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EDITORIAL: The Concept of "Intelligence": Useful or Useless?

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This editorial discusses recent developments in the conception of intelligence in the light of experimental evidence, particularly in work on reaction time and averaged evoked potentials. It is argued, in the first place, that the conception of a general factor of intelligence should not be abandoned, as many recent investigators have suggested, but is not only useful but necessary in order to explain empirical data furnished by confirmatory factor analysis, multidimensional scaling, and so forth. It is further argued that attempts to explain differences in cognitive functioning in terms of learning, cultural, and environmental variables and educational factors cannot account for recent evidence showing high correlations between elementary physiological (evoked potentials) and perceptual–motor processes (reaction times, movement times, inspection times) and IQ. It is suggested that controversy about the meaning of intelligence has been due largely to a failure to observe the threefold nature of intelligence, and that any adequate theory must take into account the experimental data and theoretical considerations here summarized. Together these have given rise to a "new look" in the conceptualization of intelligence (Eysenck, 1986).

There has perhaps been more controversy concerning the nature and existence of intelligence than of any other psychological concept. During the between-wars years, the measure of intelligence through IQ tests was regarded as the greatest achievement of modern psychology, proving once and for all that mental qualities could be measured with a fair degree of precision, reliability, and validity. In more recent years, doubts have been expressed about the very existence of intelligence, the possibility of its measurement, and the meaningfulness of IQ data.

Some have attacked the concept on what seemed to be ideological grounds (Eysenck & Kamin, 1981; Kamin, 1974; Keating, 1984). Others have tried to break up the concept into a large number of small and limited abilities (Guilford, 1967) or rather larger lumps (Thurstone, 1938). Others, like Thomson (1939), have opposed the statistical bases of Spearman's *g* by reference to an alternative theory of "bonds," which would explain the "positive manifold" usually observed among intercorrelations between cognitive tasks without positing a general factor (Eysenck, 1987).

Some of the objections to the concept of intelligence are of a philosophical

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kind. Thus, Keating (1984) argues that those who believe in the usefulness of the concept of intelligence adhere to a belief "that *it* is a thing that exists in the head of a person" (p.2). He and many others would argue that intelligence does not exist and that, hence, all efforts to measure it must be useless. This argument is erroneous on both counts. Spearman and his followers have never posited the *existence* of intelligence; they have regarded it as a scientific *concept,* analogous to such concepts as gravitation, humidity, or mass. These are all scientific concepts and, as such, they carry an implication of existence just as little as does intelligence. It is possible to assert the existence of pigs or psychoanalysts or the yeti, although philosophers might have a great deal of fun arguing about even that. But, as a scientific concept, no reputable psychologist would have attempted to reify it or to assert its existence in this sense. Intelligence is a scientific concept that may be useful or useless; the main point of this article is that it is *useful* and, at the moment, accounts for the known facts better than any other concept or collection of concepts.

The second criticism often voiced refers to the lack of agreed theory concerning intelligence. It is said that, in the absence of such a theory, intelligence cannot be regarded as a useful scientific concept. Such a view would certainly run counter to anything that the history of science can teach us. Concepts develop for centuries before agreed theories arise, and often the theories on which they are based are known from the beginning to have faults. Gravitation is a good example. Newton's Action at a Distance theory was already known to him to be absurd, but it served a very useful purpose. Even now, 300 years later, there is no agreed theory of gravitation. What we have are two quite dissimilar theories between which it is impossible to make a rational choice. On the one hand, we have Einstein's view according to which gravitation is a distortion of the space–time continuum, and on the other, we have the quantum mechanics interpretation in terms of particle interaction (gravitons).

Much of the same may be said about the theory of heat, where we have the thermodynamic and the kinetic theories side by side. Thermodynamics deals with unimaginable concepts of a purely quantitative kind: *temperature,* measured on a thermometer; *pressure,* measured as a force exerted per unit area; and *volume,* measured by the size of the container. Nothing is said in the laws of thermodynamics about the nature of heat. This, on the other hand, is the foundation stone of the kinetic theory of heat, using Bernoulli's view that all elastic fluids, such as air, consist of small particles which are in constant irregular motion and which constantly collide with each other and with the walls of the container, their speed of motion creating the sensation of heat. Many formulae are quite intractable to kinetic interpretations even today but yield easily to a thermodynamic solution. The unified theory here, as elsewhere, eludes physics, after centuries of endeavor. Should we expect psychology to do better? The unified theory appears at the end, not at the beginning, of scientific search, and to demand such a theory before a concept is taken seriously is to make impossible all scientific research.

