Hans J. Eysenck and Raymond B. Cattell on intelligence and personality

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A b s t r a c t

The two most prominent individual differences researchers of the twentieth century were Hans J. Eysenck and Raymond B. Cattell. Both were giants of scientiﬁc psychology, each publishing scores of books and hundreds of empirical peer-reviewed journal articles. Inﬂuenced by Hebb's distinction between physiological (Intelligence

A) and experiential (Intelligence B), Eysenck focused on discovering the underlying biological substrata of intel- ligence. Analogously, Cattell proposed the Gf–Gc theory which distinguishes between ﬂuid and crystallised intel- ligence. Cattell's *Culture Fair Intelligence Test* (CFIT), a measure primarily of ﬂuid intelligence, was constructed speciﬁcally to minimise differences in test bias in IQ scores between different ethnic/racial groups. Within the personality realm, Eysenck adopted a pragmatic three-factor model as measured via the *Eysenck Personality Ques- tionnaire* (EPQ-R) and its variants. In contrast, Cattell employed a lexical approach that resulted in a large number of primary and secondary normal and abnormal personality trait dimensions, measured via the *Sixteen Personal- ity Factor Questionnaire* (16PF), and the corresponding *Clinical Analysis Questionnaire* (CAQ), respectively. Recent molecular genetics ﬁndings provide empirical conﬁrmation of Eysenck and Cattell's positions on the biological underpinnings of personality and ability traits, allowing an improved understanding of the causes of individual differences.

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1. Introduction

The study of personality and individual differences in the second half of the twentieth century was signiﬁcantly inﬂuenced by two prominent ﬁgures: Hans J. Eysenck and Raymond B. Cattell. Both have their roots in British psychology. While Eysenck gained his PhD under Burt's supervision at University College, London, Cattell earned his PhD at King's College, London under the supervision of Francis Aveling — then President of the *British Psychological Society*. Both Eysenck and Cattell were key players in the movement to pro- mote scientiﬁc psychology, as currently advocated expressly by the *Association for Psychological Science*. As [Boyle (1998, ‘Remembering](#_bookmark7)

[R. B. Cattell’, para. 2)](#_bookmark7) stated:

“Two of the greatest and most proliﬁc contributors to the science of human personality during the 20th century were Professor Raymond B. Cattell, Ph.D., D.Sc., and Professor Hans J. Eysenck,

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Ph.D., D.Sc. While Cattell pursued his academic career in presti- gious USA universities (Harvard, Clark, Illinois), Eysenck under- took his lifelong work at the Institute of Psychiatry, University of London. It is indeed ironic that the world would lose the two most eminent personality researchers within the space of only a few weeks. So prominent were these two men, that their work is now enshrined in the Cattellian and Eysenckian Schools of Psy- chology, respectively.”

Both Eysenck and Cattell were ranked among the most highly cited psychologists of the twentieth century. Indeed, Eysenck was the most highly cited psychologist of his generation ([Gray, 1997](#_bookmark32)). Based on the peer-reviewed journal literature alone ([Haggbloom et al., 2002](#_bookmark32), Table 1), Eysenck was the 3rd most highly cited psychologist (after Freud, and Piaget, respectively), while Cattell was 7th most highly cited. In relation to Cattell's impact on the ﬁeld of psychology, [Eysenck](#_bookmark32) [(1985, p. 76)](#_bookmark32) remarked that:

“Cattell has been one of the most proliﬁc writers in psychology since Wilhelm Wundt….According to the Citation Index, he is one of the ten most cited psychologists, and this is true with regard to not only

citations in social science journals but also those in science journals generally. Of the two hundred and ﬁfty most cited scientists, only three psychologists made the grade, namely, Sigmund Freud in the ﬁrst place, then the reviewer [H.J. Eysenck], and then Cattell. Thus there is no question that Cattell has made a tremendous impression on psychology and science in general.”

Illustrative of the esteem in which these two giants of psychology were held by their peers, [Buchanan (2010, p. 4)](#_bookmark7) wrote about Eysenck:

“There can be little argument about the importance of Eysenck as an historical ﬁgure. His name ranks alongside American contempo- raries such as Gordon Allport, B.F. Skinner, and Raymond Cattell… and he hardly had a rival on the UK scene…”

Likewise, [Horn (2001, p. 72)](#_bookmark36) wrote about Cattell:

“The seven past-presidents of the American Psychological Associa- tion who selected [Cattell], despite his controversial writings, for a lifetime contributions' award were correct in their judgment. He must rank among the most important contributors to psychological science.”

Clearly, both Eysenck and Cattell have left their mark on the study of human intelligence and personality. Eysenck's contribution to the as- sessment of intelligence is augmented by his various attempts to discov- er its biological bases. Cattell will be remembered largely for his ideas about cognitive functioning and his theory of ﬂuid and crystallised intelligence.

With respect to personality assessment, although Eysenck utilised both self-report measures and psychophysiological measures, Cattell systematically constructed measures of personality traits in different media of measurement – Life-Record including ratings of/by others (L-data); self-report Questionnaire (Q-data); and Test (T-data). With regard to T-data, [Cattell and Warburton (1967)](#_bookmark14) com- piled a list of over 2000 objective test measures of personality and moti- vation, and constructed the Objective-Analytic Test Battery (OAB) that measures 10 factor-analytically derived personality trait constructs — see [Schuerger (2008)](#_bookmark32).

