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Intelligence Research and Assessment in the United Kingdom

Ian J. Deary and Pauline Smith

OVERVIEW

British contributions to research and practice in human intelligence are described and discussed. The emphasis on individual differences in humans' cognitive abilities and the search for the origins of human intelligence differences are British contributions. Some applications of intelligence testing are described in education, in the workplace, and in clinical settings. In theory and research, British contributors commune with those from other countries, especially the United States and, therefore, their contributions are not distinctly different. In the application of intelligence testing there is more United Kingdom-specific practice, with tests and procedures that are specific to the United Kingdom. There are differences in practice even within the United Kingdom's nations.

DISSEMINATING AND CRITICIZING RESEARCH ON INTELLIGENCE: U.K. CONTRIBUTIONS

There are several U.K. academic psychologists who have written books on the research surrounding psychometric intelligence-in-the-round. These include introductory books and higher-level monographs.

Among the entry-level, introductory books – intended for lay people, junior students, and other non-experts – there is a range of opinions. Some are critical appraisals of the field but are from researchers whose work is within the psychometric tradition (e.g., Cooper, 1999; Deary, 2001b; Kline, 1991). Included in this group is Brand's (1996) *The g Factor*, which was withdrawn by the publisher soon after publication despite positive critical evaluations (e.g., Mackintosh, 1996a). Other books at this level are highly critical of the concept of intelligence and the psychometric approach more generally. For example, Richardson's (1999) book concludes by arguing that intelligence testing should be banned as a social evil. This is congruent with Richardson's (e.g., Richardson & Webster, 1996) research commentaries, which argue that reasoning cannot be assessed in a context-free manner, a view contested by Roberts and Stevenson (1996). Another very negative assessment of psychometric intelligence research was one of a number of books by Howe (1997). This accords with Howe's research into high-level skill acquisition, which tended to emphasize factors other than innate talents, such as experience and practice (Howe, Davidson, & Sloboda, 1998).

Higher-level books included Mackintosh's (1998) well-received critical appraisal of research on psychometric intelligence. This had special impact because of his disinterestedness: Mackintosh is an expert in animal learning. His other valued services to intelligence research included assessments of sex differences (Mackintosh, 1996b), an edited volume assessing the nature of Cyril Burt's alleged misdemeanors (Mackintosh, 1995), and his many expert commentaries in the field of intelligence research (e.g., Mackintosh, 1981, 1996a, 2000). Anderson's (1992) book was an original fusion of neuropsychological and developmental psychology with the psychometrics of intelligence, producing a novel account of the origins, structure, and cognitive bases of intelligence differences. Deary's (2000a) monograph was a critical appraisal of the success of reductionistic research into individual differences in psychometric intelligence.

UNDERSTANDING INTELLIGENCE: U.K. CONTRIBUTIONS

There continues to be discussion and some incomprehension between those who emphasize the usefulness of experimental versus individual differences approaches to human cognitive functions, between those who sought the structure of modal cognitive function in humans and those who were interested in how and why people differed in these functions (Novartis Foundation, 2000). Historically, these complementary points of view were represented in Britain by the difference between the Cambridge (Bartlett, 1932) and London (Spearman, 1927) schools of psychology, respectively. Bartlett paid tribute to the London school's forerunner Galton as "a brilliant and original investigator," dubbing him "the father of experimental psychology in England" (p. 7). He further lauded the contribution made by differential psychologists, "as all the psychological world knows, in the extremely important work of Prof. C. E. Spearman" (p. 7). But Bartlett worried that

> Such statistical treatment gives, not, indeed, the mode of determination of the individual reaction, but a picture of trends of response and their interrelations. . . . Largely by direct influence, but probably also because Galton's outlook contains something that is peculiarly attractive to the English temperament, the methods initiated by him have become very widely used in English psychology, and have been greatly developed by his successors. (p. 7)

