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Intelligence: A Brief History

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Abstract

The issue discussed in this paper is the loss of meaning for the expression 'intelligence'. The term taken from everyday language has been applied to various psychological definitions, theories or psychometric tests across a period of time which has contributed to the corrosion in meaning of the original term. Attempts by science to isolate and identify the qualities or attributes of intelligence have altered if not entirely destroyed the meaning of the expression. A brief review of the history of the modern investigation into intelligence is thereby presented.

Spearman as early as 1927 wrote that "in truth, 'intelligence' has become a mere vocal sound, a word with so many meanings that finally it has none' (p. 14). Sixty years later, Jensen (1987) repeated the same sentiment: "For scientific purposes, then, 'intelligence' can best be thrown out altogether" (p. 196). From the 14 experts who contributed their views on the nature of intelligence in an issue of the *Journal of Educational Psychology* in 1921, to a symposium of 25 experts (Sternberg & Detterman, 1986), there seems to be almost as many conceptualisations and definitions of intelligence as there are experts to write them. All of this indicates that respected writers in psychology find it hard to agree on either a definition of intelligence or to what extent certain factors affect it. This paper explores the issue and problems of measurement bound up in the confusion around defining the concept of intelligence. Discussion and suggestions as to how language usage around the concept might be more articulate is offered.

Introduction

Respected writers in psychology find it hard to agree on either a definition of intelligence or to what extent certain factors effect it. Spearman as early as 1927 wrote that "in truth, 'intelligence' has become a mere vocal sound, a word with so many meanings that finally it has none' (p. 14). Sixty years later, Jensen (1987) repeated the same sentiment: "For scientific purposes, then, 'intelligence' can best be thrown out altogether" (p. 196). From the 14 experts who contributed their views on the nature of intelligence in an issue of the *Journal of Educational Psychology* in 1921, to a symposium of 25 experts (Sternberg & Detterman, 1986), there seems to be almost as many conceptualisations and definitions of intelligence as there are experts to write them. Sternberg himself (1999) makes an attempt at definition by stating, "intelligence may be defined as the ability to adapt to, shape, and select environments", but this simple statement leaves the issue of measurement in dispute.

Nowhere are the differences in opinion on intelligence more graphically illustrated than in Eysenck and Kamin (1981). Each states his position regarding their ideas relating to intelligence and a variety of related issues individually and then replies to, and critically comments upon, the other's work. The items addressed include the concept of intelligence itself, IQ tests, the relevance of biological or environmental factors and cultural issues. In his "Rejoinder to Eysenck" Kamin is adversarial in his style almost to the extent of personal insult. [Kamin fails, however, to offer convincing opposing arguments.] Such differences of opinion are illustrative of the strength of feeling such issues are capable of arousing. Other writers in the field show a similar lack of agreement on the subject, including that of definition.

Horn, (Ackerman, et al., 1988) states that intelligence is a synonym for cognitive abilities. Fontana (1988) echoes and amplifies this idea by stating that "... we define intelligence as the ability to see relationships and to use this ability to solve problems." Both the ideas of Horn and Fontana tie together in the notion that whatever intelligence is, it is delineated by ability. Bigge (1976) takes this idea further. He again uses the idea of ability but is specific about those that define intelligence. For Bigge, intelligence is an individual's ability to respond to a given situation by anticipating the possible consequences of his actions.

While there is a clear relationship between the definitions offered by Horn, Fontana, and Bigge, the definition of the latter is more informative in that it provides examples of what represents intelligent behaviour. Bigge describes a man trying to lift a log from among a pile of other logs. The man straddles the log and attempts to move it. Bigge argues that if in doing so he dislodges other logs and they cause him to be lifted in the air by a fulcrum effect and left dangling, then his lack of foresight, judgement and awareness show him to be unintelligent in those actions. Successful extraction of the log would, however, be representative of intelligent behaviour.

