Person. individ. Diff. Vol. 7, No. 5, pp. 603–607, 1986
Printed in Great Britain

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

INSPECTION TIME AND INTELLIGENCE: A HISTORICAL INTRODUCTION

H. J. EYSENCK
Department of Psychology, Institute of Psychiatry, De Crespigny Park, Denmark Hill, London SE5 8AF, England

As I have pointed out elsewhere (Eysenck, 1986) there are two major paradigms in psychology, relating to intelligence, which have persisted over the past century and which are opposed to each other on many points. One of these is due to Sir Francis Galton (1892, 1943), the other to Alfred Binet (1903, 1907). The three major differences are as follows.

(i) For Galton, intelligence as a general factor underlying all cognitive processes, and responsible for individual differences in problem-solving was a useful and meaningful concept which could explain many of the facts available to him. For Binet, intelligence was a statistical artifact, a mere average of what was really a number of separate abilities, like verbal, numerical or visuo-spatial ability, suggestibility, emotional reactivity etc. Strictly speaking, the term 'intelligence' had no meaning for Binet and should not have been used by him as he did not believe in a unitary concept of this kind.

(ii) Galton strongly believed in the genetic determination of intelligence; Binet, being an educationalist much more interested in modifiability and educability of his pupils, rejected any far reaching genetic interpretations.

(iii) Last but not least, Galton and Binet differed with respect to the measurement of intelligence. For Galton, intelligence was a biological given, and hence should be measured by means of simple biological tests, such as reaction times (RT). (In his time, of course, the EEG had not been invented yet, and hence he was unable to suggest direct measures of the electrical functioning of the brain.) Binet, on the other hand, advocated measures taken from everyday life, or from education, inevitably involving a good deal of cultural specificity and learning.

As is well-known, the battle over point (iii) was won by Binet, and all our present-day tests of intelligence are IQ tests of the Binet type. Galton's hypotheses were tested by such men as Clarke Wissler (1901) whose research has often been cited as disproving Galton by showing no correlation between intelligence and RT. It is an interesting reflection on the importance of the Zeitgeist that Galton's proposal was rejected on the basis of study so weak methodologically that no conclusions can in fact be drawn from it. The number of RT determinations used to establish an average for each person was dirisively small (3–5); no proper criterion of intelligence was used, other than the academic achievement of the students involved, which is known to have very little if any correlation with IQ in student samples; and the range of ability in his student sample was so small as to make the discovery of any kind of significant correlation unlikely. Experimentally much superior studies, like those of Peak and Boring (1926) gave rise to highly significant correlations, but were disregarded.

In recent years Eysenck (1953, 1967) and Furneaux (1952, 1961) revived interest in the Galtonian approach by putting forward the view that differences in IQ were largely dependent on mental speed but that, in addition, non-cognitive factors such as continuance (or persistence) and error-checking (or impulsivity) were also involved.

Three groups began to take up the Galton-type investigation of intelligence as a function of mental speed, using RT experiments in the process. The first group, which I have called the Erlangen group, consisted of people like Roth (1964), Lehrl (1980, 1983) Oswald (1971) and Frank

(1960, 1971) [see also Lehrl and Frank (1982), Oswald and Roth (1978) and Oswald and Seus (1975)]. Their work has been reviewed in detail by Eysenck (1986a).

The second group is made up of some Australian psychologists including Nettelbeck, Lally, Brebner, Brewer, Cheshire, Kirby, Vickers and others [see, for instance, Lally and Nettlebeck (1977), Nettlebeck and Brewer (1981), Nettelbeck, Cheshire and Lally (1979), Nettlebeck and Kirby (1983) and Nettlebeck and Lally (1976)].

Third, we have the Jensen group in Berkeley, including P. A. Vernon as the most important collaborator [see, for instance, Jensen (1982a, b), Jensen and Munro (1979), Jensen, Schafer and Crinella (1981) and Vernon (1983)].

Of special interest as far as inspection time (IT) measurement is concerned is a fourth group, located in Edinburgh, and made up of Brand and Deary (Brand, 1981; Brand and Deary, 1982; Deary, 1980). These various groups have used a great variety of RT measures in their efforts to find correlates of intelligence. These might be formed into four main groups.