A third objection relates to the absence of an agreed definition of intelligence. To read such a set of views as those contained in *What is Intelligence?* (Sternberg & Detterman, 1986) or its forerunner, the classic symposium published in the *Journal of Educational Psychology* 65 years ago under the title "Intelligence and its Measurement," is to see quite clearly that indeed there is no agreement on definition. This could hardly be expected in the absence of an agreement on theory; definition follows theory. However, what is interesting and important is the lack of the majority of participants in the symposia to consider for a moment the *nature* of definition in a scientific context.

When we look at the usual definitions offered by psychologists, these turn out for the most part to be examples of what intelligence might be expected to do, rather than definitions of any underlying concept. Consequently, definitions in terms of learning, remembering, problem solving, following instructions, educational success, worldly achievement, or even in terms of Spearman's eduction of relations and correlates, are not even attempts at definitions of intelligence. What would we think of a physicist who tried to define gravitation in terms of the apple falling on Newton's head, the shapes of the planets, the occurrence of tides or black holes, the equatorial bulge of the earth, planetary movements, the laws of gunnery, or the formation of galaxies? These are all examples of the *operation* of gravitational forces; they are not definitions, and any physicist who tried to define gravitation in those terms would be laughed out of court. So would any critic of the concept of gravitation who argued that because different physicists used different examples of the effect of gravitational forces the concept therefore was useless!

There is, indeed, a problem of definition, but it is very different from that usually discussed by psychologists. The term is traditionally used in three entirely different senses, which are not unconnected, but which have to be rigorously distinguished if discussions on intelligence are not to resemble the Tower of Babel. Figure 1 illustrates these three concepts, namely those of biological intelligence, psychometric intelligence, and social (or practical) intelligence. Biological intelligence is the kind of concept Galton was concerned with; it refers to the structure of the human brain, its physiology, biochemistry, and genetics which are responsible for the possibility of intelligent action on the part of human beings. It is this that distinguishes us from pigs, dandelions, and stones, and it is not unreasonable to suggest that it is responsible also for *individual differences* between human beings. It may be measured by means of the electroencephalograph (EEG), evoked potentials, contingent negative variation (CNVs), galvanic skin response (GSRs), or possibly reaction times, although of course such possibility must receive experimental support before it can be accepted as reality (Eysenck, 1986; Eysenck & Barrett, 1985). This conception of intelligence, it may be suggested, is the most fundamental of all and the purest, least adulterated by social factors.

Psychometric intelligence, or IQ, is to a large extent determined by biological intelligence but, clearly and inevitably, cultural factors, family upbringing, so-

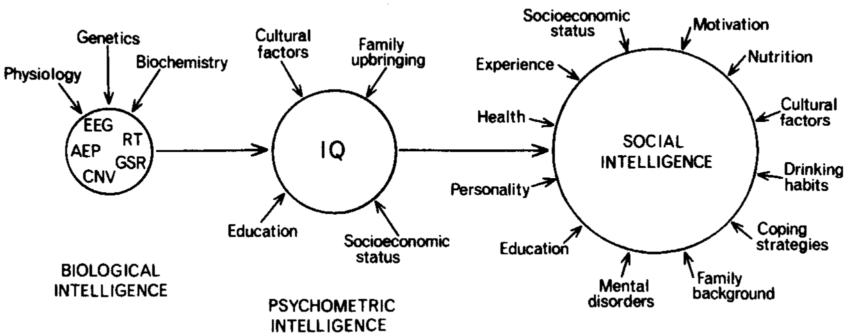

FIG. 1. Three concepts of intelligence.

cioeconomic status, education, and other factors also play a part. Insofar as something like 70% of IQ is determined by genetic factors, it is perhaps reasonable to suggest that biological intelligence accounts for a large proportion of psychometric intelligence (Eysenck, 1979). It would, however, be a fatal error to *identify* IQ with biological intelligence, and criticisms that IQ is *not* entirely biological are clearly misplaced when the distinction is made.