It has often been assumed that Eysenck used his knowledge of psy- chopathology to derive theoretically-based ‘top-down’ measures of per- sonality traits, whereas Cattell relied on an atheoretical ‘bottom-up’ lexical approach. However, Eysenck's approach was not entirely theo- retically driven. As Goldberg wrote to Eysenck (February 6, 1995; see [van Kampen, 2009, p. 13](#_bookmark45)):

“It is not clear to the world at large how your PEN model is not well described as an example of the heuristic school, given that you explicitly adopted ‘some psychiatric system of classiﬁcation’ for [Psychoticism and Neuroticism], and you used your own ‘no- tion of what traits might be important’ to select [Extraversion].”

Nevertheless, Eysenck's pragmatic approach clearly contrasted with Cattell's emphasis on the empirical lexical approach. Accordingly, the measures and theories of personality structure that resulted from their respective factor-analytic studies emerged with some distinct differ- ences. [Boyle (1998, ‘Remembering R. B. Cattell’, para. 2)](#_bookmark7) pointed out that:

“Critics of the psychology of individual differences have often claimed naively that the use of factor analysis in test construction has ‘only led to confusion – since Eysenck found three factors, while Cattell found 16 factors’ within the personality domain. Yet … Eysenck and Cattell were talking about personality measurement at different levels within the hierarchical trait model. Cattell concen- trated on primary factors, while Eysenck focused on broader second- ary dimensions. Indeed, at the second-order 16PF level, the degree of

communality between the Eysenckian and Cattellian factors was striking!”

Clearly, Eysenck and Cattell's contributions to the delineation of per- sonality structure were compatible. As [Eysenck (1984, p. 336)](#_bookmark31) himself stated:

“The Cattell and Eysenck constructs and theories should be seen, not as mutually contradictory, but as complementary and mutually sup- portive.”

On the other hand, Cattell was not so willing to readily accept the compatibility between his and Eysenck's approaches. According to [Cattell (1986, p. 153)](#_bookmark9):

“Eysenck's resort to 3 factors is shown to be theoretically faulty and unable to equal the criterion predictions obtainable from the 16PF primaries.”

Indeed, the empirical evidence does support Cattell's argument about the greater predictive variance obtainable from a larger number of primary factors than from a smaller number of broad secondary fac- tors ([Mershon & Gorsuch, 1988](#_bookmark32)).

Eysenck and Cattell investigated individual differences using the hypothetico-deductive method (or inductive-hypothetico-deductive method — [Cattell, 1978](#_bookmark10)). In other words, Eysenck attached considerable importance to theoretically-driven research, whereas Cattell was much more skeptical about theory preceding empirical evidence. Although, historically, there had been a gap between differential and experimental psychology ([Cronbach, 1957](#_bookmark16)), [Eysenck (1997a)](#_bookmark32) explicitly combined both experimental and correlational approaches, while Cattell was at the forefront in promoting multivariate experimental research ([Cattell, 1966a; Nesselroade & Cattell, 1988](#_bookmark8)).

Both Eysenck and Cattell subscribed to the prevailing positivist paradigm and to the nomothetic approach (e.g., [Allport, 1937;](#_bookmark27) [Cattell, 1973; Eysenck, 1954; Piekkola, 2011](#_bookmark27)). It is worth examining this predilection in some detail if only because committing one's re- search program to a particular paradigm inevitably alienates it from other paradigms. The twofold temptation may then arise to turn a blind eye to the limitations of the chosen paradigm and to attempt to disparage alternatives (cf. [Eysenck, 1986](#_bookmark32)). Yet, Eysenck's critique of non-positivist approaches such as psychoanalysis ([Eysenck,](#_bookmark17) [1952](#_bookmark17)), contrasted with his willingness to entertain other controver- sial topics, such as parapsychology ([Eysenck, 1982](#_bookmark28)) and astrology ([Eysenck & Nias, 1982, 1987](#_bookmark32)). Presumably, one of the reasons for Eysenck's dislike of psychodynamic psychology was that its tenets could not easily be put to the empirical test (see [Kline, 1972](#_bookmark42)), where- as Eysenck considered that valid experiments could be carried out to test parapsychological and astrological predictions.

However, the chasm between nomothetic and idiographic ap- proaches is not conducive for a holistic psychology with the individual person as its main focus. The tendency of trait psychologists to align with nomothetic approaches, which they equate with ‘scientiﬁc,’ and to distance themselves from idiographic approaches, which they equate with ‘unscientiﬁc’, is problematic for at least two reasons. Firstly, it vastly underestimates the ineradicable contributions of giants of psy- chology, such as Freud, Jung, Maslow, and Piaget, who worked mostly within the idiographic tradition. Secondly, and perhaps more impor- tantly, the uncritical overreliance on nomothetic approaches, as typical- ly applied in mainstream personality psychology, has brought about a ‘triumph of the aggregate’ ([Danziger, 1990](#_bookmark18)) that is threatening to estab- lish a personality psychology devoid of the person.

Cattell and Eysenck worked at a time when the foundations of con- temporary academic psychology as we know it were being laid. They spearheaded the movement towards a quantitative psychology, which they perceived as equivalent to a scientiﬁc psychology and which even- tually became the dominant paradigm. Their key ideas for a scientiﬁc

(meaning positivist) psychology, were enthusiastically shared by many others, and gradually became central to individual differences research, speciﬁcally, and to academic psychology, more generally.