Some commentators bemoaned the separation of differential and experimental psychology, insisting that it is important to know both the modal structure and function of cognition as well as the parameters governing individual differences. Thus, Spearman (1904, 1923) insisted that the understanding of human ability differences must be founded upon valid variables delivered by experimental psychologists, and that the study of intelligence differences must be preceded by an understanding of the "principles of cognition." To bridge the gap, Spearman, prior to writing his statistics-strewn *The Abilities of Man* (1927), wrote *The Nature of Intelligence and the Principles of Cognition* (1923), which was deemed the first textbook of cognitive psychology (Gustafsson, 1992). Sporadically, as the 20th century matured, the calls to combine experimental (or cognitive) and differential approaches to human ability and its differences have echoed more or less strongly back and forth across the Atlantic (Cronbach, 1957; Eysenck, 1967; Sternberg, 1978; Eysenck, 1995), with the result being an intermittently satisfying but rather desultory affair (Deary, 1997, 2000a, 2000b).

A related disagreement was between the British, London-school approach to intelligence differences and that of Binet and Simon. The former aimed to "understand" intelligence differences in terms of elementary psychological processes, such as sensory discrimination and reaction times (Deary, 1994a, 1994b Galton, 1883; Johnson et al., 1985; Spearman, 1904), whereas Binet's approach was to construct a "hotchpot" (Spearman's 1927 epithet) of higher-level tasks to gain a "measurement" of ability (Binet, 1905).

The contrast between Spearman's and Binet's approaches is often portrayed as a disagreement about the best way to measure human mental abilities (see Deary, 1994a, for an historical review and discussion). That is incorrect: They agreed on the matter of how to measure. They parted on two other matters. Binet, according to Spearman, preferred a faculty (modular) structure for mental abilities, whereas Spearman sought a structure that could incorporate *g*. Second, Spearman worried that proceeding with measurement prior to any theory of, or explanation for, intelligence differences would curtail the necessary work of understanding the general factor. Though Binet's test might measure the general factor, its nature was still mysterious:

> But notice must be taken that this general factor *g*, like all measurements anywhere, is primarily not any concrete thing but only a value or magnitude. Further, that which this magnitude measures has not been defined by declaring what it is like, but only by pointing out where it can be found. (Spearman, 1927, p. 75)

It was these British concerns about the nature of intelligence differences that would be taken up seriously over half a century later with the "information processing approach" to intelligence differences (e.g., Hunt, 1980; Deary, 2000a, 2000b).

U.K. CONTRIBUTIONS TO UNDERSTANDING THE STRUCTURE OF HUMAN INTELLIGENCE DIFFERENCES

Academic argument about the structure of human intelligence differences continues (e.g., Mackintosh, 1998; Gardner, 1999; Deary, 2000a). The central issues of the argument are the best way to construe the associations among those correlations that occur between psychometric test scores, and whether such psychometric tests omit important aspects of human ability. British psychologists made a large contribution to the partial consensus that emerged in the mid-1980s and early 1990s concerning the structure of psychometric intelligence.

Five of the greatest books in the history of psychometric intelligence and mental measurement were written by Britons in the first half of the 20th century: Spearman (1923, 1927), Thomson (1939), Burt (1940), and Vernon (1950). The authors impress the reader on a number of fronts: their erudition and knowledge of disparate research literature, their ability to devise complex novel statistical methods, their empirical contribution (this must be qualified for Burt; Mackintosh, 1995), and their contribution to theory. Moreover, they lasted the course. Among them, they emphasized the facts about psychometric intelligence that emerged in the next 50 years: that mental ability differences may be described as a hierarchy of more or less specific packets of variance with *g* on top; that psychometrics will never explain intelligence differences; and that ability factors, especially *g*, should be treated as discoveries to be explained rather than things in the brain.