(1) The first is *simple RT*, i.e. a paradigm in which a single signal is used as a stimulus, and a single movement is used as a reaction. In the most widely used paradigm the stimulus signal is a light which goes on, causing the *S* to left his finger off one button (a) and move his hand to depress another button (b) adjacent to the light. Two measures are taken, namely RT, which denotes the time from the appearance of the signal to the release of button a, and movement time (MT) which denotes the time elapsing between the release of button a, and the depression of button b. With suitable alterations, auditory, somato-sensory and other stimuli can of course be also used.

(2) At a more complex level we have *choice RT*, in which one of several lights might constitute the signal, and correspondingly one of several buttons has to be depressed. Usually there are two, four or eight choices involved, corresponding to one, two or three bits of information, i.e. $\log_2$ of the number of lights. Blank's law [Blank (1934) often referred to as Hick's law (1952)] tells us that RT increases linearly as bits of information in the stimulus array increase.

(3) As a third variant we have RT models which involve in small measure cognitive processes additional to simple perceptual recognition. These may involve perceptual comparison, as in the IT paradigm (Brand and Deary, 1982), short-term memory, as in the Sternberg (1966) memory scan paradigm, long-term memory, as in Posner 1969; Posner, Boies, Eichelman and Taylor, 1969, or the education of relations, as in the Eysenck (unpublished) 'odd-man-out' paradigm, in which out of an array of eight lights three are lit simultaneously, with two close together and the third some distance apart, the latter being the target.

(4) Finally, time taken over the execution of very simple tasks may be used as an indication of RT, typical tasks being card-sorting (Oswald, 1971), the speeded pronounciation of 20 numbers (Lehrl, Gallwitz and Blaha, 1980 or a numbered version of a trail-making test (Oswald and Roth, 1978). There are hundreds of studies in all four categories reporting correlations with intelligence, going back to the early years of this century. McFarland (1928) has reviewed early work on RTs, i.e. Categories 1 and 2, and Jensen (1982a, b) has brought this review up to date. Studies falling under Categories 3 and 4 also go back a long time; Burt (1909) has reported on tests like card-sorting (Category 4) and a precursor to the IT paradigm (Category 3) which he called a 'spot pattern'. For this last test he reported correlations between 0.7 and 0.8 with intelligence, and with a factor analysis found a factor loading of 0.83, as compared with 0.76 for card-sorting. Berger (1982) has given a historical review of the literature, and Eysenck has summarized the evidence and related it to the theory of intelligence and the psychophysiology of cognition (Eysenck, 1986a, b). This relationship between psychophysiology and intelligence (Eysenck and Barrett, 1985) is of particular importance for a theoretical evaluation of work on RT, and Eysenck (1983) has indeed suggested that these new studies constitute a revolution in the theory in measurement of intelligence. Further details about the way in which these studies fit into a general theory of intelligence will be found elsewhere (Eysenck, 1973, 1979, 1982).

How can we summarize the main results of all this work? There are many difficulties, as indicated for instance by the criticisms made by Carroll (1986) and Longstreth (1984). These relate to experimental factors which may be difficult to control, to sampling and the range of abilities involved, to the small number of *S*s and other features of many investigations reported in the literature. Correlations reported certainly vary very widely even for similar paradigms, ranging from the insignificant (−0.2) to the overpowering (−0.9). Much of this variability can be eliminated if we agree to exclude studies involving retardates, or otherwise disproportionately increase the range of talent; similarly, we must exclude (or correct for range) studies using only students, or in other ways restricting the range of talent. One should also be very chary of paying too much attention to studies involving small numbers (20 or below). When this is done, there is now apparent a fair degree of agreement. Simple RT and MT measures correlate negatively with intelligence, but the correlations are uniformly low (around -0.2), and of little interest. Choice RT paradigms give higher correlations, ranging from -0.3 to -0.5. This applies both to RT and MT measures, to the variability of RT measures, and to the slope of the Hick line, which is steeper for duller *S*s. Taking shrunken multiple correlations with more than one of these scores gives correlations which may go up to -0.6 or above. Similar correlations can be obtained from the measures in Category 3, and those in Category 4 may give correlations even higher than that.

