, it embodied an implicit theory—a string of a priori causal assumptions or axioms—that predetermines how results are interpreted. It is theory by silent decree: socioeconomic inequality manufactures individual differences, which then reproduce social inequality. Both individual differences and inequality are man-made.

2.4. Radical social constructivism of sociology's reigning theory of inequality

Conflict theory was ascendant when I entered graduate school. The most influential statement was 'IQ in the Class Structure' by economists Samuel Bowles and Herbert Gintis (Bowles and Gintis, 1972/1973). It never mentions Arthur Jensen but was written to rebut his 1969 explanation for why compensatory education programs had failed to boost low IQ and scholastic achievement. Their treatise adopts many features of the standard social science model but is more radical in several respects. First, it suggests that environments do not actually create economically-relevant individual differences in capability. Rather, the elite promotes an ideology that just makes people think so. According to Bowles and Gintis, intelligence differences are merely socially generated chimeras of no practical import. IQ scores reflect degree of privilege, not talent, and serve only to legitimize inequality by providing it a meritocratic veneer.

Second, people's fates are determined directly by the advantages bequeathed or denied them by the privileged and powerful classes. The only environment that truly matters is ideological. Elites spread false beliefs that hoodwink the populace into believing that people differ in merit (when they actually don't) and therefore inequality is inevitable and socially just (when it is not). Inequality, according to conflict theorists, exists entirely by design. The first aim of social policy should therefore be to eradicate the seemingly legitimate practices (e.g., credentialing) and ideologies (e.g., functional theory) used to manufacture and sustain it.

2.5. Plausible and implausible theories equally consistent with the data on intelligence

The conflict theorists' explanation of social inequality was utterly implausible. Yet, it was equally consistent with the data linking intelligence to unequal life outcomes as the explanation provided by its

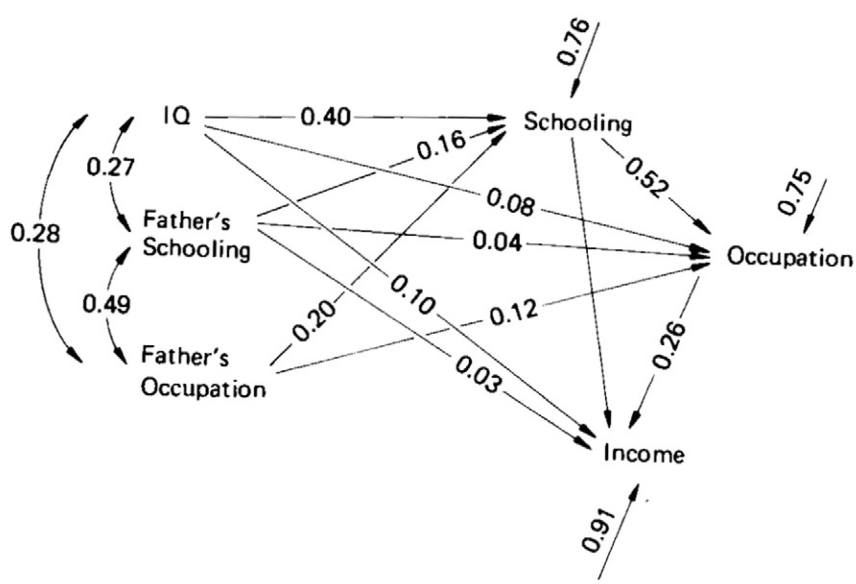

Fig. 3. Eysenck's revised ordering of variables in the standard status attainment path model (Eysenck, 1979, pp. 158).

disciplinary competitor, functional theory (Davis & Moore, 1945). Yes, higher IQ individuals do tend to get better jobs and higher level jobs do tend to employ brighter workers, as functionalists would predict, but an irrational employer preference for higher-IQ individuals could explain that. Do higher level jobs actually need brighter workers to get the job done, as functional theorists claimed? Conflict theorists thought not. Brighter workers got higher performance ratings, but higher ratings might reflect employer favoritism—favoring one's own kind—as many sociologists claimed. Did job performance in any job truly depend on the worker's intellectual ability? One influential sociologist, Randall Collins (1979), argued that virtually anyone could perform virtually any job. He said all that workers needed is on-the-job training. Functionalists could not refute his claims by pointing to correlations between worker IQ and ratings of job performance, because both could be socially constructed by the same machinations of social privilege. Others argued the non-sequitur that educational level doesn't predict on-the-job performance, so IQ can't either (Berg, 1970). And since IQ supposedly has no functional value, any genetic component would only reflect unfair *genetic* discrimination favoring the higher classes if IQ were used to select employees.

Functional theory could not answer conflict theory, and neither theory addressed the genetic, ECT, and psychometric evidence that Eysenck reported for intelligence. Eysenck's theory of intelligence, a species of functional theory (higher *g* has practical value), could not disprove conflict theory's claims about intelligence's role in social inequality any more than sociology's functional theory could. His 1979 book contains the shadow of an answer. It has nothing to do with individual differences in traits, but with the stimuli that call them forth. Sociologists and psychologists alike had focused on finding social environments that might widen or narrow individual differences in *g* itself, but they had mostly ignored the task environments within jobs that pull those latent differences into public view. Data on the latter—tasks, not persons—would be essential for testing the competing explanations for how intelligence differences generate social inequality (Gottfredson, 1985).

Eysenck's theory of intelligence was correct. But it would take several more decades of studies replicating old results with more exacting methods, new technologies, and bigger samples to persuade even a fraction of psychologists of its fundaments: that *g* exists, is heritable, correlates with brain structure and function, and has functional value outside of schools (cf. Plomin et al., 2016).