Miles (1957) advocates a similar approach to seeking an understanding of intelligence. Rather than defining intelligence in some manner, he suggests that the term 'intelligence' be replaced by 'intelligent behaviour.' His reasons for doing this are given as a desire to eliminate popular misconceptions of what intelligence is [i. e. something we possess as a finite quantity and probably located in the head.] The fact that intelligence has grown in popular conception to mean something akin to a personal quality or a personality characteristic also concerned Eysenck (1978; Eysenck & Kamin, 1981). In both works he speaks of the idea of intelligence as held by "the man in the street. " These ideas, he states, are somewhat different from those held by psychologists. However, it could be argued that in using only behaviour as a guide to intelligence, Bigge and Miles are falling into a similar trap as Eysenck's 'man in the street.' Additonally with situational definitions there is the problem of consistency of evaluation. If subjects under observation fail in one context but suceed in another, how are they to be described; as intelligent in one case but not in another?

By concentrating on behaviour, other important issues are ignored. Why did not the unfortunate log mover anticipate the movement of the logs? It may be the case that he had no prior experience in similar situations. Bigge may have carried off his argument that the man was "unintelligent" had he stated that the man had worked in this field for some time. To repeat errors that he could have foreseen due to his experience would have been evidence that he had not assimilated prior experience, or had not recalled that past experience, or related that experience to his current situation. The argument here is behaviour alone is not sufficient evidence of intelligence, and to base an evaluation of an individual on that alone would be flawed. Furthermore this argument suggests aspects of intelligence which are assumed to support the quality: 1) learning from prior experience, 2) good or excellent memory, and 3) abstract conceptualisation of experience which serves to inform new or related experience through appropriate association.

Howe (1990) expresses a similar argument in a paper that questioned the very existence of intelligence. He warned against using the term "intelligence" as both a descriptor and a definer. To do so he argues is "linguistic sleight of hand" and constitutes a fallacy causing the ideas of intelligence to become a circular argument. This is qualified in the example of a statement such as "My factory produces more goods because it is more productive. " This statement is not an explanation, Howe asserts, it simply restates the initial clause. This is further evidence against the value of Bigge or Miles drawing conclusions about intelligence from behaviour. To state that someone does X because he or she is intelligent (or not) is similarly circular to the statement above on factory production.

This may appear to be something of a semantic argument, but it is illustrative of the problems faced in reaching a definition of intelligence. It must be decided whether intelligence is what causes *performance* in a certain manner, or if it is a quantifiable quality for which norms can be established - one which can be used to evaluate performance - as with psychometric tests. The basic problem with the behaviourist definition above is that Bigge and Miles are merely applying the latter option. The problem with any definition of intelligence relying on outcomes such as behaviour or performance is the danger of confusing intelligence with other constructs which are more clearly defined, such as attainment. Attainment is defined as a measure of what an individual is capable of due to his experience, training, or learning.

Psychometric Issues and Problems

A major problem in the psychometric field of intelligence is deciding what qualities the term intelligence relates to and whether it is a causal factor or a quantifiable outcome. The difficulty in quantifying the constructs involved is in clearly specifying that which is to be measured. On the other hand, if intelligence is the causal element behind behaviour, it implies that it is some kind of capacity, or even 'mental power' (Gillham, 1975).

Additionally, Snow and Guilford (1982 - in Wagner and Sternberg, 1984) suggest intelligence can be divided into individual 'constructs' (Snow) or specific factors (Guilford). Guilford postulates such factors may total as many as 150. In Eysenck (1983), Guilford is quoted as having identified only 120 'factors' with evidence to directly support 80 of them. Eysenck calls these claims 'absurd' and states that most 'factors' are merely facets of other more basic types of intelligence (A, B, C described below) and are all linked in some way. He feels the claims are ridiculous because he adheres to Spearman's 'g' theory.