How much of this inﬂuence actually originated with Cattell and Eysenck and how much merely reﬂected the zeitgeist of the time is difﬁcult to tell. In the 1950s and 1960s when the two personality psychologists became established, psychology was characterised by a ner- vousness to imitate the apparent success of the natural sciences, which had blithely espoused a philosophy of materialism ([Sheldrake, 2013;](#_bookmark32) [Whitehead, 2011](#_bookmark32)). This caused an unrestrained import of methods, con- cepts, and technologies from the natural sciences at the expense of meth- odologies that are *prima facie* more compatible with a psychology of the individual person (e.g., [Stern, 1911](#_bookmark38)), such as introspection and psychoanalysis.

Cattell and Eysenck were key players in the movement to emulate the natural sciences even though many natural scientists seemed loath to consent to such advances. Yet the question of whether the methodologies of the natural sciences are appropriate for the investigation of psycholog- ical phenomena has always loomed large (e.g., [Bickhard, 1992; Snygg,](#_bookmark7) [1955](#_bookmark7)).

The dominant paradigm in personality research – differential psychol- ogy – has not grappled well with challenges such that knowledge about individual differences is not the same as knowledge about individuals, that individual behaviour cannot be explained in terms of differences be- tween individuals ([Lamiell, 1997](#_bookmark46)), that ordinal measures are not neces- sarily quantitative ([Michell, 2009](#_bookmark32)), and that psychometrics lacks valid units of measurement ([Kline, 1997](#_bookmark43)). It has been all too easy for differential psychology to ‘sweep these issues under the carpet’.

Despite these caveats, here we outline some of the many contributions of these two important ﬁgures to the ﬁeld of individual differences and point to some areas of contemporary research inﬂuenced by their work. We also mention a couple of events that brought both Eysenck and Cattell into the limelight within the broader community, as well as re-examining new evidence from molecular genetics that provides vindication for Eysenck and Cattell's focus on the biological basis of complex trait dimensions.

1. Eysenck on intelligence and its biological substrata

Eysenck was from the ‘London School’ of psychology with its lineage of Galton, Spearman, and Burt. Eysenck's hypothesis was that general in- telligence (g) is underlain by mental speed, which he tested through var- ious response and inspection time protocols aided by complex algorithms (e.g., [Barrett, Petrides, & Eysenck, 1998](#_bookmark7)). Within the experimental psy- chology paradigm, Eysenck strongly advocated a theoretical and laboratory-based approach for intelligence research ([Eysenck, 1967a,](#_bookmark19) [1979](#_bookmark19)).

In the 1960s, Guilford's *Structure of the Intellect* (SOI) model became popular although Eysenck previously had similar ideas ([Eysenck, 1971](#_bookmark24)). In Eysenck's model one dimension corresponded to content (verbal, nu- merical, and spatial), the other to mental processes (reasoning, memory, and perception). The third dimension was ‘quality’ which refers to the na- ture of test administration – the distinction between ‘speeded’ and ‘power’ tests. However, neither Guilford's nor Eysenck's models of ability structure have survived the test of time, and subsequent studies with psy- chometric tests of intelligence have not derived factors corresponding to either model (see critique of SOI model — [Brody & Brody, 1976, pp.](#_bookmark7) [43–57](#_bookmark7)).

The biological underpinnings of intelligence depend on genetic poten- tial expressed through developmental and neurochemical pathways ([Eysenck, 1982, 1998](#_bookmark28)). Biological correlates of intelligence can be found in measurements from the electroencephalogram (EEG), averaged evoked potential (AEP), contingent negative variation (CNV), galvanic skin response (GSR), reaction time (RT) and other methods including functional magnetic resonance imaging (fMRI).

*Psychometric intelligence* is measured by IQ tests. While related to bi- ological intelligence, it is also inﬂuenced by cultural and experiential factors, family upbringing, socio-economic status, education, and the like. Approximately 30–40% of the total variance is accounted for by non-genetic inﬂuences ([Deary, 2000](#_bookmark20)). The relative importance of genetic and environmental inﬂuences on psychometric intelligence varies as a function of age: genetic factors account for approximately 20% of individual differences in intelligence in infancy but 80% in later adulthood ([Plomin & Deary, 2015](#_bookmark32)).

Finally, there is *social intelligence* (practical intelligence) — the applica- tion of intelligence in everyday social life and work ([Sternberg et al.,](#_bookmark39) [2000](#_bookmark39)). Social intelligence involves factors additional to psychometric intelligence. For example, even if an individual has high IQ but is an alcoholic, is mentally or physically ill, has poor education, and/or has low motivation/drive, it is unlikely that s/he will be a high achiever.

Evidently, much of Eysenck's empirical work was reductionist in linking intelligence to its biological substrata. Although Eysenck employed several measures, the bulk of his work focused on mental speed and EEG measures.

* 1. *Mental speed*

[Eysenck's (1967a)](#_bookmark19) article, which examined Galton's hypothesis about the close link between mental speed and intelligence, proved to be quite inﬂuential and timely. His article promoted the ideas which he had developed in collaboration with [Furneaux (1960)](#_bookmark32), who had published a paper in a book edited by [Eysenck (1960)](#_bookmark21), while an equally important work by Eysenck's student (P.O. White), subsequently appeared in another book ([Eysenck, 1973](#_bookmark29)). All these works assumed three components of intelligence: speed and two aspects of personality labelled as persistency (tendency to invest effort when the solution is not easy) and error checking (tendency to check the answer to an item prior to registering it).