3. Intelligence theory and scientific climate in the 1980s and 1990s

3.1. Eysenck's theory of intelligence in 1998

Eysenck's 1998 textbook, *Intelligence*: *A New Look*, strengthened his theory but did not change its now-confirmed fundaments. He dropped some ideas he thought promising in his 1979 book, including Sternberg's componential theory and Jensen's Level I/II theory, and he added new insights from behavior genetics, personnel selection, psychometrics, and other research in the intervening years. The theoretical and empirical progress made in those decades seems amazing when compared to the state of knowledge Eysenck (1973b) had showcased in his edited 1973 volume, *The Measurement of Intelligence.*

Where intelligence researchers had been on the defensive in the 1960s and 1970s, now critics were put on the defensive. More scientists were persuaded of the field's basic findings, at least privately. Resolute critics remained, however, because inequality remained. As the evidence became more compelling, their evasions of it evolved apace.

3.2. Advances and evasions

3.2.1. Construct validity of psychometric g

Jensen's (1980) *Bias in Mental Testing* convinced most serious scholars that professionally developed intelligence tests are not biased against (predict equally well for) American blacks and other native speakers. Later work by Jensen and others showed that tests of intelligence, broad mental abilities, and standardized academic achievement all measure mostly *g*, and that the average black-white IQ difference represents a difference in *g*. It also demonstrated that the *g* factors extracted from different IQ test batteries and populations converge on the same true *g*.

Carroll's (1993) reanalysis of hundreds of factor analytic studies finally convinced most scholars that there is, in fact, only one general factor of mental ability (*g*), as Eysenck himself had confirmed in 1939. Jensen (1998) would soon summarize multiple types of evidence for the empirical meaning and biological basis for psychometric *g*. It is a worldwide phenomenon; is highly heritable; provides the common spine for all cognitive tests, complex or elementary, seemingly different or not; and has pervasive correlates throughout the body, brain and behavior.

Also very important, multivariate behavior genetic analyses showed that the hierarchical structure of phenotypic abilities is replicated at the genetic level. At the phenotypic level, variation in *g* soaks up most of the variance in verbal, spatial, quantitative, and (less so) memory ability. Moreover, its genetic correlations with these abilities nearly exhaust its phenotypic correlations with them. Similarity of phenotypic and genotypic structures has been replicated in the personality domain as well.

By the early 1980s, it was clear to the empirically minded that the *g* factor is real and has functional value. But as night follows day, there arose new efforts to minimize *g*'s conceptual and practical importance. Among the first was Gould's 1981 book, *The Mismeasure of Man*, which aimed to destroy the scientific credibility of *g*, *g* researchers, and anyone suggesting that intelligence might correlate with brain size.

Next were proposals for multiple, co-equal intelligences: Gardner's (1983) seven (later eight, then nine) and Sternberg's (1985) three. When actually quantified and independently analyzed, both sets of multiple intelligences yielded but a single general factor, yet falsification of their claims has done little to dim the popularity of these theories, especially in education circles. In 1995, Goleman (1995) proposed an Emotional Intelligence, measured by self-report, which he claimed rivals the importance of IQ in the workplace. Once again, implausibility has been no barrier to avid adoption, especially in business settings.

3.2.2. Patterns in the heritability of g

Behavior geneticists were surprised by evidence that the heritability of intelligence rises with age, and linearly so, from 20% in early childhood up to 80% by mid to late adulthood. Moreover, by adolescence shared environments have nil influence on intelligence, while non-shared environments continue to matter.[1] Researchers also replicated a convergent finding that had been overlooked in earlier years (though not by Eysenck), namely, that adopted children become more similar to their biological parents with age and less like the adoptive parents who raised them. Developmental behavior genetic analyses provided a crucial insight into these phenomena by showing that the high age-to-age stability of (rank in) intelligence is genetic whereas non-shared environments account for change. All these surprises tell the same story—the effects of shared environments dissipate—fade out—by young adulthood. And they contradict the critics' hedge against possible genetic differences at birth, which is that any genetic influences would soon be overwhelmed, in their view, by powerful social forces.

Eysenck points to other findings that converge from different directions to falsify the standard social science model's claim that family environments determine children's IQs and socioeconomic outcomes. One

[1] These heritabilities are for populations in the developed world, primarily of European origin, during the last 100 years. As Eysenck points out, we would expect heritabilities to be lower in places and eras where individuals are less able to exploit their own genetic inclinations and abilities. Heritabilities would rise in conditions where all individuals have access to the same resources and opportunities, which is the reverse of what many people mistakenly assume.

is the falsified assumption that the same family environment will produce the same child IQ. Common observation tells us this is false because biological siblings (except identical twins) raised in the same home often differ noticeably in IQ (11–12 points, on average), as would be expected given their genetic dissimilarity. Turning to outcomes, biological brothers who are raised in the same home but differ in IQ also differ in education, occupation and income to about the same degree as do non-kin males with commensurately different IQs. Third, studies reconfirmed that education, occupation, and income are themselves moderately heritable, and fourth, their phenotypic correlations with *g* are substantially genetically mediated. All of these findings are predicted by intelligence theory but none by the standard social science model. The challenge for intelligence theory is now to explain *why* these relations with *g* are genetically mediated.

A second surprise was that all psychological traits show significant and substantial heritability (typically about 50%): not just core personal traits such as intelligence, personality and psychiatric disorders, but also beliefs, attitudes, behaviors, and socioeconomic outcomes. Most surprising was that all personal environments are significantly heritable (average 27%), for instance, rearing environments and social support. These include life events over which we have at least some influence, such as financial problems and divorce. When people are free to do so, they actively select, shape, evoke, and exit personal environments depending on their genetic proclivities. Our genome seems to leave its marks everywhere. The process probably begins at birth, because measures of rearing environments correlate genetically with the *child's* attributes.

The pervasive heritability of environments dramatically contradicts the standard social science model, which posits only one-way influence, from the outside in; that individuals are passive objects molded this way or that by external forces. The challenge for intelligence theorists is to explain the systematic differences in the magnitude of these phenotypic and genetic correlations between environments and *g*. The challenge for adherents to the standard social science model is to explain why they continue to ignore the genetic component in all of their environmental and non-environmental variables.