Wechsler (as cited in Gillham, 1975) compared what he called general intelligence to electricity, a kind of energy. Gillham asserts that this is a suitable analogy as we do not know what electricity is either! (This is, of course, untrue.) Spearman (1927, in Wagner and Sternberg, 1984), also spoke of general intelligence. Spearman said that intelligence came in two forms, *general* intelligence and *specific* intelligence. All performance or activity contains a factor of general intelligence and a factor of specific intelligence. He called the general intelligence factor (*g*) and the specific factor (*s*). What specific factors are at work at any one time depends upon what task is being performed.

It will prove informative and useful to take the time to expand Wechsler's analogy, and model of intelligence in the electrical world. Any system, electrical or mechanical, may be modelled against three basic factors. These are called the *prime mover*, an *effect*, and the *opposition* to that effect. In electricity, the prime mover is voltage, often called electromotive force or electrical potential. The effect is the resultant current in the form of a movement of free charge carriers (electrons). The opposition to that effect is resistance. How then may Wechsler's analogy be expanded? One aspect of cognitive functioning could be equated to voltage suggesting a motive force to intelligence which might take the name Cognito Motive Force (CMF). In this case the second part of the analogy relates to the goodness of the conducting material expressed in electrical terms as resistance. Currently, measurement of cognitive capability is centred on the outcomes of the process which in the analogy would be equivalent to measuring electrical current. However, the amount of current has a relationship not only to the motive force, but also to the ability or nature of the conducting material transmitting the current. Under consideration here are the physiological differences in synaptic connections or some other psycho-physiological aspect of cognition.

The notion of intelligence being related to physiological qualities is not new. Hebb (1949) introduced a model of intelligence that has proved useful and has been accepted by other psychologists (Vernon, 1972; Eysenck, 1983). In his model Hebb distinguished between what he called intelligence A and intelligence B. Intelligence A is representative of innate abilities. It is derived from a biological basis. Intelligence A with its biological/physiological basis must, by implication, be effected by genetic factors and be responsible, at least in part, for the individual differences in intelligence between people (Eysenck, 1983).

Intelligence B on the other hand, although inevitably built upon the foundations of intelligence A, is developed through an individual's interaction with his/her environment. The major problem here is evaluating an individual's overall intelligence if this arrangement of components of intelligence is accepted. How much of the differences between individuals is due to the presence, or lack of, innate ability? Or, how much of individual differences is due to the richness or poverty of that individual's life experience? This problem is indicative of one of the most fundamental arguments within psychological perspectives on intelligence, and broadly defines the diametric differences mentioned between Eysenck and Kamin (1981) in the introduction. It is also the basis for criticism of Bigge's evaluation of his log-lifting friend.

The writings of Eysenck are broadly representative of one school of thought suggesting that intelligence is ultimately biologically or genetically based, and that genetic factors tend to be of greater significance than environmental factors. Kamin on the other hand is representative of the opposing school of thought which suggests intelligence is influenced to a much greater degree by environment than genetic or physiological make-up. This is of course a simplification of the arguments on both sides, but provides a summary to illustrate the point.

The direct measurability of either intelligence A or B remains, even to date, a problem. Relatively little is truly known about the relationship between cognitive functioning and the brain, although much of the more scientific work in psychology is now taking place in this area. The work of Cattell, Hendrickson & Hendrickson, Berger, Jensen, and Sternberg (Eysenck, 1982) investigates the possibilities of identifying physiological/neurological aspects that directly correlate with IQ. Nonetheless, it is not possible to place a meter across the brain and measure directly the 'goodness' of the quantity between the ears. It follows then, that if intelligence A can not be quantified then measuring its influence is even less likely.

Vernon (1960) also addressed this problem. He introduced intelligence C to describe the sampling of intelligence B by standardised (IQ) tests. We must note that within this concept we are not *measuring* intelligence B, we are *sampling* it. This distinction is both necessary and informative. One concern about intelligence testing (particularly for the 'man in the street') is that IQ tests purport to measure innate (and therefore finite and unalterable) abilities. Within the concept of intelligence C it is possible to encompass both schools of thought mentioned above and produce meaningful quantification of an aspect of intelligence. What is still unclear is the extent to which intelligence A or B is the primary factor effecting intelligence C. Indeed this is a return to the debate outlined above. The link between A and C is clear all the same. Intelligence B has a function of A in its make-up. Intelligence C is a quantity obtained by sampling B. This theory is further legitimised if physiological processing models such as those proposed by the Hendricksons, Jensen and Sternberg (all in Eysenck, 1982) are considered.