Social intelligence, in our diagram, relates to the application of biological intelligence and IQ to the problems an individual encounters in his life space. Clearly, IQ plays an important part in determining his ability to solve these problems and successfully follow his interests and use his abilities. However, there is a large group of noncognitive factors which also play a part, such as health, experience, socioeconomic status, motivation, nutrition, cultural factors, drinking habits, coping strategies, family background, mental disorders, education, and personality. Examples have been given by Eysenck (1979) that among children of equally high intelligence, those with a high degree of neuroticism will be failures from the social point of view, that is, earn less, have less desirable jobs, be lower in the social scale, and so forth, than other children of a more stable emotional background. Sternberg (1985), with his triarchic theory of intelligence, would seem to be a typical representative of those who would define intelligence in terms of what we have called *social intelligence,* or what he calls *practical intelligence* (Sternberg & Wagner, 1986).

It is here suggested that, although IQ, because of its close relationship with biological intelligence, may be an acceptable definition of intelligence (provided its weaknesses are kept in mind), this is not true of social intelligence. If we follow Bridgeman (1927, 1951) in accepting operational definitions of scientific concepts, then it may make some sense to use Boring's often quoted statement about intelligence being what intelligence tests measure. However, operational definitions have their weaknesses, and the weaknesses of defining intelligence in terms of IQ are adequately portrayed in our figure.

It should be obvious that social intelligence is far too inclusive a concept to have any kind of scientific meaning. Sternberg (1985) acknowledges that his view

> 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 . . . for example, motivational phenomena relevant to purpose of adaptive behavior—such as motivation to perform well in one's career—would be considered part of one's intelligence broadly defined. (p. 55)

This is unacceptable. Scientific advance is based on analysis, and analysis means that artificial compounds should be shunned, and that we should insist on reducing them to their unitary constituents. To bring together dispositional ability factors, personality, and motivation into one concept simply means that this concept is scientifically meaningless and cannot be measured. Even personality is obviously too vague a concept in this context; we may be able to measure certain aspects of personality, such as extraversion or neuroticism (Eysenck, 1981), but no measurement of personality as such is conceivable. The same applies to motivation. To bring together all these (and many other constituents) in one concept of social intelligence is to move it out of the field of scientific investigation and theory altogether. What we may do is to measure each of the variables in question separately and then, if we wish, define social intelligence by means of a formula including each of the variables as a term. Whether this is or is not a meaningful process is questionable, but it is not an issue of interest for the moment.

Sternberg is clearly motivated by a desire to bring the scientific concept of intelligence into line with popular conceptions. It may be useful to consult Newton (1771/1969) on this point. This is what he has to say in the Scholium at the beginning of his *Mathematical Principles of Natural Philosophy:*

> I do not define time, space, and motion, as being well known to all. But it must be observed that the vulgar conceives these qualities, only from their relation to sensible objects. And thence arise certain prejudices, for the removing of which, it is proper to distinguish them into absolute and relative, true and apparent, mathematical and vulgar. (p. 12)

In other words, popular conceptions contain "certain prejudices," and it becomes important to distinguish between "mathematical and vulgar" definitions. Sternberg goes against the whole tradition of natural science in opting for the vulgar, whereas Spearman, Thurstone, Thompson, and their followers have preferred the mathematical. It would seem desirable to return to this more scientific usage.

It will be clear why it is so important to discriminate between these three different conceptions of intelligence. Failure to do so will lead to misunderstandings which make any discussion meaningless. When Burt (1909) defines intelligence in terms of innate, general, cognitive ability, he is clearly speaking about biological intelligence; it is no reply to argue that social intelligence involves many environmental factors or that IQ is only partly determined by genetic factors. Similarly, it would be no answer to Sternberg and his conception of intelligence to point out that biological intelligence is genetically determined. The literature on intelligence, unfortunately, is full of such misconceptions, and only strict adherence to the discipline imposed by the clear-cut differentiation outlined in Figure 1 will make discussion more meaningful.

