Person. individ. Diff. Vol. 7, No. 5, pp. 731–736, 1986
Printed in Great Britain

0191-8869/86 $3.00 + 0.00
Pergamon Journals Ltd

TOWARD A NEW MODEL OF INTELLIGENCE

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As recently pointed out (Eysenck, 1983), there has been a Kuhnian revolution in the theory and the measurement of intelligence (Kuhn, 1970; Barnes, 1982). This revolution marks a return to the ideas and conceptions of Sir Francis Galton, and a partial rejection of the views of Alfred Binet (Eysenck, 1985). The revolution in question opposes what might now be called the 'orthodox' view of human intelligence (Sternberg and Salter, 1982), which identifies that concept for all practical purposes with *social intelligence*, i.e. the ability to adapt to social requirements (Sternberg, 1985). Instead, it identifies 'intelligence' with the *biological* determinants of cognitive ability, imperfectly measured by IQ tests (because these show an undue amount of environmental determination), and partly (but only partly) responsible for differences in social intelligence. *Social intelligence*, on this view, is determined by very many factors other than *biological intelligence*, such as personality, motivation, cultural and educational factors, socio-economic status, etc. Figure 1 shows in diagramatic form the model which links biological intelligence, IQ and social intelligence.

The original differences between Galton (1892, 1943) and Binet (1903), 1907) were three-fold. In the first place, intelligence and the general factor of cognitive ability was a meaningful scientific concept to Galton, whereas for Binet 'intelligence' was a statistical artifact, nothing but the average of a number of disparate and independent mental abilities. In the second place, genetic factors were paramount for Galton in the causation of individual differences in intelligence, whereas Binet as an educationalist was much more interested in environmental factors. And thirdly, as far as measurement was concerned, Galton favoured physiological methods (he suggested reaction time measurement *inter alia*), whereas Binet preferred lifelike measures of problem solving, learning, remembering, following instructions etc. IQ tests, following Binet's original conception, have concentrated on educational tests of the type he originated, with the result that typical IQ tests such as the Wechsler or the Binet have heritabilites, uncorrected for attenuation, of between 0.50 and 0.70 (Eysenck, 1979; Vernon, 1979). They are thus imperfect but nevertheless practically useful measures of biological intelligence, correlating with it to an extent given by the square root of the broad heritability (i.e. between 0.84 and 0.71).

Binet's views have been taken to absurd lengths by many recent writers who have concentrated on the complexities of problem solving and learning mechanisms, and have neglected the Galtonian suggestion of looking at reaction times and even more directly physiological measures of intelligence. The main pressure for the recent revolution has come from empirical studies showing quite high correlations between IQ and measures of choice reaction time (for a review, see Eysenck,

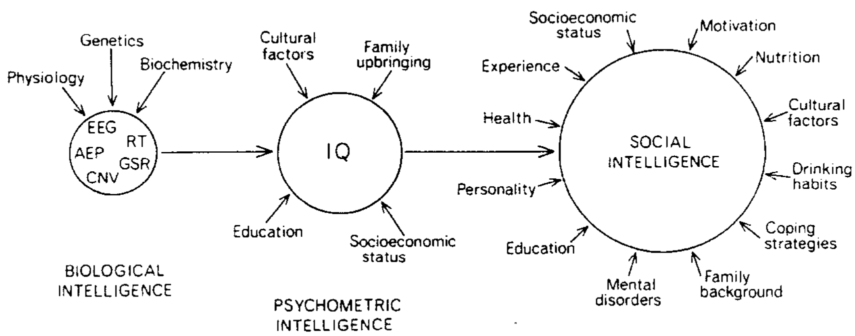

Fig. 1. Relationship between Biological Intelligence, IQ and Social Intelligence.