Eysenck's suggestion to investigate mental speed fell on fertile ground. In the 1960s, a revitalised cognitive psychology began to employ RT mea- sures. Its usefulness was demonstrated in Saul Sternberg's studies of memory search. The advent of micro-computers subsequently facilitated precise measurements of timed performance. While Eysenck was only marginally interested in new developments in experimental cognitive psychology, his plea to examine Galton's ideas was taken seriously by others. In several studies, [Jensen (1982)](#_bookmark40) demonstrated that both simple RT and choice RT correlate about 0.20 to 0.30 with psychometric mea- sures of intelligence. However, the relationship between IQ and mental speed is insufﬁciently strong to indicate that it might lead to a compre- hensive understanding of the biological underpinnings of intelligence.

Initially, Eysenck viewed more intelligent people as having faster thinking, information transmission and processing. Jensen also sub- scribed to this notion, but believed that mental speed is important because of the role of working memory in thinking. Since information in working memory fades quickly, people with higher intelligence and faster mental speed can perform more operations in a limited timespan than those with slower processing speed.

Towards the end of his life, Eysenck modiﬁed his account of the rela- tionship between mental speed and intelligence due to ﬁnding notable correlations between intelligence test (IQ) scores and measures of vari- ability in RT. Over the many trials needed for reliable RT measurement, some individuals show considerable instability from trial to trial, although more intelligent individuals generally show relatively small variability. Eysenck proposed that less intelligent individuals transmit information less efﬁciently with a greater probability of errors occurring. However, the ﬁnding of high correlations between measures of mental speed and measures of variability of speed calls for a single rather than two distinct mechanisms (i.e., speed and probability of synaptic error) to explain the observed phenomena. [Roberts and Stankov (1999)](#_bookmark32) showed that mental speed measures deﬁne several distinct factors, such that mental speed is not the basic process of intelligence. An alternative capacity view that

emphasises the role of attention and working memory instead of speed in intelligence has also gathered support ([Stankov, Boyle, & Cattell, 1995](#_bookmark35)).

* 1. *Electroencephalography and intelligence*

Towards the end of the 1960s, Eysenck started using a more direct (psychophysiological) measure of biological intelligence — the EEG. Two methods were employed. In the ﬁrst, the EEG was recorded while the individual was in a resting position. Signiﬁcant but relatively small correlations (comparable to those reported with RT) were obtained be- tween measures of intelligence and EEG parameters. In the second method, the person was again resting but a light (or a tone) was presented at certain time intervals. The light evokes a change in the EEG records which are averaged over many trials to obtain the ‘average evoked potential’ (AEP). In Eysenck's studies, various AEP measures were correlated with intelligence test scores. Eysenck with his students, [Hendrickson and Hendrickson (1980)](#_bookmark34), developed a new AEP measure reﬂecting the signal complexity (extent of small departures from the smooth AEP recording). Eysenck proposed that the differences in com- plexity of AEP recordings (like RTs) are related to the transmission of signals over the synapses within the central nervous system. In his auto- biography, Eysenck reported correlations between 0.30 and 0.40 in a study undertaken with children ([Eysenck, 1997b](#_bookmark32)). While failures to replicate Hendrickson and Hendrickson's ﬁndings initially were thought to be due to subtle differences in methodology used across different laboratories ([Barrett & Eysenck, 1992a](#_bookmark7)), there were also failures to replicate within the same institution from which the original ﬁndings had been obtained ([Barrett & Eysenck, 1992b](#_bookmark7)).

Some AEP studies point to another way that speed may be important for intelligence. Using fast Gamma waves, [Stankov et al. (2006)](#_bookmark37) correlat- ed the speed of synchronisation (or ‘tuning-in’) between different brain regions involved in processing a particular stimulus. Following [Hebb](#_bookmark33) [(1949)](#_bookmark33), it was expected that individuals with higher intelligence test scores would show faster activation of distinct brain regions involved in a particular cognitive activity. High correlations between IQ scores and speed of synchronisation were indeed found ([Stankov et al.,](#_bookmark37) [2006](#_bookmark37)). While a recent meta-analysis ([Basten, Hilger, & Fiebach, 2015](#_bookmark7)) found little evidence that high intelligence is associated with greater neural efﬁciency, it did provide convincing evidence that integration of frontal and parietal brain regions is greater among highly intelligent individuals.

1. Cattell and non-cognitive correlates of intelligence

While Eysenck's work on intelligence was inﬂuenced by [Hebb](#_bookmark33) [(1949)](#_bookmark33) who postulated the existence of Intelligence A (physiological), and Intelligence B (experiential), Cattell's Gf–Gc theory ([Cattell, 1963;](#_bookmark7) [Horn & Cattell, 1966](#_bookmark7)) analogously distinguished between ﬂuid intelli- gence (Gf) — (broad ability to reason, form concepts, and solve prob- lems using *unfamiliar information or novel procedures*) and crystallised intelligence (Gc) — (the ability to reason using *previously learned knowl- edge or procedures*) — (see [Brody & Brody, 1976](#_bookmark7)). Subsequent empirical work led to the identiﬁcation of several additional broad cognitive factors (e.g., see [Boyle, 1988](#_bookmark7)) including quantitative ability (Gq), read- ing and writing ability (Grw), short-term memory (Gsm), long-term storage and retrieval (Glr), visual processing (Gv), auditory processing (Ga), processing speed (Gs) and decision/RT speed (Gt) — now known as the Cattell-Horn-Carroll (CHC) theory of intelligence (see [Schneider](#_bookmark32) [& McGrew, 2012](#_bookmark32)).

Cattell (with wife Karen) founded the *Institute for Personality and Ability Testing* (IPAT), which produced many psychometric tests of intel- ligence and cognitive abilities, including the historic *Culture Fair Intelli- gence Test* (CFIT), and the *Comprehensive Ability Battery* (CAB), among others (see [Cattell & Johnson, 1986](#_bookmark15)).