In all this, it must be remembered that these are all simple correlations, and that the test–retest reliabilities of all measures of RT are fairly low, ranging from 0.6 to 0.7. This sets a limit to the size of correlations that may be obtained when *S*s are only tested once; when corrections are made for attenuation, all the observed correlations increase considerably of course. It is the corrected correlations which give a truer picture of the relationship between RT and intelligence, purged of avoidable errors of measurement. Unfortunately practically all studies have eschewed the labour of testing the *S*s on several days, so that we have to rely on formulae which may not represent the facts with entire accuracy. Nevertheless, it may be stated with some confidence that the 'true' correlation between RT and intelligence, when both RT and IQ are measured without chance errors, would be between -0.7 or -0.8. Admittedly this is a theoretical value, of no practical importance; i.e. we could not use this figure to advocate the use of RT measures for prediction and selection purposes. Nevertheless, from the theoretical point of view this augmented value is the correct one to look at, because it represents the inherent relationship between speed of mental processing, as measured by RT, and the central core of IQ tests, i.e. Spearman's *g*.

Even at this level, it may be said that the correlations are far from perfect, and share only some 50% of the variance. This is true, but it should noted that different IQ tests, such as the Binet and the Wechsler, only correlate to about the same extent. (These correlations would increase a little if corrected for attenuation, but the reliability of these IQ tests are so high that correction makes very little difference.) Thus it would be possible by making repeated measures of RT values in Category 2, and combining these in a single score, to obtain a measure of IQ equivalent to that obtained by Binet-type tests. Addition of measures from Categories 3 and 4 would undoubtedly increase the reliability and validity of such RT measures.

These results are incompatible with the kind of theory of intelligence advocated by the contributors to Sternberg's (1982) *Handbook of Human Intelligence*. These theories deal mainly with educational, social and other environmental influences, and with learned strategies; it is difficult to see how one could predict the obtained size of correlations between simple measures of RT, on the one hand, and IQ tests on the other. It is for this reason that we may say that the results here reviewed constitute a revolution, although in another sense they merely constitute a return to the Galton-type theory of intelligence.

Can we say, on the basis of all this work, that mental speed is really the fundamental variable in general intelligence? Basing himself on the work of Hendrickson and Hendrickson (1982a, b), Eysenck (1985) has suggested that there may be an even more fundamental aspect than speed to the observed relationships. The Hendricksons posited *error-free transmission of information* through the cortex as the fundamental variable in general intelligence, and supported this view with some very original work on the relationship between event-related potentials on the EEG and intelligence. Eysenck (1985), basing himself on well-known facts in psychophysiology, and Sokolov's (1963) notion of a 'comparator', suggested that slow speed might be a function of high error rate, and that hence it is the error rate which is the fundamental variable rather than speed. It is well-known that nerve impulses never travel singly, but along multiple routes. Sokolov's comparator would then compare the incoming messages, and decide on action when there was a sufficiency of agreement about the nature of the message. Let us assume for the sake of the argument that 10 messages, all agreeing with each other, would be sufficient to initiate action. This would easily be achieved in an individual whose nervous system was transmitting error-free messages, but in someone prone to error it might take 20, 30 or more messages before the comparator was satisfied about the nature of the message, thus delaying reaction and leading to long RTs. Clearly the issue is not decided at the moment, and much experimental work will be needed to clarify the true relationships. However that may be, the work already published demonstrates quite clearly that the results are incompatible with traditional Binet-type theories of intelligence.

In our theoretical discussions, it will be more necessary than ever to distinguish between intelligence A (Hebb, 1949), i.e. biological intelligence, intelligence B, i.e. social and adaptive intelligence, and intelligence C, i.e. IQ measurement. Intelligence B is a compound of intelligence A, personality, education, socio-economic status and many other factors, and hence cannot be regarded as a scientifically meaningful unit; it requires analysis into its components. Intelligence A is the most important of these components, and recent work on RT has significantly added to understanding of its nature (Eysenck, 1985, 1986).

REFERENCES

Berger M. (1982) The "scientific approach" to intelligence! An overview of its history with special reference to mental speed. In *A Model of Intelligence* (Edited by Eysenck H. J.). Springer, New York.