Though there seemed to be a U.K.–U.S. argument about the existence of a general factor for a sizeable portion of the 20th century, the cognoscenti knew very early on that there was no substantial difference in results obtained across the Atlantic; it was one of emphasis rather than substance. Those who – for example, Gould (1981, 1997) – retained the erroneous notion that Thurstone (1938) rid the scene of *g*, or that *g* is an arbitrary artifact of statistical whim, should note two things. First, even Thurstone was aware very early on that his data contained a *g* factor (Eysenck, 1939). Second, Gould's (1981) incorrect comments on the psychometric nature of abilities have been corrected (Carroll, 1995). Gustafsson (1984) explained clearly why *g* does not go away with different factor analytic approaches, and Humphreys (1979) commented:

> The neglect in the United States of the general factor in human abilities has arisen from the popularity of the group factor model and the almost universal restriction of that model to factors in the first order only. (p. 107)

Today the converging consensus about mental ability differences incorporates ideas from Thurstone (concerning primary-level mental abilities), Burt and Vernon (concerning a hierarchy of intelligence factors ranging from specific abilities to *g* with group factors in between) and Spearman (concerning specific factors and *g*; in his 1927 book he was rather dismissive about group factors). Whether one examines the analyses of diverse mental test batteries given to large, discrete samples of subjects (Undheim, 1981a, 1981b; Gustafsson, 1984; Carretta & Ree, 1995; Bickley, Keith, & Wolfle, 1995), or considers Carroll's (1993) standardized re-analyses of hundreds of mental test data sets gathered throughout the 20th century, the result is similar: Human mental ability differences show near universal positive correlations; the packets of covariance in a heterogeneous mental test battery given to a broad sample of adults or children can be arranged into correlated group factors; and a *g* factor can be extracted that accounts for around 50% of the variance among individuals. Gustafsson referred to "this unifying model" of mental abilities (p. 193) and summarized its characteristics as follows, The Spearman, Thurstone, and Cattell-Horn models may, in a structural sense at least, be viewed as subsets of the HILI [Hierarchical, LISREL (Linear Structural RELations)-based] model: the Spearman model takes into account variance from the third-order factor; The Thurstone model takes into account first-order variance; and the Cattell-Horn model takes into account both first- and second-order variance. The Vernon model comes close to the proposed model: The *g*-factor is included in both models, and at the second-order level v:ed [Vernon's (1950) verbal-educational factor)] closely corresponds to G_c [crystallised intelligence], and k:m [Vernon's spatial-mechanical factor] corresponds to G_v [general visualization].

The "three-stratum" (Carroll, 1993) account of human ability differences is sometimes nowadays referred to as a "theory" (Bickley et al., 1995; Bouchard, 1998). It is, rather, a taxonomy that construes covariance into different-sized packages that serve the purposes of providing predictive validity and the substrate for explanatory science. Burt (1940) warned,

So far as it seeks to be strictly scientific, psychology must beware of supposing that these principles of classification can forthwith be treated as "factors in the mind," e.g., as 'primary abilities' or as "mental powers" or "energies." (p. 251)

It is interesting to see equal criticism thus aimed specifically at both Thurstone and Burt's London-school forerunner Spearman.

Similarly, Vernon (1961) was concerned that

the best-established factors, such as Thurstone's, represent the external qualities or materials of the tests – verbal, numerical, spatial, etc. – rather than central mental functions. It may be that statistical analysis alone is incapable of yielding these more fundamental functional components of the mind. (pp. 138–139)

The exact same factors do not appear from every analysis, nor would one expect that, given the variation in test batteries, and the possibility – first suggested by Spearman and Burt – that human abilities might be structured slightly differently at different levels of ability (Deary et al., 1996).

Burt's (1940) mid-century "four factor" (the three strata model plus error variance, essentially) solution to human ability differences was very similar to, perhaps even more general than, the model that attracted some consensus half a century later,

Four kinds of factors may be formally distinguished – (i) general, (ii) group or bipolar, (iii) specific, and (iv) error factors, that is, those possessed by all the traits, by some of the traits, by one trait always, or by one trait on the occasion of its measurement only. . . .