[Cattell (1987)](#_bookmark11) was interested in processes that led to the emergence of crystallised from ﬂuid intelligence. Cattell's *Investment* theory posits

that individual differences observed in the development of skills and knowledge (Gc) are partially attributed to the ‘investment’ of Gf in var- ious aspects of the learning process. Investment theory also suggests that non-cognitive traits and dispositions including interests, motiva- tion and personality all affect cognitive abilities. This set up the stage for exploring links between cognitive and non-cognitive processes. One extension was the *Process*, *Personality*, *Intelligence and Knowledge* (PPIK) theory ([Ackerman, 1996](#_bookmark25)) which elaborates on Cattell's original ideas. Another extension derives from the efforts of educationists to identify the best non-cognitive predictors of achievement and intelli- gence. From among the many non-cognitive variables considered, those related to self-beliefs (i.e., conﬁdence, self-efﬁcacy and anxiety) proved to be the most important ([Stankov, 2013](#_bookmark34)).

1. Measurement of personality

Eysenck aimed to place personality trait factors within a psychobio- logical network of constructs ([Eysenck, 1967b](#_bookmark26)), dictating his preference for interpreting somewhat crude unrotated centroid factors, in contrast to Cattell who employed optimal factor analytic procedures and rotated factors to maximum simple structure ([Cattell, 1978](#_bookmark10)). Cattell pioneered some of the now standard factor-analytic techniques such as the Scree test ([Cattell, 1962, 1966b](#_bookmark7)). However, aiming for deﬁnitional precision, Cattell labelled his factors idiosyncratically, thereby inadvertently distancing his work from mainstream psychology.

As indicated above, the early stages of Eysenck's attempts to describe personality were by no means entirely ‘top-down’ or theory-driven. He was inﬂuenced by earlier theorists (e.g., Jung) and by previously devised questionnaires (see [Eysenck & Eysenck, 1985](#_bookmark32)). The *Maudsley Personality Inventory* (MPI) included several items to assess extraversion that were similar to items previously used by Guilford. The three broad factors Eysenck identiﬁed - Extraversion, Neuroticism, and Psychoticism — be- came the focus of an international research program (e.g., see [Barrett,](#_bookmark7) [Petrides, Eysenck, & Eysenck, 1998](#_bookmark7)).

Eysenck constructed numerous personality measures, among which the *Eysenck Personality Questionnaire*, in its various forms is the most widely recognised ([Eysenck, Eysenck, & Barrett, 1985](#_bookmark32)). [Furnham,](#_bookmark32) [Eysenck and Saklofske (2008)](#_bookmark32) provided reasons why many of Eysenck's measures remain in use today: (1) they focus on broad factors that can be easily integrated into wider nomological networks; (2) they strive to reach beyond mere descriptions to provide actual explanations of pro- cesses; (3) they have been validated in many empirical studies;

1. they have been widely applied across different disciplines; and
2. they have undergone continued rectiﬁcation. Eysenck's self-report questionnaires include the *Maudsley Medical Questionnaire* (MMQ), the *Maudsley Personality Inventory* (MPI), the *Eysenck Personality Inventory* (EPI), the *Eysenck Personality Questionnaire* (EPQ), the *Eysenck Personality Questionnaire - Revised* (EPQ-R), the shorted form (EPQ-R-S), and the *Eysenck Personality Pro*ﬁ*ler* (EPP).

While Eysenck focused on broad personality trait dimensions — Extraversion, Neuroticism and Psychoticism, Cattell focused on primary trait dimensions, although at the 16PF second-order level, ﬁve broad personality factors were labelled Extraversion, Anxiety/Neuroticism, Tough Poise, Independence, and Control, respectively ([Cattell & Mead,](#_bookmark7) [2008; Krug & Johns, 1986](#_bookmark7)). The ﬁrst two line up with Eysenck's Extra- version and Neuroticism factors, and the corresponding Big Five dimen- sions ([Goldberg, 1993; Saucier, 2008](#_bookmark32)). Yet, both [Eysenck (1992a)](#_bookmark32) and [Cattell (1995)](#_bookmark12) had severely criticised the Big Five model (see [Boyle,](#_bookmark7) [1989, 2008](#_bookmark7)) which accounts for less than 60% of the variance in the normal trait sphere alone ([Boyle, 2008, p. 298; Boyle, Stankov, &](#_bookmark7) [Cattell, 1995, p. 432](#_bookmark7)).

Aside from producing psychometric measures of intelligence, IPAT also generated many personality instruments and their downward ex- tensions including the *Sixteen Personality Factor Questionnaire* (16PF, HSPQ, ESPQ); the *Clinical Analysis Questionnaire* (CAQ) — providing measures of 12 abnormal personality traits in addition to the 16PF

factors; the *Objective-Analytic Test Battery* (OAB) — 10 objective tests of personality trait constructs; the *Motivation Analysis Test* (MAT, SMAT, CMAT) — an objective test of 10 dynamic motivational trait constructs; the *Eight State Questionnaire* (8SQ) — which measures eight clinically important emotional/mood states. The 16PF is a widely used measure of normal personality traits which has been adapted for use in numer- ous languages (e.g., see [Boyle & Barton, 2008](#_bookmark7)).

One important difference between the Cattell and Eysenck models of personality is related to the conceptualisation and measurement of Psychoticism. Using factor analytic methodology, Cattell constructed the multidimensional CAQ (revised as the *Psychological Evaluation Per- sonality Questionnaire* or PEPQ) — (see [Krug, 2008](#_bookmark44)). In contrast, Eysenck focused on a single broad abnormal personality factor – Psychoticism – as measured in the EPQ and EPQ-R instruments.