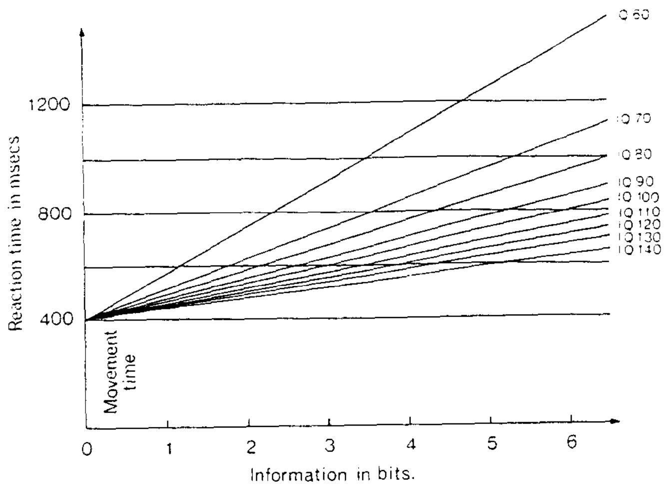

Fig. 2. Slope of regression lines relating information in bits and reaction times, as dependent on IQ (after Lerhl, 1983).

1986), and the even more impressive evidence showing similarly high relationships between the evoked potential on the EEG, on the one hand, and IQ on the other (for a review, see Eysenck and Barrett, 1985). These studies suggest that speed of information processing is a fundamental property of biological intelligence, as originally suggested by Eysenck (1953, 1967; see also Eysenck, 1982). The literature on the EEG has suggested that possibly error-free transmission of information through the cortex may be responsible for the observed differences in speed (Eysenck, 1985), but this point is not entirely relevant to our discussion at the moment, and will not be stressed.

Early work on the connection between reaction time and IQ has been summarised by McFarland (1928). He concluded that: "In the six more recent studies of the past four years where investigations have been conducted under carefully controlled conditions, the evidence, although contradictory, decidedly tends to favour the existence of a positive relationship between rate and ability in mental tests." (p. 610). More recent studies, reviewed by Jensen (1982a, 1982b) have justified this confidence, and in the most recent study of an RT paradigm, Frearson and Eysenck (1986) have shown that even quite short RT tests can give correlations on random samples of the population in excess of 0.60. Correlations between averaged evoked potentials (AEPs) and IQ have been even higher, reaching the 80s for random samples of the population, or where necessary corrected for range of talent (Hendrickson, 1982; Schafer, 1979, 1982). These figures approach the predicted level of a correlation between IQ and a perfect measure of biological intelligence.

Theoretical interest in the use of choice reaction time measurement was awakened by the fact that the log of the number of stimulus choices was linearly related to the subjects' reaction time in a multiple choice paradigm, as first pointed out by Blank (1934). This invariance, sometimes known as Hick's Law (Hick, 1952) links reaction time in a lawful manner with gain of information, and was used by Roth (1964) in a particularly interesting manner to argue that the slope of the Hick regression line would be corrected with IQ, in the sense that for brighter subjects the slope would be less than for duller ones, indicating that the increased difficulty of having more bits of information to process (higher number of choice stimuli) would be more easily dealt with by high IQ than by low IQ subjects. His own work, and that of Jensen (1982a) and others, has shown that such correlations do indeed exist, although the work of Barrett, Eysenck and Lucking (1986) suggests that the correlations are not particularly high, unless subjects whose regression lines do not follow Hick's Law are excluded. Figure 2, showing Roth's results as graphed by Lehrl (1983) suggests a much closer relationship than actually exists in unselected populations.

The possibility of producing a theory of intelligence and a method of measurement not dependent on simple comparisons, as IQ tests invariably are, but capable of using absolute values on a physical scale, as is possible with RT measures, was seized upon by the Erlangen School (Lehrl, 1980, 1983; Lehrl and Frank, 1982; Frank, 1960, 1971; Oswald, 1971; Oswald and Roth, 1978; Oswald and Seus, 1975) and others to produce a very ambitious theory of intelligence interpreted in terms of information processing. The theory has been discussed in some detail by the writer (Eysenck, 1986); it has not given rise to any discussion in English-speaking countries because it has been published exclusively in German journals, most of them rather obscure and unobtainable outside Germany.