Molecular genetics would soon confirm a third surprise with its new technologies for interrogating individuals' genomes (Plomin, DeFries, Knopik, & Neiderhiser, 2016). Genome wide association (GWA) studies, all post-2000, have repeatedly found that the allelic variations, or SNPs, associated with complex traits like intelligence and schizophrenia are highly dispersed and have tiny effects (e.g., in one study, each averaging .0002% of variance in years of education). GWA studies can provide lower-bound estimates of heritability when they employ GCTA (genome-wide complex trait analysis). A recent such 'GWAS Plus' study (Kirkpatrick, McGue, Iacono, Miller, & Basu, 2014) that examined 2.5 million common SNPs for 7100 individuals in two longitudinal family studies could account for 35% of the phenotypic variance in general cognitive ability, even though no single SNP reached statistical significance. The authors conclude that "trait-relevant SNPS are each Lilliputian in effect size, but together, are legion in number" (pp. 11). Although intelligence can be devastated by a single allele or gene segment, differences in normal intelligence, like height, are radically polygenic—the confluence of seemingly myriad differences in the genome that affect untold numbers of developmental and physiological processes. It is no wonder that *g*'s functional and structural correlates in the brain, as we shall see, are so thoroughly dispersed throughout the brain.

GWAS plus GCTA studies, which can calculate genetic correlations among traits and outcomes have found that the phenotypic correlations between IQ and various indicators of socioeconomic status are mostly genetic. A study of almost 3000 unrelated children (Trzaskowski et al., 2014) found that genetic factors explained most of the phenotypic correlation between a child's IQ and age-7 parental socioeconomic status: 100% for age-7 IQ and 66% for age-12 IQ. A study of 6815 unrelated adults (Marioni et al., 2014) reported that their adult IQs were genetically correlated .95 and .29, respectively, with their years of education and a deprivation score for area of residence. Such studies provide ever more compelling evidence that the standard social science model is grossly mistaken. They also vindicate Eysenck's prescient view that not only is intelligence biological but also that its biological nature would profoundly influence human affairs.

Yet the mere heritability of intelligence remained controversial during the 1980s and 1990s, even among psychologists. Anne Anastasi (1983, pp. 181) was still saying there was no need to hypothesize any innate properties. The APA's monthly news magazine, *The APA Monitor*, continued to describe behavior genetic research on intelligence as controversial. For example, it headlined its 1991 feature on Thomas Bouchard's latest MISTRA results: "Seeing double? Controversial twins study is widely reported, debated" (Adler, 1991). The feature opened with Bouchard's 'controversial' finding of 70% heritability for intelligence, followed immediately by a disclaimer: "However, some behavioral geneticists and psychologists doubt that genetic influence plays as large a role as Bouchard argues." The article then quoted assorted skeptics offering mutually inconsistent critiques. One would never guess from such reportage that most intelligence experts had already reached much the same conclusions as had 'controversial' Bouchard, Eysenck and Jensen (Snyderman & Rothman, 1988).

When proof for the high heritability of intelligence became incontrovertible, environmentalists attempted to undercut this knowledge by depicting genetic influences on intelligence as unmeasurable, irrelevant, or environmental. First was interactionism—the logical fallacy that we cannot calculate the heritability of individual differences in intelligence within a population because an individual's intellectual growth depends on the interplay between their genes and environments. Second was seizing on the secular rise in IQ total scores to assert that intelligence is malleable, this despite decades of evidence to the contrary, in turn allowing environmentalists to ignore the much-replicated heritability and age-to-age stability of intelligence differences. Third was asserting that genes are actually the handmaidens of social and intellectual inequality, for instance, that differences in *g* arise because systematically unequal social processes recruit genes to instantiate in phenotypes a tightly organized inequality of cognitive abilities (i.e., the *g* factor).

Environmentalists often took a different tack for racial differences. One was to argue that there can be no genetic differences in intelligence by race because races do not exist biologically. Their argument ignores, among other things, common knowledge that physical anthropologists and coroners possess good techniques for determining the age, sex, and race of human skeletal remains. Another tack has been to first concede that even longer lists of increasingly subtle indicators of social disadvantage (e.g., stereotype threat)—none of the data genetically sensitive—still cannot account for more than a third of the black-white IQ gap, but then argue, as Jencks and Phillips (1998) did, that environments have not been measured comprehensively enough to identify how they create the large racial gaps in test scores. Even for these highly skilled policy researchers, it appears that the only persuasive evidence is the evidence that no one can find. Sounding like conflict theorists, they add that "A successful strategy for raising black children's test scores must also try to convince both blacks and whites that the gap is not genetic in origin" (pp. 46).

3.2.3. Brain physiology of g

Eysenck's research on intelligence focused on what *g* is in the brain. It clearly is not a place or thing but a property of the brain as a whole. The brain has many pieces and processes but works as a unit. Intelligence, he proposed, is a function of how efficiently that unit processes information. Eysenck and his colleagues continued to test their theories of what makes some brains more efficient, especially speed of processing. The EEG had provided them a non-invasive way to observe the brain in action. Average evoked potentials (AEPs) showed that brighter brains respond faster to stimuli (have shorter latencies).

To test the speed hypothesis further, Eysenck used Spearman's (1923) description of *g* as a theoretical basis for designing progressively more complex choice reaction time (CRT) tasks: apprehension, then *eduction* of relations, and then eduction of correlates, as in his odd-man-out task. His team again found that brighter brains react faster, and disproportionately faster when reaction time tasks are more complex. Deary's 2000 book on inspection time tasks, *Looking Down on Human Intelligence*, described how intelligence also predicts speedier apprehension of tachistoscopically presented stimuli. Most interesting is that intelligence predicts consistency (lack of variability) of both reaction time and inspection time better than it does speed itself. Eysenck and his colleagues theorized that errors in processing slow the speed of processing, and they specified some mechanisms that might increase error rates, such as degradation of the myelination sheaths insulating nerves in the cerebral cortex.