The question of what the Psychoticism scale really measures ([Eysenck, 1992b; Eysenck et al., 1985; Ortet, Ibáñez, Moro, Silva, &](#_bookmark32) [Boyle, 1999](#_bookmark32)) remains controversial. Its score distribution shows positive skewness, and lower item homogeneity (the scale is composed of rela- tively unrelated traits) than either the Extraversion or Neuroticism scales. Indeed, one of the present authors (GJB) in a brief visit with Eysenck at the Institute of Psychiatry in 1988 argued that measurement of a single Psychoticism trait seemed problematic given the occurrence of distinctly different forms of psychotic illness, and the fact that Cattell had empirically delineated 12 separate abnormal trait factors. Despite these arguments, Eysenck maintained his position that Psychoticism was a unidimensional factor.

[Ibáñez, Ortet and Moro (2000)](#_bookmark38) and [Eysenck et al. (1992)](#_bookmark32) compared the bias of different Spanish versions of the Psychoticism scale. As ex- pected from Cattell's work with the CAQ, factor analyses of the Psychoticism, Extraversion and Neuroticism scales of the EPQ-R indicat- ed a larger heterogeneity of the Psychoticism scale as compared with the other two scales. When more socially acceptable Psychoticism items are included, there is a slight reduction in scale bias. However, de- spite Eysenck's assurances as to the validity of the Psychoticism scale, conceptual and psychometric issues remain unresolved ([Eysenck, in](#_bookmark32) [press](#_bookmark32)).

Eysenck's research into personality and coping (see [Marqués,](#_bookmark32) [Ibáñez, Ruipérez, Moya, & Ortet, 2005](#_bookmark32)), and his research into cancer and coronary heart disease enriched health psychology, generating extensive debate, and quite often controversies, such as his ﬁnding of multiple synergistic causal factors in smoking-related illnesses (e.g., [Eysenck, 1991a](#_bookmark32)). As with other topics he researched, and while certain detractors have questioned Eysenck's objectivity in his research into personality, stress and physical disease using Grossarth-Maticek's rather unwieldy epidemiological data sets, the fact is that remaining true to character, Eysenck always carefully and logically considered the empirical evidence in attempting to solve controversial issues and advance psychology as a science (e.g., see [Eysenck, 1991b, 1993](#_bookmark32)). After carefully considering all the disparaging criticisms and the likely impact on the outcomes obtained, [Eysenck, 1993, p. 73](#_bookmark32)) concluded that:

“The Grossarth-Maticek data are genuine – even though at times marred by errors that fortunately make no difference to the overall conclusions.”

Rather than somewhat pedantic, relentless criticism, and in order to settle the controversy once and for all, detractors would do well to undertake independent replication studies on multiple large samples to ascertain the veracity or otherwise of Eysenck and Grossarth-Maticek's ﬁndings.

The impact of Eysenck and Cattell's work is readily apparent in contemporary research programs, such as that of trait emotional intelli- gence, where we can witness the use of factor analysis for conceptuali- sation ([Petrides, Pita, & Kokkinaki, 2007](#_bookmark32)) and the investigation of constructs from multiple perspectives ([Petrides et al., 2016](#_bookmark32)). While there are many measures of emotional intelligence, most consist, in

part, of a combination of low neuroticism and high extraversion ([Matthews, Zeidner, & Roberts, 2004](#_bookmark32)). However, such research pro- grams represent a continuation of Eysenck's and Cattell's loftiest ideals, and aim to integrate the research approaches that both these pioneers advocated.

1. Controversies that spilled beyond academic psychology

The views of both Eysenck and Cattell particularly in relation to their scientiﬁc curiosity about ethnic differences in intelligence test scores or their speculations about eugenics have been maligned by certain ill- informed critics. As it frequently happens, the media and broader community were interested in sensationalism and controversies. Here, we mention two controversies that were linked to the issues of genetic heritability and intelligence.

1. Disruption of Eysenck's talks at Melbourne University and Sydney University

In 1977 Hans Eysenck and Arthur Jensen were invited to give talks at several Universities in Australia. Jensen discussed the relationship be- tween intelligence and learning while Eysenck's focus was on intelli- gence and behaviour therapy. At the closure of the ‘hippy era’, these authors were often misperceived as ‘academic racists’. Their ﬁrst stop- over was in Melbourne and from media reports it became clear that demonstrations protesting their positions were both relatively large and well-organised. Australian media reported that the speakers were physically assaulted and pelted with tomatoes and eggs by noisy pro- testers at the University of Melbourne, making it virtually impossible for either researcher to deliver their addresses. The next stopover was at the University of Sydney where Eysenck was scheduled to give two public lectures. At the ﬁrst talk, protestors who had gained entry into the lecture theatre were abusive and shouted many derogatory re- marks, and while a water bomb hit the professor who was to introduce Eysenck to the audience, this time there was no physical attack on Eysenck himself. Nevertheless, the talk was cancelled due to the unruly crowd. Security arrangements for the second talk were increased but al- most nothing could be heard due to the noise produced by 'loud- mouthed' demonstrators at the door. It was remarkable to see Eysenck keep his composure and behave in a digniﬁed way in the face of such disruptive behaviour. For the second talk, one of the present authors (LS) organised a group of postgraduate students and tutors with the in- tention of helping the NSW police in defending Eysenck against violent physical attacks. When, 20 years later, the news of Hans Eysenck's death reached Australia, the University of Sydney showed a ﬁlm depicting the 1977 event and the more dispassionate audience in attendance in 1997 wholeheartedly agreed that the accusations of academic racism levelled against Eysenck had been unwarranted and misplaced.