It is worth noting the above analogy of intelligence to electricity by Wechsler proved somewhat inspired. The work of Hebb in particular (1949, 1972) integrated the separate disciplines of neurology and psychology. He postulated models of brain function and the significance of synaptic/neuron action in learning. These models have been accepted in the artificial intelligence (AI) world as the basis for modelling silicon based (MOS) learning devices such as neural networks. While we do not have a so called 'Ohm's Law of Intelligence', there is an expression referred to as the 'Hebbian Learning Law' which is being used to build artificial synaptic circuits (Card & Moore, 1993)!

The expansion of Wechsler's analogy illustrates 1) the complexity of constructing a definition of intelligence and 2) the differences between some current definitions. Consider Horn's (in Ackerman et al, 1989) statement that intelligence is synonymous with cognitive functioning. Our model was constructed from Wechsler's analogy that intelligence was the force behind cognitive functioning. The two definitions are somewhat at variance with each other. The approaches of Guilford and Spearman seem to suggest that intelligence may be defined by the factors effecting functioning. Indeed, Spearman's (*g*) could relate to CMF, and there could be some of (*s*) in intelligence B. This is simply further evidence and elucidation of the situation outlined in the first section of this paper which says psychologists find it difficult to agree on a definition.

Eysenck states,

> Questions of a definition usually worry the scientist much less than the interested layman; the former realises as the latter does not that a proper definition comes at the end, not at the beginning of the quest.
>
> The man in the street, and often the unwary psychologist too, thinks of intelligence as something really existing 'out there'; something the psychologist may or may not recognise successfully or measure with more or less success. . . . Such reification is utterly mistaken; there is nothing 'out there' which could be called intelligence, just as there is nothing out there that could be called gravitation (1978).

The point is that intelligence is a concept often used in a descriptive fashion, just as concepts to model the world around us are used. As long as those concepts continue to provide accurate predictions or withstand rigorous empirical investigation there is no reason to dispense with them. As Howe (1990) points out, the use of the concept of intelligence is fine as long as no one believes that in describing one's performance, reasons have been provided for it.

Binet, considered the grandfather of intelligence tests, adopted a relatively broad operational definition of intelligence as shown in the wide variety of tasks which are used to assess intelligence on some of the first tests developed (Binet & Simon, 1905, 1911; Gould, 1981). Wechsler (1939) clearly influenced by Binet's approach, defined intelligence as "the aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment" (ibid., p. 3). In the same text he also stated "One of the greatest contributions of Binet was his intuitive assumption that, in the selection of tests, it made little difference what sort of tasks you used, provided that in some way it was a measure of the child's general intelligence" (ibid., p. 6). Initially, Wechsler's belief that intelligence is more than the sum of intellectual abilities led him to include some sub-tests that are not good measures of (*g*) in his widely used intelligence batteries. Wechsler's method of obtaining IQ's from a diverse collection of tasks, some of which have low g-loadings, has been used in many individually administered mental ability tests and has become almost the accepted way of estimating intelligence.