The first in vivo brain imaging study of normal intelligence (Haier et al., 1988) found that the brains of brighter individuals use less glucose when solving mental problems, which is consistent with intelligence reflecting efficiency in the brain's processing of information. Imaging studies have since confirmed that intelligence correlates with total volume, cortical thickness, and many other aspects of brain structure and function. They have tended to use miscellaneous, psychometrically deficient measures of *g*, but nonetheless find that cognitive scores correlate with just about everything imaged in the brain, all of which is heritable besides. Neuroimaging studies show that intelligence is widely distributed across both gray and white matter. Moreover, differences in intelligence are predicted by how well different brain structures function together as networks, or information highways. Jung and Haier (2007) integrated this evidence in a Parieto-Frontal Integration (P-FIT) Theory of intelligence, which has had the salutary effect of stimulating much *theory-driven* research on the physiology of intelligence.

Many critics still cite Gould's *Mismeasure of Man* to reject the reality of *g* and its correlation with brain size, and all too many academics still assign his book to their students. Neither disproof of Gould's falsehoods nor proof of his fraudulent behavior seems to have done much to blunt their enthusiasm for his misleading book.

A newer evasion is to claim that brain physiology holds the key to raising intelligence because such a dynamic system must surely be malleable. Some researchers imply this when they purport to show that cognitive training improves scores on tests of executive function, as if it were a piece of the brain rather than just a neuropsychological construct. Others infer that brain structure is improvable because, when imaged, it differs by children's social background and then, in circular reasoning, advocate giving more resources to poor families to improve their children's brains and subsequent academic achievement—as if such policies had never been tried or failed.

The focus on social inequality distracts attention from more plausible, biological routes to improving brain functioning. Eysenck himself tested whether vitamin and mineral supplements would raise intelligence. He predicted, and found, that supplements would improve fluid *g* (proficiency in learning) but not crystallized *g* (past learning), and only among children with a vitamin or mineral deficiency. Intelligence, like all abilities, is a maximal trait—your personal best when the conditions are right, such as getting a good night's sleep and eating well before taking a big test. Alas, like the vitamin-deficient children in Eysenck's research, we often operate under conditions that drag us below our physiological best.

Common drains on cognitive power, often preventable, include fatigue, sleep deprivation, hunger, nutrient-poor diet, alcohol, certain medications, and illicit drugs. Years of smoking, drinking to excess, eating to excess, and being sedentary—all evolutionarily novel opportunities to damage one's health—lead to chronic conditions such as diabetes that corrode the physiological integrity of organ systems essential for a healthy brain, thereby accelerating cognitive decline. As Eysenck's research suggests, the best way to improve our brains may be to avoid substances and remediate circumstances that keep them operating below capacity. He told me that he avoided alcohol for that reason. Biological constraints may preclude brain upgrades that boost an individual's cognitive maximum, but behaviors and environments that downgrade the brain are malleable.

3.2.4. Patterns in g's impact on job performance

Advances in personnel selection psychology during the 1980s and 1990s confirmed that variation in *g* has pervasive functional value in the workplace, not just in school. Personnel selection psychologist Frank Schmidt and statistician John Hunter developed validity generalization (VG), a form of meta-analysis, to correct for three statistical artifacts that were muddling interpretation of employment test validation results (measurement unreliability, restriction in range, and sampling error). When they applied VG to large military and civilian datasets as well as to hundreds of previous validation studies, their results revolutionized theory and practice in the field. Instead of general mental ability having only spotty and unpredictable associations with job performance, as previously believed, it actually has a highly generalized and linear effect on quality of job performance. It predicts performance to some extent in all jobs, but better in more complex ones and when performance is measured objectively (Hunter, 1986).

This pattern of effects parallels the findings in education that *g* predicts performance in all school subjects but better in more difficult ones and when assessment is standardized. Schmidt and Hunter's VG work also demonstrated that mental ability predicts job performance equally well for blacks, whites, and Hispanics (Schmidt, 1988). This demonstration of *g*'s global ‘job relatedness’ a legal requirement, helped employers start using *g*-loaded tests again in hiring and promotion despite their having disparate impact by race.

In 1980 the U.S. Congress mandated that all four military services determine whether the Armed Forces Qualifying Test (AFQT) predicts on-the-job performance, not just success in training. All the services had long used it to select and place recruits based on its validity for predicting success in training. The study's largest component, the Army's Project A, confirmed that the AFQT's *g* factor not only predicts job performance but is also by far the strongest predictor of core technical proficiency in diverse Army specialties (Campbell & Knapp, 2001). These findings dovetail with more recent findings for college entrance exams. The SAT correlates very highly with the AFQT (Frey & Detterman, 2004), as if the two were alternative IQ tests. So do the two major graduate school entrance exams in the U.S., the MAT (Miller Analogies Test) and GRE (Graduate Record Exam). Like the AFQT, the MAT and GRE also predict academic and professional success in their intended realm, including grade-point average, comprehensive exam scores, time to degree completion, research productivity, ratings of career potential, creativity, and performance in internships and student teaching (e.g., Kuncel, Hezlett, & Ones, 2004).

The Army's Project A made another important contribution to *g* theory when it showed how the relative importance of cognitive (‘can do’) vs. non-cognitive (‘will do’) traits differs depending on the kind of worker performance an organization might wish to predict, for instance, efficient and accurate completion of core duties vs. showing good organizational citizenship. Project A was able to do so because, in the first effort of its kind, it systematically mapped both the predictor and criterion domains for a diverse collection of jobs. It identified five dimensions of good performance in the Army. Although *g* predicted performance on all five, non-cognitive traits became increasingly important as the tasks became less instrumental. For the five dimensions, predictions using *g* alone vs. *g* plus personality/temperament were: for core technical proficiency in a specialty—.63 vs. 63; general soldiering—.65 vs. .66; effort and leadership—.31 vs. .42; physical fitness and military bearing —.20 vs. .41; and personal discipline—.16 vs. .35. Both personality and intelligence are important, but not equally so for different types of valued outcomes. And to understand *g* itself, it is as important to know where *g* matters least as where it matters most. A good theory of *g* must predict how its gradients of effect steepen and flatten across the landscape of work and social life.

Beginning in the late 1990s, research on health and health behavior began to reveal that they relate to intelligence in the same pattern observed in the worlds of work and education. The relations are pervasive across outcomes: health knowledge, behavior, illness, injury, and mortality. Based on available data, they also seem to be linear. This body of research mushroomed with the advent of cognitive epidemiology in the 2000s (Deary, 2010).