From the four-factor theorem (as it may be termed) all the familiar factor theories may be derived. (p. 249–250)

The diamond jubilee of Burt's (1940) suggestion witnessed many psychometricians unwittingly re-converging on his conclusion. Others continued to differ to some degree (see Neisser et al., 1996). Among these was the quondam Briton Raymond Cattell whose influential theory of fluid and crystallized intelligences recognized correlated general factors in human ability but, by way of diktat rather than data, never quite accommodated Spearman's *g* (Horn & Cattell, 1966; Cattell, 1998; Horn, 1998).

Godfrey Thomson (1939) was famous within intelligence research for his statistical innovations and debates with Spearman about the interpretation of the general factor in mental ability. However, whereas his "anarchic" theory of intelligence differences is largely absent from mainstream intelligence research worldwide, his lasting contribution might be the part he played in the Scottish Council for Research in Education's (1933) national surveys of psychometric intelligence. In the first of these surveys, in 1932, almost the entire nation of Scottish children born in 1921 took a version of the Moray House Test on June 1. This test was like the general reasoning section of the "eleven-plus" tests, which were used in the United Kingdom between about the 1930s and the 1960s to select children for different types of secondary school education. Small pockets of eleven-plus testing remain in the United Kingdom today. The number of children tested in the 1932 survey was 87,498, representing well over 90% of the population. As it turned out at the time, this proved mostly to be a descriptive achievement. However, the data were retained and, therefore, within Scotland there are high-quality mental test data for an entire birth cohort. Our research team followed up on 101 of the Scottish cohort 66 years to the day after the original test. They took the same test using the same instructions and the same time limit. Comparing the 1932 and the 1998 results on the Moray House Test gave a correlation of 0.63 (0.73 when corrected for attenuation) (Deary et al., 2000). Two better-established British contributions to aging-related studies of intelligence should be noted. Among other cohort studies worldwide the United Kingdom has contributed some large scale studies of cognition and aging (e.g., Rabbitt et al., 1993). On the theoretical side, Cattell's (e.g., 1998) ideas of fluid and crystallized intelligence find much application in the contemporary study of aging and intelligence differences.

SOME CAUSES OF HUMAN INTELLIGENCE DIFFERENCES

Spearman's (1904) first investigations examined the association between psychometric intelligence and sensory discrimination, an idea that had been suggested and tried by others, Galton (1883) among them. Review and re-analyses of largely British studies before and during World War I showed that there was a small, significant correlation between visual and auditory discrimination and mental test scores (Deary, 1994a). These hold up in more recent investigations, and Raz, Willerman, and Yama (1987) commented that

> no matter what the exact mechanisms of information processing underlying intelligence, Galton's (1883) suggestion of an important link between "the avenues of the senses" and good sense may not be as far-fetched as previously supposed. (p. 209)

However, correlations between any one information-processing index and psychometric intelligence are not large, and there are few current researchers who search after the Holy Grail (Hunt, 1980) of a single information-processing index that will explain *g* or other abilities in the psychometric hierarchy.

Currently, the lively but heterogeneous research activity that seeks the causes of psychometric intelligence has the following agenda. It examines associations between psychometric test scores and indices of brain function at putatively lower levels of reduction than the test scores themselves. When correlations are obtained and replicated, it then considers the possible mechanisms of the associations and the validity and tractability of the brain indices. Properly self-critical investigators consider the possibility that, in some cases, the cause of any correlation might be the reverse of that which is supposed, that is, better performance on supposedly lower-level brain indices might be caused by, rather than be the cause of, psychometric intelligence differences. Collections of this type of research may be found in Eysenck (1982), Vernon (1987, 1993), and Deary (2000a). For the purposes of a resumé, it is convenient to describe the state of this area by descending through different levels of reduction. Thus, brain indices have been sought at, arguably, psychometric, cognitive, psychophysical, psychophysiological, physiological, and biological levels. The focus of this area is the continuity that recent research shows with ideas contributed by British psychologists. Though his most prominent contributions were to the science of personality, the British psychologist H. J. Eysenck championed and supported the experimental study of intelligence from the 1960s onward, several years before such a movement really took off in the United States (Eysenck, 1967; see also 1982 and 1995).