The British Abilities Scales which is presently used in England as the accepted educational standard for measurement of intelligence broadly defines intelligence based on Spearman's (*g*) as being, "the general ability of an individual to perform complex mental processing that involves conceptualisation and the transformation of information" (Elliott, 1997). But Elliott insists that only sub-tests are used in the battery that have high statistical g loadings on the central composite score (called General Conceptual Ability, the GCA). So contemporary thought operationally defines intelligence as the composite score (now called psychometric g) produced from sub-tests and scales which evaluate skill in various areas assumed to relate to intelligence because of their mathematical correlation to clusters of factors produced statistically on these sub-tests. Elliott (1997) defines GCA as "the first component in a principal-component analysis, the first factor in a common-factor analysis, or the most general factor in a hierarchical-factor analysis" (ibid., p. 16). This is a definition which he says came from Jensen (1979, 1987), and is to be used in place of the more general concept of "'intelligence' which may convey a variety of meanings" (ibid., p. 16). But historically, in fact, the most influential individual in developing this statistical approach to defining intelligence with testing, factoring and correlation of components of sub-tests has been Spearman.

The Measurement of Intelligence

The statement "intelligence is what intelligence tests measure" (Boring, 1950) has been repeated on several occasions. (Gleitman, 1986; Eysenck, 1986). This is a fairly tongue in cheek observation, but it is a statement that Eysenck contends is not so circular as it may seem. It is simply an operational definition of intelligence, similar to the statement that heat is what thermometers measure. The complication in the case of intelligence is that there are several related terms used in related contexts that overlap (as indicated earlier) which require clarification of meaning. It would also be possible to argue that each of the items discussed below are what intelligence (IQ) tests measure to varying degrees. The reason why there is an almost compulsive need to quantify intelligence in some way is beyond the scope of this paper. What is briefly covered next are some of the issues and problems relevant to intelligence measurement.

First, the term attainment (often the term 'achievement' is used in an identical manner) may appear confusingly similar to what is measured in an intelligence test. According to Gleitman (1986), attainment is a measure of what an individual can do at the time of testing. On the other hand, it is a popular belief that aptitude is what such tests measure. Gleitman also defines aptitude; "tests of aptitude... predict what an individual may be able to do later given the appropriate training and motivation" (ibid., p. 39). Eysenck (1978, 1986) defines another property often attributed to IQ tests, i. e., measurement of what the layman would identify as general cleverness, a problem solving ability that can be applied to all situations or disciplines. (This kind of general cognitive skill is exactly what Cicero was referring to in his term 'intelligentsia' and thus giving birth to the idea of what is now called intelligence.) This is subtly different from aptitude as aptitude is regarded as being specific to a skill area as in engineering aptitude, or music aptitude.

The question arising from these points is still, what do IQ tests measure? To suppose they are measuring 'basal ability' in general would go against the point previously made that intelligence A is not directly accessible since physiological/biological factors seem to be mostly responsible for this attribute. To suggest that IQ tests are purely a measure of future success is also equally flawed. Indeed, much of the opprobrium related to IQ testing has risen from the misconception that such tests were supposed to give such information, and have been found to be inappropriate. An often cited example of this, and probably one of the primary causes of 'the man in the street's' reservations about IQ testing, was the "11+" examination used in England. The 11+ examination was a procedure designed to predict future performance (*attainment*) on the basis of current performance (*aptitude*); although, the relationship between these attributes is tenuous at best, in spite of the link at a basal level with intelligence A.

Ultimately the 11+ was not an intelligence test at all. It was a test of English ability, mathematics, and verbal reasoning. In his explanation of the failure of the 11+ examination to correlate to a higher degree with future academic success, Eysenck (Eysenck & Kamin, 1981) used Cattell's term 'crystallised ability' (CA, which was defined as knowledge gained through experience and exposure to the educational environment, and internalised into meaningful schemata). Again, this term by definition is synonymous with attainment. Fluid ability (FA) is that innate 'cleverness' as expressed above, similar to Spearman's (*g*). Eysenck asserted that there was no test of fluid ability at all in the 11+! The distinction between CA and FA should be emphasised here. This model of intelligence which takes into account life experience in fluid intelligence is a measure of cognitive power that can be brought to bare on a set of problems outside previous experience. The implications of this are not often explicitly expressed but are, in fact, that fluid ability probably has a strong basis in genetic/physiological factors and is possibly a fixed quantity from birth - a frightening and probably unpopular view to take.