It might be said that the very fact that there exist these different conceptions means that psychology is different from physics, and that the conception of intelligence is different from (and inferentially inferior to) conceptions in physics, such as that of heat. A simple consideration of heat will show that this is not so. Here, also, we can encounter three different conceptions of heat, and here, also, we will find the same kind of difficulties which we encounter in the measurement of intelligence. Corresponding to our conception of biological intelligence, we have what might be called physical heat, that is, the Bernoulli definition in terms of speed of movements of molecules or atoms. However, we measure this not directly but in terms of its consequences, very much as we measure intelligence through IQ tests in terms of certain varied consequences of differences in the underlying dispositional state. Thus, in physics, we have the mercury-in-glass thermometer, depending on the change in volume of the mercury with increase in heat; the constant-volume gas thermometer, depending on the reactance of the welded junction of two fine wires; resistant thermometers, depending on the relation between resistance and temperature; thermocouples, depending on the setting up of currents by a pair of metals with their junctions at different temperatures; and so forth. Nelkon and Parker (1968), in their *Advanced Level Physics,* point out that temperature scales differ from one another, that no one of them is any more "true" than any other, and that our choice of which to adopt is arbitrary, though it may be decided by convenience (p. 186). Thus, when a mercury-in-glass thermometer reads 300°C, a platinum-resistance thermometer in the same place and at the same time will read 291°C! There is no meaning attached to the question of which of these two values is correct, and it is clear that the notion that a temperature scale has equal steps is a myth. Thus, the fact that different IQ measures may give somewhat different results for the same person is not an indictment of IQ measurement; apparently the same is true of the measurement of heat.

These different measures of heat may be considered to correspond to the psychometric definition of intelligence. But we may go one step further. Heat and cold, as experienced by living beings, are certainly determined by temperature, as measured by one of the methods outlined above, but there are many other factors that influence them also. One of these, of course, is air movement (the so-called chill factor); others are the food intake of the person, the amount of alcohol in the blood, the amount of exercise taken, and many others. This conception of experienced heat is, from a practical point of view, more important than the more scientific conceptions, and it corresponds much more to what human beings talk about and discuss as "cold" and "hot." Nonetheless, it is not a scientific concept, just as social intelligence is not a scientific concept, and, as scientists, we are required to measure the different aspects separately.

But surely, it is often argued, the selection of the particular problems in an IQ test is somewhat arbitrary, and such arbitrariness has no place in science. Again, this is a misconception. Selection of items in IQ tests is not arbitrary; it derives essentially from the fact of the positive manifold, that is, the existence of uniformly positive correlations between cognitive tasks. In taking a large number of tasks, some are clearly more central than others, in the sense that they have higher correlations overall, and it is such items and tests that one would select to measure what is common to all. Much the same is true in the measurement of heat.

Let us take the field of liquid-in-glass thermometers and ask ourselves what kind of liquid we would choose. Clearly, water would not be a good liquid to use because it contracts from the ice point to the temperature of maxium density, which is 4°C above the ice point, thus giving an illusory decline in temperature when actually the temperature is increasing! In actual fact, the liquids most widely used (mercury and alcohol) were chosen in part because they fit in best with the kinetic theory of heat which predicts that the final temperature reading of a fluid obtained by mixing two similar fluids of masses m_1 and m_2 at the initial temperatures t_1 and t_2 should be

$$t_p = \frac{m_1 t_1 + m_2 t_2}{m_1 m_2}$$

The linseed oil thermometer was discarded because measurements made with the instrument did not tally with the prediction made by the kinetic theory; mercury and alcohol thermometers do tally. Thus, a choice of a measuring instrument is in part based on its agreement with theory; the same is true of psychological measurement.

But is there, in fact, a theory which would enable us to pick out "good" tests as opposed to "bad" tests? The answer, I think, must be in the affirmative, and it is the reasoning behind this answer which would seem to be the strongest argument in favor of some such concept as Spearman's *g*. We have already mentioned the fact that intercorrelations between cognitive tasks in any random population are uniformly positive, giving rise to the positive manifold which is such a noticeable feature of work in this field. This alone would suggest very strongly the explanation of the observed phenomena in terms of a general factor underlying all these different manifestations of intelligence; but there are alternative explanations, such as that of Thompson (1939) already mentioned, although it must be said that such explanations appear somewhat forced and can now be seen to be contradicted by many empirical facts (Eysenck, 1987).