R. J. Sternberg (1977, 1985) executed inventive experiments using psychometric tasks. Developing a legacy from Spearman, Sternberg dissected, using a partial cueing technique and regression models, analogical reasoning performance into "mental components." He chose analogical reasoning because so many past researchers on psychometric intelligence had placed this type of reasoning near to the center of their thinking about psychometric intelligence differences. Sternberg's models of component function accounted successfully for performance differences on reasoning tasks. Sternberg's components of reasoning bore strong resemblances to Spearman's "principles of cognition" (1923), especially the eduction of relations and correlates. And they also suffered the same problems as Spearman's principles and components: They were brought into being from the armchair and not the lab; they were never validated outside the rarefied world of the mental test item; and it was never finally established whether they were components of mind or merely components of mental test items (Deary, 1997, 2000a).

Successors to Sternberg have also concentrated on reasoning ability and have applied newer analytic techniques. Carpenter, Just, and Shell's (1990) analysis of performance success on Raven's matrices used subjects' verbal reports and eye tracking information to construct computer models of average and good performers on the task. Raven's (1938) Matrices, a British-built task based on Spearman's (1923) principles of cognition, is widely acknowledged as just about the best single group test of *g* (Westby, 1953; Marshalek, Lohman, & Snow, 1983). It is not easy to decide whether Carpenter and colleagues got beneath the psychometric skin of performance of the Raven task or just elaborately redescribed Raven's own task building principles, but the key processes involved in task success were rule-finding (like Spearman's eductions of relations and correlates) and keeping track of multiple goals in working memory (like Spearman's [1927] mental span).

Working Memory

Accounts of reasoning performance frequently appeal to the British construct of working memory (Baddeley, 1986, 1992a) as a basis for individual differences. Working memory is "a limited capacity system allowing the temporary storage and manipulation of information necessary for such complex tasks as comprehension, learning and reasoning" (Baddeley, 2000, p. 418). Baddeley's articulation of the construct of working memory arose from the growing problems with the notion of a single short-term memory store. A key observation was that reasoning, comprehension and learning could still take place in patients whose short-term memory was damaged or in healthy people who had to remember digits while performing a dual task. Baddeley (1992a) replaced the single short-term memory notion with a tripartite working memory model with

> an attentional controller and the central executive, supplemented by two subsidiary slave systems. The articulatory or phonological loop was assumed to be responsible for maintaining speech-based information, including digits in the digit span test, whereas the visuospatial sketch pad was assumed to perform a similar function in setting up and manipulating visuospatial imagery. (p. 556)

Baddeley (1992a) described two complementary types of research on working memory. The first, more British-based, used dual-task methodology to examine neuropsychological cases and thereby explore the modal structure of working memory in humans. This approach dominated Baddeley's own research. He continued to explore the structure and function of working memory in humans and, in response to limitations in the original model, added a fourth component. This "episodic buffer" is

> a limited capacity system that provides temporary storage of information held in a multimodal code, which is capable of binding information from the subsidiary systems, and from long-term memory, into a unitary episodic representation. (Baddeley, 2000, p. 417)

The second, more common in North America, devised tests of working memory to discover whether this construct could account for variance in related cognitive tasks, including the reasoning tasks that are common in tests of psychometric intelligence. It is the second approach that has had such a large influence on intelligence theory. Baddeley (1992b) stated that

> An emphasis on individual differences has the further advantage of linking up with more traditional psychometric approaches. This appears to be meeting with some success, since working memory measures appear to correlate very highly with performance on a range of reasoning tasks that have traditionally been used for measuring intelligence. (p. 287)