Certainly many of the tests used in industry and education today are not truly intelligence tests as they only measure aptitude or attainment. They seem to gain the term 'intelligence test' by malapropism. There is however a recent movement in the business community to employ psychometric testing of a more appropriate nature in a rapidly increasing use of occupational assessment in evaluating employees for selection for everything from original employment, in-house training programs to promotion (Miller, 1996). The general view now is that the predictive validity of ability tests (or GMA tests) is stronger than that of intelligence testing in terms of future performance, and consequently a more reliable approach to the kind of information sought (Schmidt & Hunter, 1998).

In conclusion, it seems it must be realised only limited information relating to intelligence can be gained with the use of IQ tests. The concept of intelligence C seems most useful in this respect. The results of such tests are in some manner indicative of the innate, fluid ability of intelligence A. They are also measures of intelligence B, where attainment (or achievement) becomes an appropriately related function and environmental issues become of much greater importance than innate ability. This will be qualified as factors effecting intelligence are discussed shortly; however, the use of such IQ results as predictors of future achievement, particularly academic development, show a very uneven relationship (Eysenck & Kamin, 1981). It is clear that all tests need to be designed with care and their results judged with the limitations of testing firmly in mind, but if this is done, such testing can in a limited sense be a useful tool.

The standardisation of such tests gives us a yardstick against which the progress of individuals in relationship to a theoretical norm can be measured. Psychometric tests are most useful as diagnostic tools to assist when things are not going as expected, rather than as a divisive means of judging an individual's quality. After all, Binet, the man who pioneered such testing intended his work to be used in this manner (Vernon, 1960). Wechsler's definition, and Binet's approach to putting very diverse tasks in the measure of intelligence, were the foundation of present day tests. This approach has been somewhat modified with the work of Spearman. Publication of his two major texts in 1923 and 1927 has had a major and continuing influence on the field. Central to his concept of the nature of intelligence are two aspects of performance - the eduction of relations and the eduction of correlates. These are complex mental functions and are typified by tests of analogies, similarities and matrices. Such tests are recognised to be good measures of both fluid intelligence and overall (*g*). Spearman (1927) also held to a doctrine he called the 'indifference of the indicator' that he applied to the development of tests of the general factor (*g*). This doctrine held that it made no difference what cognitive tests are included in a battery provided all the tests are good measures of (*g*). It is this last clause that distinguishes Spearman, Wechsler, and the more recent British Abilities Scales which takes into consideration as its main organising principle the loadings of various tasks on the central composite score - General Conceptual Ability - which is the equivalent to Spearman's general factor (*g*), also commonly called psychometric *g* (Elliott, 1997).

Factors Effecting Intelligence & Artificial Intelligence

One of the greatest arguments in the field of intelligence has been the question of which factor - nature or nurture - has the greatest influence on intelligence. Since the work of Galton (Gleitman, 1986; Eysenck, 1982, 1983; Sternberg, 1982) the heritability of intelligence has been strongly debated.

The issues are clear in this area. If intelligence is hereditary, then its basis must be biological/genetic. In a modern metaphor, intelligence is 'hardware' related. The implication of this needs careful evaluation. It seems to be that those such as Kamin (Eysenck & Kamin, 1981) who most strongly contest the evidence, fear the proof of heritability. Their fear seems to be based on the notion that if intelligence is proven to be predominantly genetic, individuals may be judged to be of poor base quality material, and written off early in their academic careers. In their defence, such fears are not completely groundless (Gould, 1981). After all in Britain, the 11+ system was perceived by many as operating in just such a manner. The Americans had Goddard (1913, 1917), Terman (1916), and Yerkes (1921) who all helped prepare the way for passage of the Immigration Restriction Act of 1924 with its restrictions on immigration to the U. S. based on "the blight of poor genes" and its resultant lower IQ levels.