Nevertheless, what is even more convincing than the simple existence of the positive manifold is the actual structure of the matrices of intercorrelations generated by empirical research into different types of tests and cognitive tasks. Let us consider, first of all, the application of the technique of multidimensional scaling to the observed interrelations between different types of cognitive tests (Snow, Kyllonan, & Marshalek, 1984; Snow, Lohman, Marshalek, Yalow, & Webb, 1977). The aim of such multidimensional scaling is to find the geometric configuration of points in N-dimensional space in which the interpoint distances best correspond to the similarities of the object scale. The results of such an analysis are shown in Figure 2, which shows clearly the central position of fluid intelligence (G_f). This concept of fluid intelligence is most clearly defined by tests such as Raven's matrices, as shown clearly in Figure 2.9 in Snow, Kyllonan, and Marshalek (1984). Interested readers should also look at Figure 2.5, in which nonmetric scaling of Thurstone's ability test have been correlated and show *g*-loadings for different contours.

Of equal interest is Figure 3, which is taken from Gustafsson (1984), who used a confirmatory factor analysis (LISREL) model to unify the structure of intellectual abilities. Here, too, a central place in the structure is given to fluid intelligence, here denoted simply by G. Thus, what is clear is that regardless of the method of analysis employed (multidimensional scaling or confirmatory

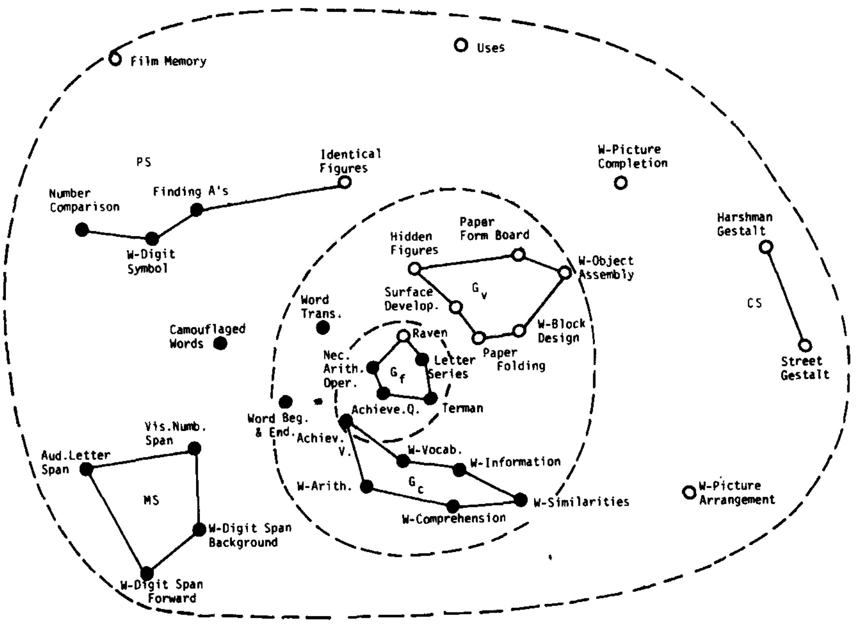

FIG. 2. Multidimensional scaling of IQ tests (Snow et al., 1977).