1. Withholding of Cattell's APF Gold Medal Award

While both Eysenck and Cattell were prodigious researchers and scholars, [Goldberg (1968, p. 618)](#_bookmark32) had described Cattell as ‘Psychology's Master Strategist’. In recognition of Cattell's monumental contributions to psychological science spanning more than seven decades, the *American Psychological Foundation* (comprising no fewer than seven past APA presidents) identiﬁed Cattell as the 1997 recipient of psychology's most prestigious *Gold Medal Award for Lifetime Achieve- ment in Psychological Science*. The ofﬁcial citation read as follows:

“In a remarkable 70-year career Raymond B. Cattell has made prodi- gious, landmark contributions to psychology, including factor ana- lytic mapping of the domains of personality, motivation, and abilities; exploration of three different media of assessment; separa- tion of ﬂuid and crystallized intelligence; and numerous methodo- logical innovations. Thus, Cattell became recognized in numerous

substantive areas, providing a model of the complete psychologist in an age of specialization. It may be said that Cattell stands without peer in his creation of a uniﬁed theory of individual differences inte- grating intellectual, temperamental, and dynamic domains of per- sonality in the context of environmental and heredity inﬂuences.” ([American Psychological Foundation, 1997, p. 797](#_bookmark30).)

However, in a last minute political attack, Cattell at 92 years of age and frail, was accused of academic racism, leading to the withdrawal of this ﬁnal prestigious honour, despite his having stated unambiguous- ly more than a decade earlier that:

“The only reasonable thing is to be noncommittal on the race ques- tion – that's not the central issue, and it would be a great mistake to be sidetracked into all the emotional upsets that go on in discus- sions of racial differences. We should be quite careful to dissociate eugenics from it – eugenics' real concern should be with individual differences.” ([Cattell, 1984](#_bookmark13), Interview with R. B. Cattell, para. 18.)

In analysing the unsolicited, derogatory accusations that resulted in the withholding of Cattell's APF Gold Medal Award, [Lotz (2008, p. 136)](#_bookmark47) concluded that:

“Cattell was deliberately misquoted…and labelled as an academic racist. The views he developed in the 1930s were common among his contemporaries when beliefs in racial differences were widely held, and should not be distorted by judgment according to today's standards. General scientiﬁc observations should not be read as per- sonal moral statements. He was particularly wronged during the 1990s by certain writers (William H. Tucker and Barry Mehler) who picked out certain references referring to Germany, Hitler or genocide and quoted them out of context.”

Thus, despite their monumental contributions to scientiﬁc psycholo- gy, both Eysenck and Cattell's work involving the empirical measure- ment of intelligence in various cultural groups was deliberately maligned, resulting, for example, in the wrongful withholding of Cattell's APF Gold Medal Award. In direct contrast to the derogatory ac- cusations of such politically-motivated detractors, [Cattell (1940)](#_bookmark7) had speciﬁcally constructed the *Culture Fair Intelligence Test* (CFIT) in order to minimise differences in IQ scores across different ethnic groups. As Richard Gorsuch wrote in his letter to the American Psychological Foundation:

“The charge of racism is 180 degrees off track. [Cattell] was the ﬁrst one to challenge the racial bias in tests and to attempt to reduce that problem.” ([Gorsuch, 1997](#_bookmark32), Letter to the American Psychological Foundation, para. 4).

Likewise, Eysenck was vehemently opposed to racist ideology and racism. As [Eysenck (1997b, p. 40)](#_bookmark32) speciﬁcally stated:

“My hatred of Hitler and the Nazis, and all they stood for, was so overwhelming that no argument could counter it.”

In collaborating in a professional capacity on research projects with either Hans Eysenck and/or Raymond Cattell over many years (and in some instances decades), the present authors can attest absolutely that neither Eysenck nor Cattell ever advocated racism, despite the os- tensibly untoward asseverations of certain detractors, seemingly trying to ‘make a name for themselves’ by denigrating and besmirching these two giants of twentieth century empirical psychology.

1. New developments – vindication of Eysenck and Cattell's views on the biological basis of traits

Recent developments in the molecular genetics of complex traits have lent new support to the emphasis that both Eysenck and Cattell

placed on the importance of genetic factors underlying individual differ- ences in both intelligence and personality. The evidence in their day came entirely from results of family, adoption, and particularly twin studies, all of which were subjected to ﬁerce criticisms by detractors.

From about 1990, researchers started to go beyond estimating heritability (the proportion of total variation due to genetic causes) in the attempt to identify the actual genes causing variations in be- haviour. Two approaches were tried. First, candidate gene studies, in which the researcher guessed what sort of genes might be in- volved, genotyped them in phenotyped samples and tested for asso- ciation. The second approach was genetic linkage analysis which is hypothesis free, being agnostic as to which particular genes are in- volved, and entails testing for co-segregation within families of a trait with markers typed at regular intervals across all chromo- somes. In principle, linkage analysis should detect any contributing gene signal, but in practice, impossibly large sample sizes are re- quired to do so reliably, except for traits that are almost monogenic, like blue-brown eye colour. The abject failure of these two methods left the ﬁeld despondent and puzzled, but provided the ﬁrst glim- merings of just how small gene effects on complex traits might be, and provided the rationale for the only method that could detect them.