Prior to that, health psychology and medical sociology dominated research and theory on why health differs by psychological and social status. Both explain individual and group differences in health with some ad hoc version of the standard social science model or conflict theory. Setting aside the merits of their theoretical assumptions, these literatures have produced a large body of evidence that violates their own assumptions but fits *g* theory. The violation is that health inequalities are too pervasive and too linear to be explained by education, occupation, income, or other indicators of social advantage. For instance, higher income continues to predict increments in health even beyond levels exceeding the best health that money could possibly buy.

They refer to this global falsification of their theories as the mystery of the fundamental cause, which some now pursue deep into the psyche of inequality-induced self-perceptions. Their evidence fits *g* theory in part because it predicts an unnoticed pattern in their data. Indicators of social advantage consistently differ in how strongly they correlate with *g*. In order from very strong to weak, the best surrogates for *g* are functional literacy, years of education, occupational level, and income. This is also the order in which they correlate with health knowledge, behavior, morbidity and mortality. Their puzzling fundamental cause acts just like *g* (Gottfredson, 2004).

Employment testing was still under fire in the 1980s for qualifying proportionately fewer blacks than whites. Personnel selection professionals had been trying without success to meet demands by business and government to create valid selection tests with little or no disparate impact.[2] When personnel psychologists were introduced to *g* during the 1980s (Gottfredson, 1986), they learned why they had not been able to meet those demands in typical selection situations: that is, where (a) *g* matters on the job, (b) races score differently on *g*-loaded tests, and (c) non-cognitive qualities cannot substitute for aptness at learning, reasoning, and abstract thinking (manifestations of *g*). Under these conditions, valid, *g*-loaded employment tests will invariably produce disparate impact in typical applicant populations. Improving the reliability and validity of *g*-loaded tests only increases disparate impact because better measurement reveals ability differences more effectively, and adding non-cognitive tests to a selection battery does little or nothing to reduce it. In effect, avoiding disparate impact requires avoiding *g*.

Yet, eradicating disparate impact was still an overriding political and legal concern. Some selection professionals therefore began reducing or eliminating disparate impact in test results by intentionally degrading the psychometric quality of *g*-loaded tests and score reporting. First came specious statistical arguments to group applicants' scores into several broad score bands (throwing away valid variance) and having employers select applicants randomly or by race from within bands, beginning with the highest band.

Next, a National Academy of Sciences commission (Hartigan & Wigdor, 1989) found a statistical pretext to recommend that the U.S Employment Service continue race norming its employment test (standardizing scores separately for each race, thereby setting the mean standard score to be equal in all races). The USES had instituted the practice to preserve its test's predictive validity while avoiding political fall-out from its known disparate impact.

After the U.S. Congress banned race norming in 1991, lower mental standards for some races devolved into no standards for any. In one highly publicized case, top selection professionals, in concert with the U.S. Justice Department, created an “innovative” police selection test, for national adoption, that supposedly had greater validity but far less disparate impact than previous, oft-litigated tests (Gottfredson, 1996). They accomplished this logically impossible feat by violating professional protocol: they collected applicants' test scores on their experimental battery *before* deciding which tests to keep in the final battery. To markedly reduce disparate impact, they had to strip the experimental battery of virtually all cognitive demands. They then disguised the deed with hundreds of pages of nearly impenetrable statistical legerdemain. This elite team had used its technical sophistication and knowledge of *g* to deceive more creatively.

[2] Disparate impact refers to a test yielding lower average scores or passing rates for minority than majority (white) test takers.

3.2.5. Criterion-related meaning of g

IQ scores are norm-referenced (standardized relative to a reference group's mean raw score and variation), so the large body of evidence on intelligence is reported almost entirely in correlations and other highly abstract statistics. These numbers mean nothing to the average person because they are so distant from everyday understanding. The average person does know intuitively what intelligence is, but even experts could not say much in those years about why it has functional value. For example, *why* does intelligence predict job performance even in non-academic jobs? How much intelligence does a good sales manager, police officer, or truck driver really need? Moreover, IQ items do not look anything like what these people do at work, which makes it even harder to defend intelligence research against critics intent on debunking it.

And the critics came out *en masse* in 1994 when Richard Herrnstein and Charles Murray (1994) published *The Bell Curve*. I searched in vain for an individual or data repository that could tell me what people at different IQ levels actually can and cannot do in everyday life. I therefore took a more theoretical approach (as Eysenck always did) and asked what makes one job or life task more cognitively demanding (more *g* loaded) than another, thereby putting lower-ability individuals at a comparative disadvantage (Gottfredson, 1997).

Charles Spearman and later London School scholars described various task characteristics that increase the complexity (*g*-loading) of information processing, including abstractness, novelty, fineness of distinction, and inexact or changing relation between means and ends. Because *g* is general, *g* theory would predict that these same task characteristics increase the *g* loading of any human task. In fact, various lines of research had already converged in showing this. For instance, choice reaction time research had shown that more bits of information (more complex choices) increase cognitive load and better discriminate individuals by intelligence level. Sociologists had already concluded that higher-level jobs, which employ higher-IQ individuals, are more complex. Job analysis data had confirmed that complexity of work is the major factor distinguishing jobs. It also revealed attributes of work that contribute to complexity: for task requirements (e.g., compile and combine information, analyze information, plan), worker behaviors (e.g., identify problem situations quickly, reason and make judgments, learn new procedures quickly) and conditions of work (e.g., lack of structure, need for self-direction).

A final body of evidence brings the complexity story full circle by reporting norm-referenced scores for individuals on a scale of task complexity that is anchored to familiar everyday tasks. The U.S. Department of Education's national surveys of adult functional literacy use test items that simulate everyday tasks using written material, such as menus, street maps, and newspaper articles. Item difficulties and individuals' scores are reported on the same criterion-referenced scale, and often grouped into five broad levels (Kirsch, Jungblut, Jenkins, & Kolstad, 2002). A person's literacy score represents an 80% probability of their successfully performing tasks at a given level cognitive complexity.