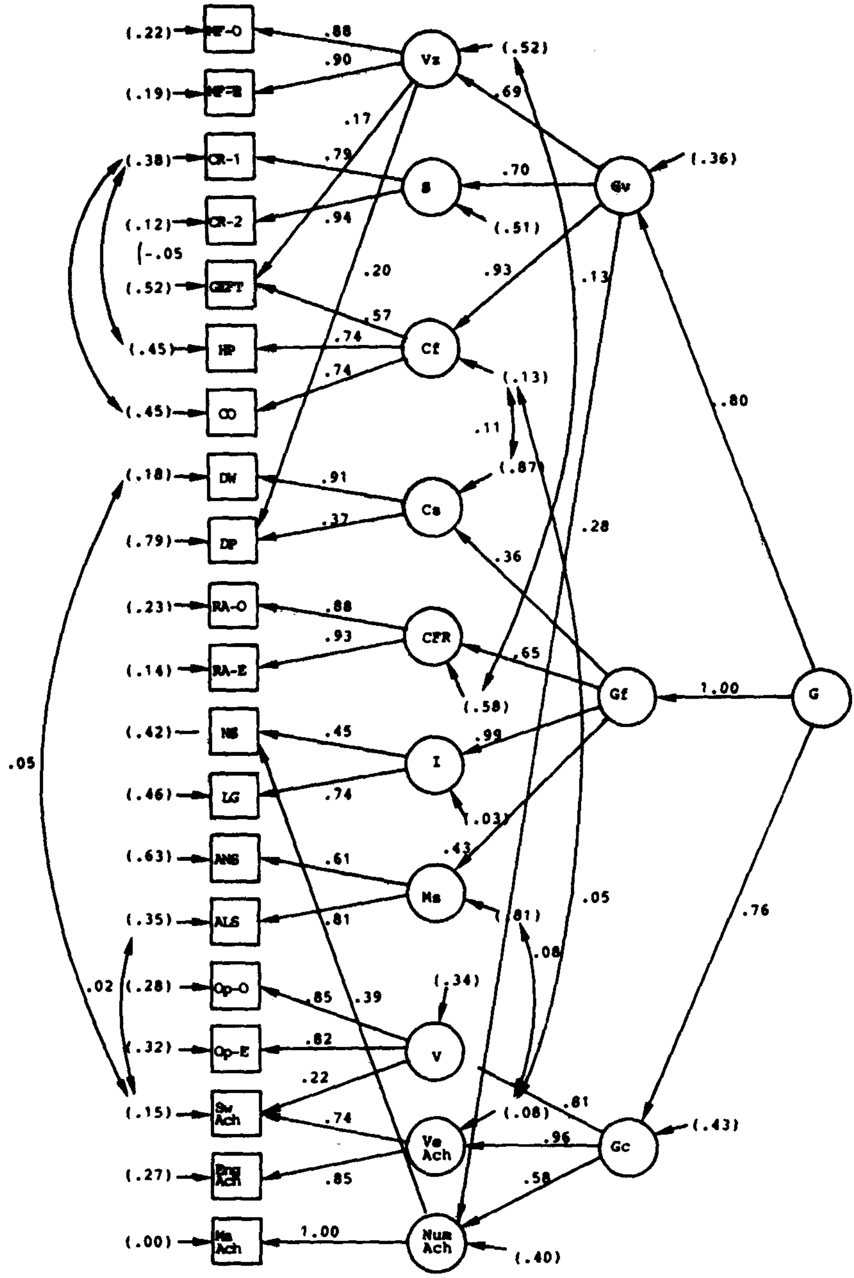

FIG. 3. Confirmatory factor analysis model of intelligence (Gustafssan, 1984).

factor analysis) very similar *structures* for the different tasks involved emerge, culminating in the construction of a general factor of fluid intelligence, penetrating all the different tests involved to a varying degree.

It is easy to misunderstand the importance of this finding. Critics often misinterpret empirical investigations of this kind by suggesting that they are examples of inductive reasoning, which has a less than enviable reputation among philosophers of science (Suppe, 1974). Such an interpretation is quite incorrect. Tests such as Raven's matrices were constructed *explicitly* according to Spearman's theories of intelligence and, in particular, the nature of the general factor which he identified with his noegenetic principles. In other words, the central position of Raven's matrices (and similar tests embodying these noegenetic principles) is not a chance phenomenon; it is an empirical deduction and proof of the correctness of the general theories introduced by Spearman (1927). The fact that two recent handbooks of intelligence (Sternberg, 1982; Wolman, 1985) could be published without any mention in the subject index of these noegenetic principles is an interesting comment on the failure of modern researchers in this field to consider seriously either some of the most important theories in this field or the quite astonishingly accurate predictions made by it, and verified by the use of methods far removed from the tetrad difference criterion put forward by Spearman.