Using Baddeley's ideas to construct psychometric tests of working memory, Kyllonen and Christal's (1990) structural equation models of thousands of U.S. armed forces applicants' test scores found reasoning and working memory to be highly correlated constructs. They were not able to decide which of the two had causal precedence over the other (see also Kyllonen, 1996), but they suggested they were not synonymous. Working memory, in Kyllonen's Cognitive Abilities Measurement (CAM) test battery, loads .95 on the CAM general factor and this factor correlated .994 from the Armed Services Vocational Aptitude Battery (ASVAB) test battery (Stauffer, Ree, & Carretta, 1996). Engle et al. (1999), using a latent trait approach, found individual differences in working memory highly related to short-term memory ($r = .68$) and to general fluid intelligence ($r = .59$) but short-term memory was not significantly correlated with fluid intelligence.

If working memory is so closely related to psychometric intelligence, then researchers in the latter field would be well-advised to make use of the extensive neuropsychological, cognitive, and biological information about working memory in thinking about the elements of mental ability differences. This would make a nice meeting ground for a proper reconciliation of the Cambridge and London school approaches to cognition.

g and Frontal Lobe Function

Working memory is, therefore, a strong British contender as an explanatory factor for *g*. Another British contender is frontal lobe function, as suggested by Duncan and colleagues (Duncan, Emslie, & Williams, 1996; Duncan et al., 2000). Duncan argued that low intelligence bears resemblances to frontal lobe dysfunction (Duncan et al., 1996). He devised a task that is performed poorly by people with frontal lobe lesions when compared with healthy subjects. This involved reading letters from a temporal stream of stimuli that appear on a computer screen as horizontal pairs of letters or numbers. Every so often a + or – sign appears, which indicates whether or not the subject should change the stream (left or right) of stimuli to which they must attend. Duncan et al. (1996) found people with frontal lobe damage often failed to implement this instruction, despite being aware of what they should have done. Among healthy subjects, this failure to implement this so-called second side instruction correlated –.52 with scores on Cattell's Culture-Fair test.

This evidence for a frontal lobe seat for differences in *g* was supplemented by evidence from positron emission tomography (Duncan et al., 2000). Verbal, spatial and numerical tasks were devised in similar-looking versions that were either low or high on *g*-loading. In each type of task the differences in brain metabolism between the high and low *g*-loading versions of the task were examined. Common to all three high *g*-loaded tasks was activation of an area in the lateral frontal lobes. Duncan and Owen (2000) reviewed a number of functional neuroimaging studies and concluded that there is a "specific frontal-lobe network that is consistently recruited for solution of diverse cognitive problems" (p. 475). The evidence was a pattern of recruitment of the mid-dorsolateral, mid-ventrolateral and dorsal anterior cingulate cortex areas in the frontal lobes.

Therefore, whereas Baddeley has produced a single cognitive function (central executive of the working memory system) that relates highly to *g* differences, Duncan has located *g* in a single cerebral location, associated with "goal activation" (Duncan et al., 1996, p. 293). These two concepts see application in others' models of intelligence differences. Also in the mode of Sternberg's componential approach, Embretson (1995) used multicomponent latent trait models to decompose reasoning performance. She found that reasoning performance differences were well accounted for by two latent traits derived from the psychometric tests she had devised: general control processing and working memory. Her opinion was that this modern methodology was rediscovering some of Spearman's ideas: "General control processing, Spearman's mental energy, is the conative directing of attention, whereas working memory capacity parallels Spearman's mental span concept" (p. 184).