Nevertheless, denying the biological basis of intelligence is not the way to combat such attitudes. If the proof of genetic/biological factors being as much as 80% responsible is to be accepted (Jensen, 1979; Sternberg, 1982; Eysenck, 1983), careful counsel is needed for those who may misinterpret such data as meaning certain individuals inherit academic hopelessness.

On the other hand, quoted in Sternberg (1982), Kamin (in 1974) asserts that none of intelligence is inherited. There is no data sufficient to reject that the differences [in people] are determined by their palpably differing life experience. Such views are rejected by Sternberg, with supporting quotes from other critics and commentators. The fact that any thinking psychologist can totally dismiss heredity as a factor in intelligence seems incredible. To deny such factors seems to fly in the face of Darwinian theories of evolution. There is also a large amount of evidence supporting heritability. It is right to continue to question such matters as the degree of heritability, but to deny it altogether is nonsense. See Vernon (1960), Hebb (1972), Sternberg (1982, 1984), and Eysenck (1983) for studies and reviews of the theory of heritability and a general concurrence on the matter.

None of the studies mentioned deny the importance of a 'quality environment' to develop the potential of inherited abilities, what has been previously called intelligence A. As Hebb (1972) points out, the IQ of a child that has inherited 'a good brain' but has suffered in a poor environment may be no better than a child who has less innate capacity and the advantage of a rich environment. These contradictory issues are of the sort that Kamin (Eysenck & Kamin, 1981) must be referring to in his arguments against heredity of intelligence. This is not so confusing if it is realised that Hebb was talking about the IQ measurement of individuals. It has already been established that IQ is a measure of intelligence C, which is in turn a sampling of intelligence B, that is in turn only built upon intelligence A. Terminology is important as much of the argument and confusion in the area is semantic.

Until now, it has been maintained that intelligence A is not directly accessible to measurement. That may no longer be strictly true. Several psychologists have been experimenting with electroencephalogram (EEG) machines and the correlation of their EEG research test results compare favourably to IQ style tests designed to measure fluid ability. Succard and Horn (in a paper reproduced in Eysenck, 1978) tested 108 individuals with an extensive IQ style test designed to measure fluid abilities. They followed these tests up with EEG tests. They were looking at what we call Average Evoked Potentials (AEPs) with the EEG. An AEP is a measurable electrical response in the brain to a given sudden stimulus. That stimulus can be either auditory or visual. In general, an AEP response looks almost sinusoidal in nature. The response builds quickly over the first two cycles and then decays. The amplitude and latency of the electrical brain response in the study as recorded by the EEG were then statistically compared to the IQ scores. As expected, the correlations were 'in the predicted direction;' the larger amplitude AEPs correlated positively with IQ score, and AEP duration correlated negatively with IQ scores. In other words, 'bright' subjects had higher AEP amplitudes and shorter latencies. The significance of such results is obvious. Cattell (reported in Eysenck, 1978) suggested that such responses are connected to the brain's reference and analytical mechanisms and the establishment of memory engrams. As such, AEPs may be a measure of how well a subject remembers, processes, and/or evaluates information.

In a comprehensive review of Response Time (RT) research, Jensen and Sternberg (1982) concluded that RT also correlated with IQ in certain instances. The most meaningful results are from tests that give a problem that requires a simple response to a simple stimulus. More complicated studies confound the results with additional variables, but it is clear that chemical reactions in the body also influence the results. This all means that not only is cognitive functioning related to genetics but also internal chemical activity! The work of the Hendricksons provides a host of information on the central nervous system reactions in information processing. The physiological/electrical processes are complex, but in essence, Hendrickson and Hendrickson (1982) outline the processes of signal transmission, information processing by neuron centers and the architecture of the synapse systems. This seems an area from which great contributions can be made in the direction of understanding intelligence physiologically and empirically.