Rather parallel developments have taken place in the United States, where Jensen (1982a, 1982b) has put forward views rather similar to those of the Erlangen School; the similarities and differences are pointed out elsewhere (Eysenck, 1986). We thus seem to be coming to a point where one might say not only that the existing paradigm, as exemplified by Sternberg and Salter (1982) and Sternberg (1985), is faced with too many anomalies to continue its sway, but that in addition there is now in existence a basic theory which is capable of challenging this paradigm and suggesting an entirely new and revolutionary view much more in line with the evidence. It is of interest that very similar theories have been elaborated quite independently by the Erlangen School and by Jensen and his collaborators in response to these new developments, in that both fit quite readily into the general framework outlined originally by Eysenck (1967). This return to Galton's ideas is indeed overdue; the existence of the anomalies mentioned was all too obvious over many years, but was disregarded by defenders of the 'orthodox' Binet tradition.

The attempt to find biological causes for differences in intelligence is often labelled *reductionist*, and the question arises whether such reductionism can go even further. Some 40 years ago, attempts were made to identify biochemical features which might be responsible for the behavioural events we identify as intelligence. An early candidate for this role was glutamic acid. Zimmerman and Ross (1944) reported that feeding glutamic acid to dull young rats resulted in a considerable improvement in maze-learning ability. Another group of workers, also at Columbia University, reported beneficial effects on the performance of rats in complex reasoning problems (Albert and Warden, 1944). This work was extended to mentally retarded children with results which suggested that glutamic acid might increase their IQ as measured by standard intelligence tests; however, not all investigations have given favourable results as indicated in a review by Hughes and Zubek (1956). Some animal experiments, too, have given negative results, very probably because positive results have only been achieved with dull rats, so that experiments using average or bright rats are strictly irrelevant to the theory.

These empirical data are supported by theoretical considerations. Zimmerman, Burgemeister and Putnam (1949) have argued that the improvement in learning ability might be due to the facilitatory effect of glutamic acid upon certain metabolic processes underlying neural activity. Thus it is known that glutamic acid is important in the synthesis of acetylcholine, a chemical substance necessary for the production of various electrical changes appearing during neural transmission. It has been found that the rate of acetylcholine formation could be increased 4–5 times by adding glutamic acid to dialysed extracts in rat brain (Nachmansohn, John and Walsh, 1943). In addition, Waelsch (1951) has shown that the concentration of glutamic acid in the brain is disproportionately high, as compared with the concentration of other amino-acids, or with its concentration in other body tissues. It alone, of all the amino-acids, is capable of serving as a respiratory substrate of the brain in lieu of glucose. And finally, Sauri (1950), experimenting on rats, discovered that the acid exerts its main action on the cerebral cortex, lowering the threshold of excitability.

All these results clearly point to the importance of glutamic acid in cerebral metabolism. Its effectiveness, in dull rats only, suggests that the cerebral metabolism of the dull rats is defective in some way, while that of average and bright rats is normal, allowing glutamic acid to facilitate or improve the defective cerebral metabolism of the dull animals, while having no particular effect on the normal metabolism of the bright ones. This suggestion is strengthened by the fact that Himwich and Fazekas (1940), in a careful study of tissue preparations from the brains of mentally retarded persons, were able to show that these tissues were incapable of utilising normal amounts of oxygen and carbohydrates. In other words, the cerebral metabolism in these mentally retarded patients was defective.

This brief review of the new look in our conception of intelligence is meant to serve as an introduction to the paper by Volkmar Weiss which follows it. It is unusual to so introduce a paper, but the circumstances seem to require it. In the first place, the unfortunate provincialism of English-speaking psychologists which prevents them from reading any non-English books and articles has made the extensive German work on intelligence and reaction time *terra incognita* even to experts in the field; thus there is no mention of it in the Sternberg and Salter (1982) *Handbook of Human Intelligence*. Indeed, the handbook also leaves out all mention of work on psychophysiological measures of intelligence, and even the Australian, American and British work on reaction time and intelligence. Such selectivity suggests that many readers may not be familiar with the background to Weiss's paper, and that such an introduction as this might be useful.