[Risch and Merikangas (1996)](#_bookmark32) proposed that genes causing varia- tion in complex traits like behaviour and common diseases could be found by a genome-wide association scan (GWAS) that entailed typing genetic markers called single nucleotide polymorphisms (SNPs) at high density right across the human genome and testing for association with each and every one of them (cf. [van den Berg](#_bookmark41) [et al., 2014](#_bookmark41)). It took almost another decade before the technology to enable this became widely available, in the form of ‘SNP chips’ – microarrays that could type initially 10,000 SNPs, then 100,000, and eventually a million or more markers. The very ﬁrst success with the GWAS technique was for age related macular degeneration (AMD) the most common form of blindness in old people ([Hoh & Ott,](#_bookmark35) [2003; Klein et al., 2005](#_bookmark35)), and obtained with a sample of only 96 cases with severe AMD and 50 controls. This gave the impression that ﬁnd- ing complex trait genes would be easy, but subsequent success re- quired much larger samples because the causal genes had small effects. For height, a trait with about the same heritability as IQ (0.80), it was only when the GWAS sample size got to around 14,000 cases that genes began to be identiﬁed, but with more than 300,000 individuals now genotyped, around 700 genes have been identiﬁed as affecting adult height.

While we still do not have genotyped samples that large for intel- ligence (IQ), we do have very large samples phenotyped for educa- tional attainment since this is a standard socio-demographic covariate collected in many biomedical and behavioural studies. Ed- ucational attainment (scored as number of years of schooling or sim- ply as the binary yes/no variable ‘Did you go to college?’ (in the north American sense) correlates with psychometric IQ scores about 0.5 and can be regarded as a proxy – the imperfect correlation being compensated for by the much larger sample sizes available for edu- cational attainment.

The ﬁrst GWAS study of educational attainment (*N* = 126.000) identiﬁed a number of associated SNPs ([Rietveld et al., 2013](#_bookmark32)). An ex- panded replication study with (*N* = 305.000) – ([Rietveld et al.,](#_bookmark32) [2014](#_bookmark32)) found more than 70 signiﬁcant SNPs for educational attain- ment and a high genetic correlation with IQ scores (rG = 0.70). In- terestingly it also showed a genetic correlation with intracranial volume of 0.23, conﬁrming one of Eysenck's prognostications on the bi- ological basis of intelligence. Perhaps most interesting was the strong negative genetic correlation with Neuroticism (rG = −0.41) highlight- ing that in addition to high IQ, emotional stability also contributes pos- itively to high educational attainment.

Although individual SNPs may contribute only slightly to the vari- ance in educational attainment, it is the cumulative effect of multiple

SNPs which has greater predictive inﬂuence. As [Domingue et al. (2015,](#_bookmark22)

[p. 2)](#_bookmark22) commented:

“The individual genetic variants discovered exhibited only very small effects on educational attainment, consistent with ﬁndings from GWASs of other complex traits ranging from body mass index to schizophrenia. But the results of the GWAS are not limited to the handful of SNPs identiﬁed. It is possible to combine information from all of the SNPs analysed in the GWAS to calculate a ‘polygenic score’ that summarizes genome-wide genetic predisposition to education- al attainment.”

Until recently, less progress had been made unravelling the genes behind personality traits. However, a large international *Genetics of Per- sonality Consortium* with collectively 63,661 participants from 29 dis- covery cohorts and 9786 participants from a replication cohort measured for Neuroticism and Extraversion found a genome-wide sig- niﬁcant SNP for Neuroticism ([de Moor et al., 2015](#_bookmark23)) in both the discovery meta-analysis, and in the meta-analysis of all 30 cohorts. As de Moor et al. (p. 642) stated:

“Common genetic variants explain 15% of the variance in neuroti- cism. Polygenic scores based on the meta-analysis of neuroticism in 27 cohorts signiﬁcantly predicted neuroticism…in the 2 other co- horts… neuroticism is inﬂuenced by many genetic variants of small effect that are either common or tagged by common variants.”

In regard to detecting underlying causal genes for Extraversion, [van den Berg et al. (2015, *Abstract*)](#_bookmark43) in a large GWAS meta-analysis based on a combined sample (*N* = 63.030) reported that:

“Extraversion is a highly polygenic personality trait, with an archi- tecture possibly different from other complex human traits, includ- ing other personality traits. Future studies are required to further determine which genetic variants, by what modes of gene action, constitute the heritable nature of extraversion.”

Breaking news from the UK Biobank (*N* = 91.000), all measured with the 12-item short-form of the *Eysenck Neuroticism Scale* and typed on a single chip in a single laboratory, has ﬁnally produced a breakthrough with one very large hit and around eight smaller ones for Neuroticism. Congruent with Eysenck's rationale of Neuroticism as the trait underlying clinical depression, the genetic correlation between the two has been measured at rG = 0.64.

1. Summary

Eysenck's tireless efforts to improve the measurement of the biolog- ical correlates of personality and intelligence have led to a better under- standing of the causes of individual differences. Likewise, Cattell's exhaustive efforts to map out a factor-analytically derived taxonomy of personality and ability traits has greatly enhanced our understanding of such constructs. With recent discoveries of speciﬁc genetic markers (SNPs), we can see that both Eysenck and Cattell's scientiﬁc interest and emphasis on the biological basis of individual differences in human personality and cognition are now ﬁnding conﬁrmation in the modern era of molecular genetics and big science. What better vindica- tion of one's scientiﬁc program/heuristic could any dedicated scientist wish for?

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