Here are sample items located at the midpoint of item difficulty for Levels 1 to 4, together with the percentage of U.S. adults who routinely function (with 80% probability of success) at each level of task difficulty but no higher.

Level 1: Locate one piece of information in a sports article (21%).

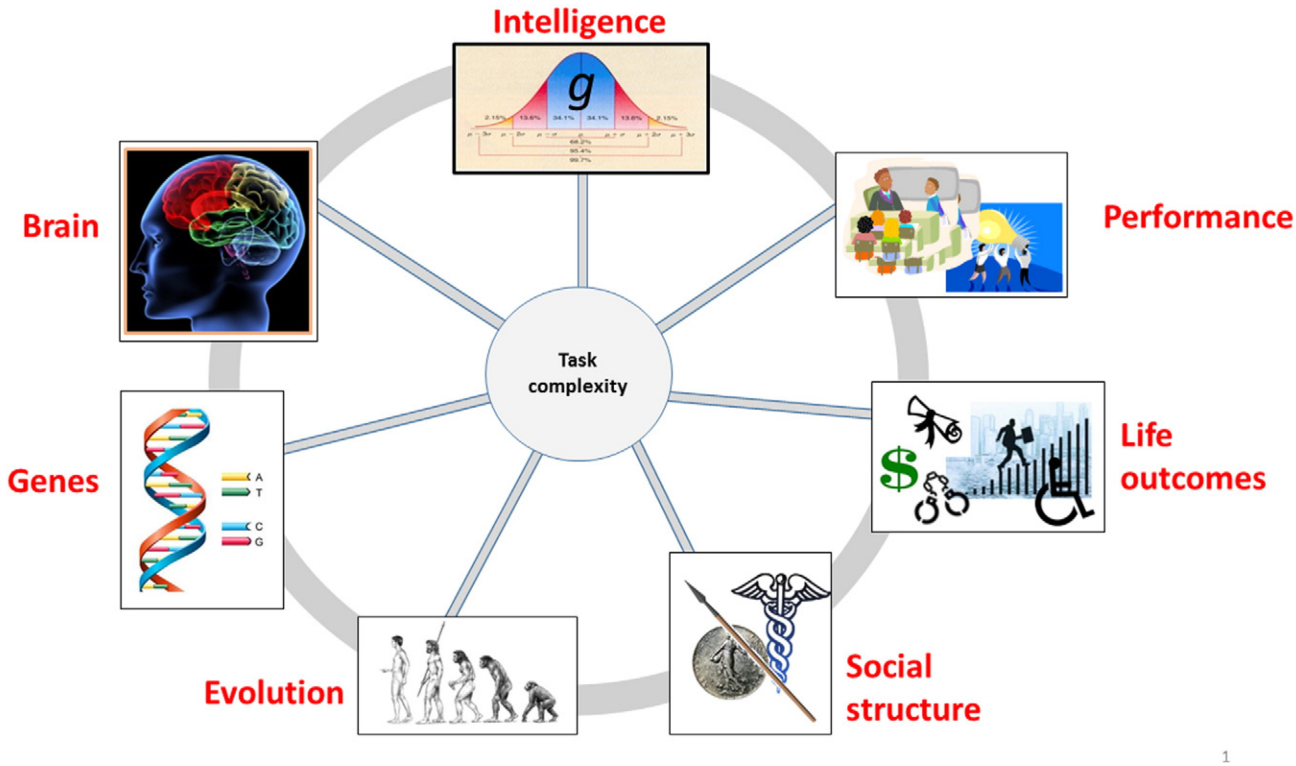

Fig. 4. Networks of evidence on *g* spanning different levels of analysis, 2016.

Level 2: Locate two features of information in a sports article (27%).

Level 3: Using calculator, determine discount from bill if paid in 10 days (31%).

Level 4: Use bus schedule to determine appropriate bus for a given set of conditions (15%).

These data drive home how big the real-life disadvantages are for individuals of lower vs. higher cognitive ability, even when performing seemingly simple everyday tasks.

Two other findings from this early literacy study are particularly important for theoretical reasons. First, the three literacy scales (Document, Prose, and Quantitative) in this 1993 survey were developed to measure independent dimensions of literacy but actually produced the same results, as if in triplicate. Second, item difficulty in all three scales was traced to the same factor, 'processing complexity'. Item features adding to information processing complexity were amount of distracting information, degree of inference required, amount of information to be integrated, and, on the quantitative scale, determining which arithmetic operation to use. Army research in the 1970s on work literacy (Sticht, 1975) had shown another kind of generalizability. It did not matter whether information was provided in written or aural form. Reading and listening produced the same results.

These government adult functional literacy studies illustrate Spearman's 'indifference of the indicator', despite the literacy investigators' expectations that literacy was multi-factorial. The studies themselves defined literacy in terms of reasoning and problem solving, both of which typify *g*. Different agencies of the U.S. government are now encouraging research into health literacy, as if it were a new dimension of literacy. It has become a major concern in health, medicine, and health education and attracts funding because measures of health literacy relate so consistently to health behaviors and outcomes. The official definition is "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions". Reports also commonly refer to patients, especially 'low-literacy' patients, as having more difficulty when instructions and treatments are more complex. Yet its study remains totally divorced from knowledge about human abilities, psychometrics, and even pedagogy. Although literacy researchers seem to speak in the language of intelligence, they never use the word. Some vehemently deny any relation. Others concede it privately but dare not say so publicly because health literacy is strongly linked to social disadvantage and to health disparities by race and ethnicity—the very links that funding agencies aim to eradicate.

This well-funded but theoretically and psychometrically impoverished research endeavor has nonetheless unhappily replicated what happens in education and work when cultural and technological progress injects more difficult items into life's daily mental test. Policy makers are at first perplexed when disparities grow rather than shrink, and then infer institutional discrimination or dysfunction. Eysenck described various ways that public policy could better meet its aims if it were grounded in facts, not false presumptions.