Binet A. (1903) *L'Etude Experimentale de l'Intelligence*. Schleicher Frères, Paris.

Binet A. (1907) *La Psychologie du Raisonnement*. Alcan, Paris.

Blank G. (1934) Brauchbarkeit optischer Reaktions Messungen. *Psychotechnology* **11**, 140–150.

Brand C. R. (1981) General intelligence and mental speed. Their relationship and development. In *Intelligence and Learning* (Edited by Friedman M., Das J. P. and O'Connor N.). Plenum Press, New York.

Brand C. R. and Deary I. J. (1982) Intelligence and "inspection time". In *A Model of Intelligence* (Edited by Eysenck H. J.). Springer, New York.

Burt C. (1909) Experimental tests of general intelligence. *Br. J. Psychol.* **3**, 94–177.

Carroll J. B. (1986) Jensen's mental chronometry: some comments and questions. In *Arthur Jensen: Consensus and Controversy* (Edited by Modgil S. and Modgil C.). Palmer Press, Lewes, Sussex.

Deary I. J. (1980) How general is the mental speed factor in "general" intelligence? An attempt to extend inspection time to the auditory modality. Unpublished B.Sc. Honours Thesis, Univ. of Edinburgh, Edinburgh.

Eysenck H. J. (1953) *Uses and Abuses of Psychology*. Pelican, London.

Eysenck H. J. (1967) Intelligence assessment: a theoretical and experimental approach. *Br. J. educ. Psychol.* **37**, 81–98.

Eysenck H. J. (1973) *The Measurement of Intelligence*. MTP Press, Lancaster, Lancs.

Eysenck H. J. (1979) *The Structure and Measurement of Intelligence*. Springer, New York.

Eysenck H. J. (Ed.) (1982) *A Model for Intelligence*. Springer, New York.

Eysenck H. J. (1983) Revolution dans la théorie et la mésure de l'intelligence. *Revue can. Psycho-Educ.* **12**, 3–17.

Eysenck H. J. (1986a) The theory of intelligence and the psychophysiology of cognition. In *Advances in the Psychology of Human Intelligence*, Vol. 3 (Edited by Sternberg R. J.). Erlbaum, Hillsdale, N.J.

Eysenck H. J. (1986b) Speed of information processing, reaction time, and the theory of intelligence. In *Speed of Information Processing and Intelligence* (Edited by Vernon P. A.). Ablex, New York.

Eysenck H. J. and Barrett P. (1985) Psychophysiology and the measurement of intelligence. In *Methodological and Statistical Advances in the Study of Individual Differences* (Edited by Reynolds C. R. and Wilson V.). Plenum Press, New York.

Frank H. (1960) Uber grundliegende Satze der Informationspsychologie. *GrundlStud. Kybernetik GeistWiss.* **1**, 25–32.

Frank H. (1971) *Kybernetische Grundlagen der Padagogik*. Kohlhammer, Stuttgart.

Furneaux D. (1952) Some speed, error, and difficulty relationships within a problem solving situation. *Nature* **170**, 37.

Furneaux D. (1961) Intellectual abilities and problem solving behaviour. In *Handbook of Abnormal Psychology* (Edited by Eysenck H. J.). Basic Book, New York.

Galton F. (1892) *Heredity Genius: an Enquiry into its Laws and Consequences*. Macmillan, London.

Galton F. (1943) *Inquiries into Human Faculty*. Dent, London.

Hebb D. (1949) *The Organization of Behaviour*. Wiley, New York.

Hendrickson A. E. and Hendrickson D. E. (1982a) The biological basis of intelligence. Part 1: theory. In *A Model for Intelligence* (Edited by Eysenck H. J.). Springer, New York.

Hendrickson A. E. and Hendrickson D. E. (1982b) The biological basis of intelligence. Part 2: measurement. In *A Model for Intelligence* (Edited by Eysenck H. J.). Springer, New York.

Hick W. (1952) On the rate of gain of information. *Q. Jl exp. Psychol.* **4**, 11–26.

Jensen A. R. (1982a) Reaction time and psychometric *g*. In *A Model for Intelligence* (Edited by Eysenck H. J.). Springer, New York.