It might be added at this point that the two studies just mentioned (as well as many others) contradict very strongly Thompson's (1939) hypothesis that the mind is almost completely structureless. They demonstrate conclusively that the mind does have a structure, and that this structure is very much as was envisaged by Spearman and Thurstone. It is often suggested, quite erroneously, that Spearman's and Thurstone's views are in contradiction to each other. This is not so. Thurstone (1938) originally suggested that, in his correlation matrices, there was no evidence for the general factor. Eysenck (1939) pointed out that (a) this might be due to the restriction of range as far as ability of his sample of his students was concerned and (b) that alternative methods of analysis did give rise to very marked general factor. Thurstone and Thurstone (1941) repeated their work on a more representative sample of children and found very strong evidence of a general factor among the intercorrelations between their primaries. Thus, Thurstone was forced to admit the existence of a general factor as well as his primary abilities, and Spearman (Spearman & Jones, 1950) had to agree that, in addition to his general factor, there was, indeed, evidence of what the English school called *group factors*. In other words, both sides agreed on the structure of intellect which is very much like that shown in Figures 2 and 3.

It is one thing to postulate a general factor of intelligence as the central conception in the theoretical framework which explains the observed phenomena in the field of mental testing; it is a different thing to suggest the nature of this factor. In other words, it is difficult to cross over from the *descriptive* to the *causal* analysis, and this must inevitably involve experimental as opposed to simple correlational types of investigation. Such theories, to be meaningful, would obviously have to go back to the conception of biological intelligence originally introduced by Sir Francis Galton (1883, 1892). He suggested that physiological tests might be of interest here, and he specially mentioned reaction time (in the absence at the time of any direct measures of cortical activity, such as the EEG.). Though Spearman (1904) and Burt (1909) used very simple tests of sensory acuity, discrimination, reaction time, motor movement, inspection time, and so forth, as measures of intelligence and reported considerable success in this endeavor, it is curious that, in their later work, they switched over, instead, to Binet-type tests. The Galton–Spearman–Burt preference for simple sensory tests, particularly using speed (as in reaction-time experiments) as a measure of intellectual ability, fell into disrepute, with only few efforts to revive it (e.g., Eysenck, 1967). More recently, Eysenck (1982) and Jensen (1982a, 1982b) have attempted to resuscitate this original theory, both by experiment and by theoretical development. Much interest has been taken in reaction time (Vernon, 1987) and inspection time (Brebner & Nettelbeck, 1986), but Spearman's original interest in sensory discrimination has also been revived (Raz, Willerman, & Yama, 1987). Using frequency discrimination of two 20-msec tones in the absence of any masking, and using a 2-interval, forced-choice procedure, they found correlations of frequency discrimination thresholds with Catell's Culture Fair Intelligence IQ in college students to range from −0.42 to −0.54. It must be said that, particularly regarding the limited range of ability in the sample, these correlations justify Spearman's original high expectations from sensory discrimination experiments in the determination of intelligence.

It is important to note that it is not only the fact that reaction times, movement times, inspection times, EEG and average evoked potentials (AEP) results correlate with intelligence that is important, but that certain details in these investigations demonstrate their relevance to the concept of intelligence. The first of these is the fact that factor loadings on different IQ tests are *directly proportional* to their correlations with (RT) tests (Hemmelgarn & Kehle, 1984) and AEPs (Eysenck & Barrett, 1985). Thus, what reaction times and AEPs measure is exactly what is central to IQ tests, like the Wechsler, that is, the general factor that runs through them.

In the second place, it is important to note that the correlation between reaction and intelligence is mediated equally strongly by so-called power tests as by so-called speed tests (Vernon & Kantor, 1986; Vernon, Nador, & Kantor, 1985). This finding is important because it demonstrates once and for all that the correlation between reaction time (RT) and intelligence is not just an artifact due to the speeded conditions of some mental tests but is a fundamental property of whatever is common to all mental tests, whether speeded or unspeeded. Nor do simple correlations between reaction-time tasks and IQ measures give an adequate picture of the relative importance of reaction time in the field of cognitive abilities. Consider the recent study by Thorndike (1987), which indicates the relative importance of reaction time in the cognitive scheme of things. Thorndike reanalyzed basic data presented in a table of correlations among a set of 65 variables, composed of 45 research tests and the 20 tests of the Air Crew Classification Battery (Guilford, 1947). For the purpose of Thorndike's study, he divided the first 48 variables into six sets of 8 variables that provided the matrix into which each of the remaining 17 tests was inserted, 1 variable at a time. The *g*-loading of each of the 17 was thus determined six times, each time in the context of a different set of eight reference tests. It was found that, regardless of the particular set of reference tests within which a given test was factored, its *g*-loading was remarkably similar, loadings intercorrelating .85 of the average. This demonstrates the relative invariance of *g*-loadings regardless of selection of tests.