"Reform of what is wrong in our society there must be, but unless this reform takes into account limitations set by inexorable biological facts it is likely to achieve nothing….We must learn to co-operate with nature; attempts to disregard her laws and get our way against her opposition are doomed to failure." (Eysenck, 1973a, pp. 270).

3.2.6. Looking backward and forward from 1998

In the 1960s and 1970s, Eysenck, Jensen, and sociobiologist E. O. Wilson had been attacked, bodily and otherwise, for their biological perspectives on human variation and human behavior. In the 1980s and 1990s, others were targeted when their intelligence research involved race, genes, or human evolution, especially J. Phillipe Rushton and Richard Lynn. My own troubles spiked when I brought some of the greats in intelligence research, including Eysenck, to my university to speak on the implications of individual and group differences in intelligence for educational policy.[3]

Publication of Herrnstein and Murray's (1994) *The Bell Curve* provoked the worst spasms of public vilification and righteous denunciation during the two decades. The book provides an organized,

[3] The others speakers were John B. Carroll, Robert Gordon, Lloyd Humphreys, Arthur Jensen, Richard Lynn, and Robert Plomin.

readable summary of basic evidence on intelligence, analyzes phenotypic *g*'s influence relative to that of social class on the early life outcomes of young white adults, and reviews the conundrum presented by the black-white gap in IQ. For intelligence researchers, the book's major results were old news. For pundits and journalists, they were outdated, discredited, pseudoscientific, racist rubbish. No falsehood or misconception was too wild to broadcast and rebroadcast. Many academics joined the feeding frenzy to discredit the book's science, often exposing their own startling ignorance.

While the science of intelligence was stronger than ever in 1998, hostility toward it had grown too, even within psychology. Public misconceptions and misrepresentations had continued to multiply even as intelligence researchers proved the old ones mistaken. There were now more constituencies for discrediting it and new media to quickly broadcast their complaints. Critics inside and outside of academe grabbed the most tenuous, marginal, outdated, and implausible research results (e.g., Nisbett, 1998) to rebut the ever-expanding, thickening nomological network of evidence on *g*, as if shooting a pea would sink a ship.

No wonder Eysenck lamented in his last book that psychology had become less scientific and described seemingly ineradicable falsehoods and their perpetuators in uncharacteristically harsh words. I suspect that the increase in invective, falsehoods and fallacies is a sign of desperation among critics who have nothing else to hold back the mounting evidence against them. The coming flood of biological evidence in the new century from neuroimaging and from molecular and evolutionary genetics would have delighted Eysenck as much as it has no doubt dismayed the detractors of *g* theory.

4. Status of intelligence theory, 2016

Eysenck intuited the vast implications of the *g* phenomenon. It was obvious to him that *g* is integral to the physical brain, so he set out to find out how. The human brain is an astonishingly complex organ, evolved in coordination with a whole suite of distinctively human traits and behaviors. It is therefore subject to strong biological constraints. Social scientists have had the causal relation between intelligence and environments backwards because they ignore the evolved nature of the trait itself. Nature creates differences in intelligence, which in turn create differences in environments.

Against the crowd, Eysenck led us in the right direction. His biological theory of intelligence has been a good guide. Indeed, for him, a carefully-conceptualized account of available evidence, objectively considered, is essential for deducing experimentally testable propositions. Intelligence theory today is quite powerful. It may be mistaken in some respects, as Eysenck would caution, but no competing theory of intelligence and social inequality can explain and predict so much, so well.

4.1. Seven domains of g and the task attribute that calls it into action

Fig. 4 provides a quick summary of where *g* theory stands today. Its seven domains of human variation represent different levels of analysis and include many if not most disciplines in the scientific study of humankind. Intelligence theory already draws evidence from dozens of fields precisely because variation in *g* turns out to be an important component or force in the phenomena they examine. As Fig. 1 indicated, Eysenck focused on the five levels from genes to life outcomes. He wrote about the others, however, especially the impact of *g* variation on social inequality and other aspects of social structure. Research since his death has entered those two domains. It has also thickened the nomological network of evidence—the theory—that Eysenck had been building for many decades.

The seven domains are ordered clockwise from micro- to macro-level processes. Processes at each level structure those at the next level of analysis, including the most macro (evolution) altering the structure of the most micro (genes). What binds them into a moving whole is a very elemental aspect of all external environments to which *Homo sapiens* has adapted especially well over evolutionary time, namely, the complexity of the information processing they require. Four meta-findings help explain how a biological intelligence operating in an increasingly complexity-ridden environment yields highly systematic, consilient patterns of effects across all levels of analysis.

The standard social science model of inequality would exclude at least two of the frankly biological realms of human difference (genes and evolution) and reverse the causal ordering of the others to make social structure the prime mover in the causal cascade. This is the perspective of conflict theory, recent work on health disparities that purports to show how social inequality 'gets under the skin' and new imaging research in medicine on how poverty changes brain structure—none of it using genetically-sensitive data.

To be clear, *g* theory focuses on *g* because it attempts to explain this one particular phenomenon and why it has such pervasive functional importance. It should be obvious that when Eysenck developed his theory of intelligence, he was not suggesting that intelligence is all important. Indeed, he had already revolutionized personality psychology.

4.2. Dispersed biological roots of recurring human variation in phenotypic g

g is remarkably dispersed throughout the human genome and human brain. Its biological dispersion may account for its resilience against evolutionarily-typical physical and social deprivations as well as modern educational interventions. Were it not for this resilience, human variation in phenotypic intelligence would not be so predictable, so recurring across generations, so alike across populations worldwide, or allow selection to move the human genome toward higher intelligence. Nor would the phenotypic architecture of cognitive abilities (the hierarchical model) have remained stable in recent human history, nor would it mirror the genetic architecture of cognitive abilities, as recently demonstrated. In turn, were the distribution of *g* unstable or malleable, *g*'s effect sizes for various types of performance and life outcomes would not remain so regular, so consistent, so *patterned* decade after decade at the population level (cf. Gordon, 1997).