The Scientific Basis of Intelligence

Presently, the most challenging questions in the area of intelligence are in the area of individual differences. Why are some people capable of extraordinary feats of cognitive-based skill at one end of the spectrum and others challenged by the functions of everyday living? If the evidence for heritability referred to above is accepted, the answer must lay in the difference between the equipment that individuals receive at birth. Still there are other variables as explained above such as environmental and personality matters that cloud the issue. Real solutions and the key to understanding the basis of intelligence (intelligence A in particular) rests with detailed knowledge of brain structure and cognitive functions. The brain after all, must be the seat of intelligence.

The most basic description of the brain is that of a tube with distended shapes at the end. These swellings form the cerebral hemispheres, the limbic system and component parts of the brain stem. These parts, the spinal cord and associated nerve connections form the central nervous system (CNS). Hebb (1972) presents a basic information processing model in which information is received via receptors, transmitted through afferent and internuncial pathways to the brain stem and cerebrum. These pathways to the brain stem and cerebrum are 'hard wired.' The component parts of the brain stem/cerebrum then act on the stimulus in a manner yet to be discussed. An 'output' is then produced that is transmitted via hard wired efferent pathways to the body's effectors. The processing that takes place in the brain is another matter.

A neuron is a single nerve cell. They come in slightly differing varieties. Each neuron has a number of fibrils extending from it. Some are responsible for receiving impulses-the dendrites. These impulses are of course chemical/electrical in nature. Each neuron connects via its dendrites and axon (an output fibril) to a massive network in the brain. The point at which an axon makes contact with a dendrite or cell body is called a synapse. The synapse can be considered as a nodal point where several dendrites make contact with an axon. These synaptic junctions are considered to be the seat of learning (Elliott, 1970; Hebb, 1972; Vander et al, 1990; Ogmen and Moussa, 1993; Card and Moore, 1993). When a stimulus is repeated, a sticky substance called myelin begins to coat these synaptic junctions building up stronger connections and reinforcing the pathway of the stimulus. Habitual behaviour and response can be directly related to this process. See E. Roy John (1967, 1986) for greater biological and physiological detail.

In the work of Suchard and Horn (in Eysenck, 1978) mentioned above, we saw how AEPs correlated with intelligence. We also know that electrical activity is the business of neurons and synapses. The work of Jensen and Sternberg (1982) outlined above related response time to intelligence. Jensen in another work (1979), postulated that hold ups at the synapses may be responsible for decreasing the frequency of AEP responses due to inhibited neuron firing and subsequently slowing down response time. The basis of intelligence then may lay with the quality of synaptic junctions, or neuron capability to effectively pass electrical stimuli! There must be of course some chemical elements linked to such processes. However, the capability of a neuron to generate an output would fit nicely in a further expansion of Wechsler's analogy between intelligence and electricity; and further, the idea of an "Ohm's Law of Intelligence" as postulated above. What this work still does not answer is the question of nature versus nurture. Although it would seem to make the question of heredity undeniable, it does not answer the question of environmental factors. How important are factors such as diet in the formative periods both before and after birth? Anyone who has worked with children in extreme poverty has no doubt.

Summary and Conclusion

Initially this paper made an attempt to describe the problems that beset an individual attempting to define intelligence in a psychological sense. Many authors refer to intelligence in subtly differing ways. There are a variety of terms available to use, such as the terms *crystallised* and *fluid* abilities, general intelligence (*g*), and specific intelligence (*s*) relating to specific tasks. In addition to this, the terms intelligence A, B, C, and psychometric (*g*) have been discussed. Each of these relating to innate ability (A), the development of that ability as facilitated by an individual's environment (B), and the measurable facet of those quantities (C). Some problems in measuring intelligence and the relevance of some specific factors relating to the possible basis of intelligence were discussed. Finally the paper addressed some of the issues current in the research of the 'hardware' systems that componentially form an intelligent being.

Whatever was achieved here is only a drop in the sea when it comes to describing the immense field of the psychological perspective on intelligence. The most valuable lesson to be learned is that in spite of all the research available, the terminology defined or the models explored, we must be aware that there is much more to learn. The field is at a threshold of fuller scientific understanding of the neuro - physiological basis of the brain/mind and its attributes.

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