Another reason for the introduction is the originality of Weiss's paper. Journal editors are always faced with the problem of avoiding what Fisher called errors of the first and second kind; in other words, they want to avoid printing articles which are perfectly adequate methodoligically and statistically, but do not contain information of any importance to the development of science. They also want to avoid articles so speculative and theoretical that their immediate interest is counterbalanced by an absence of evidence, or by faulty and erroneous citation of evidence. It is difficult to sail a reasonable course between the Scylla and the Charybdis presented by these dangers, and accordingly unusual precautions were taken to have the Weiss paper refereed. A Professor of Biochemistry, and a Nobel-prize winning Professor of Physics were asked to read relevant portions of the paper, in addition to knowledgeable psychological experts. They affirmed that the arguments put forward by Weiss did not contravene in any obvious way scientific knowledge or principles in their domains, which may reassure readers who might find the going rather tough.

To say this is not to agree with all the arguments and conclusions put forward by Weiss. His work is welcome because it leaves behind the endless wrangles of psychometricians and 'cognitive' psychologists stereotyped over the past 60 years or more, and offers a novel and much more interesting view of the field of mental abilities. Weiss is an ally of the Erlangen School, but has made many important and novel contributions, particularly in relation to genetic theory, the biochemical basis of mental energy, and the possible usefulness of quantum mechanics concepts in the study of intelligence. He has conducted some of the largest and best controlled investigations of the genetics of mathematical and general ability, and while some of his suggestions go counter to present-day orthodoxy (such as his conclusion that a major gene is responsible for differences in general intelligence), they should not therefore be dismissed out of hand. (Detailed references to his own studies and theories will be found in his book on *Psychogenetik*, published in 1982).

A third reason for introducing Weiss's paper in this manner is to demonstrate that there is a good deal of factual evidence to support the reductionist arguments. What cannot be doubted is that there are quite strong relations between biological variables, on the one hand, and psychometric intelligence, on the other. It seems more natural to assume that the behavioural manifestations of intelligence are determined to a large extent by underlying biological features, than to assume an idealistic or mentalistic position according to which biological features play no part, or are merely secondary to mental events. As T. H. Huxley once said: "No psychosis without a neurosis", meaning that there are no psychic events without an underlying physiological event taking place.

A final word may be apposite regarding our use of the term: 'intelligence'. As Fig. 1 shows, there are clearly three ways in which the term has been used by psychologists. Galton, as already pointed out, used it to mean *biological intelligence*, and it is suggested that this is the most fundamental and scientifically meaningful use of the term. Spearman, Thurstone, Cattell and their successors have equated intelligence largely with *psychometric intelligence*, a definition which has been practically very useful, but scientifically has given rise to many difficulties and anomalies, as is well known. Last, we have the concept of *social intelligence*, as understood for instance in the contextual subtheory of intelligence put forward by Sternberg (1985). He defines 'Intelligence' as "mental activity directed towards *purposive adaptation to, and selection and shaping of, real-world environments relevant to one's life.*" (p.45) This definition, which in some ways resembles that of the man in the street, is far too inclusive for scientific purposes, and renders scientific study impossible. He admits that "the contextualist view presented here is certainly highly inclusive in the sense that it includes within the realm of intelligence characteristics that typically might be placed in the realms of personality or motivation". (p.55.) The purpose of science is analysis, and analysis cannot deal with compounds which bring together quite unrelated concepts such as (biological) intelligence, personality factors, motivational factors, etc. Sternberg appears to equate intelligence with non-instinctive behaviour, and that is far too wide a concept to be scientifically useful.

We would suggest, therefore, that recent attempts to go back to Galton's concept of biological intelligence, and the successes already attained in discovering physiological measures highly correlated with psychometric intelligence, hold out the promise that this revolution in our concepts will help us in arriving at a better understanding of the nature of intelligence. The paper by Weiss makes an important and interesting contribution to this discussion, and will repay the considerable effort required in trying to follow the argument.

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