Humans' near-normally-distributed and relatively quickly rising distribution of phenotypic *g* is, other than our sociality, perhaps our species' most striking life history trait. Evolutionarily typical insults such as parasites, infections, and near starvation tend not to leave survivors permanently damaged cognitively. It is not plausible that the modern sorts of psychological, educational, and socioeconomic privations featured in the standard social science model would have any meaningful effect on the physical integrity of the brain. Evolutionarily-novel man-made toxins, yes (e.g., PCBs, radiation, drugs); social innovations, no (e.g., schools, economic structure, religion).

4.3. Ubiquitous effects of phenotypic g on behaviors and environments

The term ability refers to individual differences in performance on a defined class of tasks. *g* is general precisely because its domain includes *all* classes of tasks that require correct or appropriate mental processing of *any* sort of information for successful performance. Virtually everything we do in life requires some information processing, no matter how slight, which means that variation in *g* will leave its marks everywhere on human performance and its downstream consequences. We have seen that *g* has pervasive effects on performance, even on cognitive tasks so simple that differences in performance are measured in milliseconds of response time. Its effects are so consistent that no other trait or circumstance rivals its predictive power or disrupts the linearity of its effects on individual-level performance and outcomes in education, health, and work. Research has shown that *g*'s power to generate individual differences in behavior is pervasive; *g* theory predicts it to be ubiquitous. *g* is not shaped by environments, but environments by *g*.

4.4. Power of small, consistent effects that cumulate

Many of g's effects seem inconsequential, say, on how well I manage my diabetes today. But if its effects are consistent over time, events or populations—and more consistent than anything else—they will cumulate into more reliable, more g-loaded indicators—as do longer mental tests, grade-point averages and group differences in rates of preventable illness and injury. This is how evolution works over thousands of generations, but with far smaller, perhaps indiscernible within-generation effect sizes. This is also how catastrophic accidents, such as the spacecraft Challenger explosion, occur with the concatenation of cognitive errors across time, workers, and processes. Errors also propagate and cumulate in interpersonal and group settings depending on the ambient IQ level of the group, which changes the cognitive or physical risk for all individuals in the setting regardless of their own IQ (Gordon, 1997).

4.5. Gradients of relative risk of cognitive error

As seen, g's correlations with specific behaviors and outcomes range widely, for instance, rising from .2 with performance in the simplest jobs to .8 in the most complex.[4] Stated another way, g creates gradients of relative risk from shallow to steep depending on the circumstances of its use. The functional value of a given difference in g depends directly on the cognitive complexity of the tasks performed, a formula Eysenck demonstrated with his odd-man-out reaction time task. Gradients for g relate directly to complexity and only complexity when task performance conditions mimic those of reliable, standardized mental tests: task is performed individually, no help or hindrance, instructions clear, does *not* measure non-relevant traits, tasks are novel or unpracticed, scores are standardized against the general population, responses are objectively scored for correctness, and so on. Some everyday settings come close, for instance, public elementary schools (population of children who perform a common set of novel tasks that become increasingly difficult and are individually evaluated against reasonably objective criteria), but other settings depart from one or more of them to varying degrees.

At least one condition steadily steepens the gradients: when performances cumulate over more episodes (e.g., days, months, years) to produce the outcome of interest (e.g., years of education). Other departures from standard conditions generally work toward flattening (attenuating) the g gradients: for example, when non-g traits such as personality are important for successful performance (recall Army Project A's self-discipline and leadership job performance criteria); the individual is not solely responsible for an objectively measured outcome (help, hindrance, or teamwork); and outcomes are partly determined by factors not related to the individual's own performance (salaries and wages differ by industrial sector and unionization). Tasks can also lose their g loading when training is sufficient to automatize a performance, such rifle cleaning in military training or multiplication tables in elementary school.

Eysenck hoped that psychology would eventually produce laws of behavior, or at least theories that advance understanding by generating novel, testable predictions. It seems possible, in principle, to predict g's gradients of effect at the individual level when we know the relevant population's distribution of g, the complexity of tasks performed, and whether conditions exist that steepen or flatten g gradients for the outcomes of interest. Much educational and social policy seeks, in effect, to flatten g's gradients of effect, and it should be possible under certain circumstances, such as simplifying treatment regimens. At the very least, knowing the conditions that steepen and flatten g's effect gradients might forewarn policy makers when their interventions to narrow differences in performance will widen them instead (see Ceci & Papierno, 2005, on the Matthew Effect in educational intervention).

4 The observed correlations have been corrected for restriction in range and thus reflect what the correlation between intelligence and job performance would be if workers had been selected at random from the IQ distribution.

5. Conclusion

The penultimate chapter of Eysenck's 1998 book describes how important scientific advances were often ridiculed and their authors abused. Wegener was persecuted mercilessly when he proposed his theory of continental drift. Pasteur's theory of the fermentation process was thought unacceptable, even long after evidence for it was conclusive. Lister's theory of antisepsis was "absurd". The Wright brothers' heavier-than-air flight was a "hoax" according to the *Scientific American*, the U.S. Army and most American scientists, who opined that such flight was "utterly impossible" and the idea "absurd". Edison's electric lamp was a "completely idiotic idea", "mischievous to true progress", "a fraud on the public".

Eysenck's point was that generating an important advance is not enough. To survive, it must be defended when it threatens reigning verities. Credible threats are apt to evoke angry opposition and moral outrage, and the defender has to persevere despite such unpleasantness. Eysenck's biological, experimental, theory-driven approach to understanding human behavior threatened reigning verities in a succession of fields in psychiatry and psychology. He (Eysenck, 1986, pp. 396) persisted despite sometimes fierce and abusive opposition, never answering in kind but always with scientific logic and evidence: "It has always seemed to me that much of what I had to say was so obvious that it should hardly have needed saying.....I feel that I have really acted the part of the child in the fairy-tale of the Emperor's new clothes."

What Eysenck (1973a, pp. 17–18) said about the great early 20th-century geneticist, J. B. S. Haldane, applies to him as well: "A great scientist sniffs out the truth even from partial and often insufficient evidence."

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