Jensen A. R. (1982b) The chronometry of intelligence. In *Advances in the Psychology of Human Intelligence*, Vol. 1 (Edited by Sternberg R. J.). Erlbaum, London.

Jensen A. R. and Munro E. (1979) Reaction time, measurement time, and intelligence. *Intelligence* **3**, 121–126.

Jensen A. R., Schafer E. W. P. and Crinella F. M. (1981) Reaction time, evoked brain potentials, and psychometric *g* in the severely retarded. *Intelligence* **5**, 179–197.

Lally M. and Nettelbeck T. (1977) Intelligence, reaction time and inspection time. *Am. J. ment. Defic.* **82**, 273–281.

Lehrl S. (1980) Subjectives zeitquant als missing link zwischen intelligenz-psychologie und neuropsychologie. *GrundlStud. Kybernetik GeistWiss.* **21**, 107–116.

Lehrl S. (1983) Intelligenz, informationspsychologische Grundlagen. *Enzyklopadie der Naturwissenschaft und Technik*. Moderne Industrie, Landsber.

Lehrl S. and Frank H. G. (1982) Zur humangenetischen Erklärung der Kurzspeicher-kapazitat als der zentrale individuelle Determinante von Spearman's Generalfaktor der Intelligenz. *GrundlStud. Kybernetik GeistWiss.* **23**, 173–186.

Lehrl S., Gallwitz A. and Blaha L. (1980) *Kurztest fur Allgemeine Intelligenz*. VLESS, Vaterstetten.

Longstreth L. E. (1984) Jensen's reaction-time investigations of intelligence: a critique. *Intelligence* **8**, 139–160.

McFarland R. A. (1928) The role of speed in mental ability. *Psychol. Bull.* **25**, 595–612.

Nettelbeck T. and Brewer N. (1981) Studies of mild mental retardation and timed performance. In *International Review of Research in Mental Retardation*, Vol. 10 (Edited by Ellis R.). Academic Press, New York.

Nettelbeck T. and Kirby N. H. (1983) Measures of timed performance and intelligence. *Intelligence* **7**, 39–52.

Nettelbeck T. and Lally M. (1976) Inspection time and measured intelligence. *Br. J. Psychol.* **67**, 17–22.

Nettelbeck T., Cheshire F. and Lally M. (1979) Intelligence, work performance, and inspection time. *Ergonomics* **22**, 291–297.

Oswald D. W. (1971) Uber zusammenhang zwischen informationsverarbeitung, alter und intelligenzstruktur beim kartensortieren. *Psychol. Rsch.* **27**, 197–202.

Oswald W. D. and Roth E. (1978) *Der Zahlen—Verbindungstest (ZVT)*. Hogrefe, Gottingen.

Oswald W. D. and Seus R. (1975) Zusammenhange zwischen intelligenz, informationsverarbeitungsgeschwindigkeit und evozierten potentialen. In *Bericht uber den 29 Kongress der Deutschen Gesellschaft für Psychologie* (Edited by Tacks H.). Hogrefe, Gottingen.

Peak H. and Boring E. G. (1926) The factor of speed in intelligence. *J. exp. Psychol.* **9**, 71–94.

Posner M. I. (1969) Abstraction in the process of recognition. In *The Psychology of Learning and Motivation*, Vol. 3 (Edited by Bower G. H. and Spencer J. T.). Academic Press, New York.

Posner M. I., Boies S., Eichelman W. and Taylor R. (1969) Retention of visual and name codes of single letter. *J. exp. Psychol.* **81**, 10–15.

Roth E. (1964) Die Geschwindigkeit der Verarbeitung von Information und ihr Zusammenhang mit Intelligenz. *Z. angew. exp. Psychol.* **11**, 616–622.

Sokolov E. N. (1963) *Perception and the Conditioned Reflex*. Pergamon Press, Oxford.

Sternberg R. J. (Ed.) (1982) *Handbook of Human Intelligence*. Cambridge Univ. Press, Cambs.

Sternberg S. (1966) High speed scanning in human memory. *Science* **153**, 652–654.

Vernon P. A. (1983) Speed of information processing and general intelligence. *Intelligence* **7**, 53–70.

Wissler C. (1901) The correlation of mental and physical tests. *Psychol. Monogr.* **16**, 62.