Reaction Time

Appeals to cognitive variables in an attempt to account for variance in human ability differences have leaned heavily on various reaction time procedures. Buried within Galton's unanalyzed data from his anthropometric laboratory in South Kensington was some indirect evidence to link faster reactions with higher mental ability (Johnson et al., 1985). In recent research on intelligence differences the most researched of the reaction time procedures is that first described by the British psychologist Hick (1952). He modeled the linear increase in reaction times as a function of the log of the number of stimulus alternatives in a choice reaction time procedure. His epithet for the slope's psychological importance was that it might represent the "rate of gain of information" of the subject. Beginning with the German psychologist Roth (1964), differential psychologists alighted on the possibility that individual differences in this slope parameter might account for some of the individual differences in psychometric intelligence. However, three decades on from Roth's pioneering study something rather surprising has emerged. Along with other favored reaction time procedures, especially the S. Sternberg (1966) memory scanning task and the Posner (Posner & Mitchell, 1967) letter-matching task, the Hick task does indeed throw up significant correlations with psychometric intelligence differences (for reviews, see Vernon, 1987; Jensen, 1987; Neubauer, 1997). Galton was correct, higher test scorers do have faster reactions. They also have less variable reactions. In all three procedures the effect sizes are small-to-medium, that is, enough to be interesting but not enough to "explain" what it is to have high psychometric intelligence. But in all three procedures the elementary processing stage that attracted the differential psychologists failed to have any special association with psychometric intelligence. Thus, the slope in the Hick task, the speed of memory scanning in the Sternberg task and the speed of access to long-term memory in the Posner task are outshone by the prosaic indices assessed in the intercept and variability of the reaction times (Neubauer, 1997; Deary, 2000a). It was also British psychologists Barrett, Eysenck, and Lucking (1986) who showed that not all subject's reaction time data agree with Hick's law.

Much of the research into intelligence and speed of information processing is conducted on biased samples, often college and university students. There has been a lack of studies based on representative samples. The first large, representative study of reaction time and psychometric intelligence was a result of the West of Scotland Twenty-07 Study. Among 900 representative 55-year-olds the correlation between scores on the Alice Heim 4 test and simple and choice reaction times was $-.31$ and $-.49$, respectively (Deary, Der, & Ford, 2001). The correlation between psychometric intelligence and intraindividual variability was $-.26$ for both simple and choice reaction times. These estimates of effect size are larger than previously reported on more attenuated samples. These and other results might herald a change in research focus, away from the supposed processing components that are manufactured from differences between one reaction time condition and another, to the basic reaction times and variabilities themselves. Against this trend, some

British psychologists found an interest in complicating the choice reaction time procedure by adding an element of discrimination, which increases the correlation with intelligence (Frearson & Eysenck, 1986).

Inspection Time

At what seems to common sense like a lower level of reduction, still, than reaction times comes the study between psychometric intelligence and indices related to sensory processing. Galton (1883) hypothesized that people with higher levels of mental ability had finer powers of discrimination. But a more prescient lead was McKeen Cattell's (1886a, 1886b) discovery, in Wundt's lab, that the minimum stimulus duration required to make an accurate discrimination might be related to ability level (Deary, 1986). Also, Burt (1909–10), in his first empirical study, found a strong association between tachistoscopic recognition and imputed intelligence level. In the modern era, a mass of research has accumulated around a procedure termed "inspection time," and this research suggests that the efficiency of the early stages of sensory processing have a moderate association with psychometric intelligence. Inspection time was developed in Australia by Vickers, a student of the British psychologist Welford (Vickers, Nettelbeck, & Willson, 1972). This task involves a forced-choice, two-alternative discrimination. Typically, the subject views two parallel lines, one much longer than the other. Without any pressure to respond quickly, they indicate to the experimenter which line is longer. The task is made challenging by exposing the stimulus lines for varying durations, some of them very brief. Also, the stimulus lines are replaced by a backward mask immediately after exposure. In essence, the task appears to measure the duration needed by a subject to inspect a stimulus before making a simple decision.

In 1976, Nettelbeck and Lally reported that individual differences in this simple task correlated substantially with individual differences in psychometric intelligence. The 25th anniversary of this report was celebrated by a special issue of the journal *Intelligence* in 2001 that was co-edited by the British psychologist Deary (Petrill & Deary, 2001), who has contributed to the empirical study of inspection time and critically appraised its place in the theory of intelligence differences (Deary, 2000a, chap. 7). The British psychologist Brand was a major influence in the spread of influence of inspection time as a theoretically interesting correlate of psychometric intelligence (Brand, 1979, 1987; Brand &