What is of major interest here, however, is the *g*-loading (or rather the set of six *g*-loadings) of test number 17, which is a discrimination reaction-time test. This turned out to have a mean *g*-loading of .58, which was the second highest in the whole battery, exceeded only by a spatial orientation test (*g*-loading = .60). Reading comprehension had a loading marginally lower than that of discrimination reaction time (.56). Tests of general information, judgment, arithmetic reasoning, mechanical principles, and mechanical information all had loadings *lower* than that of discrimination reaction time. This finding indicates the central role which reaction time plays in whatever is common to tests of cognitive ability; certainly no one would have predicted on the basis of current environmentalistic theories of intelligence emphasizing social learning that discrimination reaction time would be a better measure of general ability as measured by the Guilford tests than would be reading comprehension, general information, or judgment! Findings such as these demand an explanation in theoretical terms, and it is interesting that this important finding has been completely disregarded by writers in the field up till now.

Also of interest are results of EEG studies, particularly work on evoked potentials. The review by Eysenck and Barrett (1985) indicates that several different paradigms have been used in this connection, giving very high correlations (in the 80s) between evoked potentials and IQ. It seems likely that replications will give rather lower correlations than these; it seems unlikely that the correlation between IQ and a physiological measurement of biological intelligence, such as the AEP, can exceed the square root of the heritability of IQ. Given that the heritability lies between .5 (Vernon, 1979) and .7 (Eysenck, 1979), this would give us a maximum value between .71 and .84. (According to Snyderman & Rothman, 1987, experts center on a heritability value of 60%.) However, these would be maximum values and would require error-free tests and other unlikely assumptions, so that the maximum empirical value likely to be observed would be considerably lower. Correlations in excess of .8 are therefore inherently improbable and unlikely to be replicated.

In spite of doubts and weaknesses in the experimental literature, it seems clear that the observed correlations between intelligence, on the one hand, and reaction time, movement time, inspection time, variability of RT and MT, and EEG and AEP measures are too high to conform to the usual theoretical assumptions of most current American workers in this field (Sternberg, 1982; Wolman, 1985). The paradigm widely adopted is one which regards IQ measures as essentially tests of acquired knowledge and competence, socially transmitted through educational and parental offices and readily modifiable. Such assumptions are clearly negated by the findings illustrated in Figures 2 and 3, demonstrating the central importance of fluid, as opposed to crystallized, ability. They are contradicted by the findings of the RT and AEP studies just mentioned (Eysenck, 1982, 1985). It is difficult, if not impossible, to explain these correlations in terms of current environmentalistic theories in this field, all of which predict a zero or very low relationship. Obviously, the last word has not yet been spoken on this issue, but it is curious to note that in neither of the two most recent handbooks of intelligence (Sternberg, 1982; Wolman, 1985) is there any discussion of this gross anomaly, as far as current theories are concerned.

The question of the modifiability of intelligence, which plays such a large part in many educational and psychological theories of intelligence, demands a special mention. As Spitz (1986) has recently demonstrated, the whole history of this notion is full of erroneous arguments, bad methodology, and downright fraudulence. The wholesale modifiability of intelligence is still taken for granted by many writers in this field in spite of the demonstrated failure of innumerable studies to show any such effects. Though the *possibility* of such modification cannot be denied the basis of past failures to achieve it, it certainly cannot be taken for granted that success is possible or has already been achieved. The high heritability of intelligence alone would suggest that the task is more difficult than it appears to environmentalists like Kamin. In any case, such modifiability, if it were ever to be achieved, would attach to IQ; whether or not there is any possibility of achieving it with respect to biological intelligence would still be an open question.

It is not to be wondered at that data of the kind here considered have been thought to constitute a revolution in the theory and the measurement of intelligence (Eysenck, 1983). This revolution, using the term in its Kuhnian sense (Cohen, 1985; Kuhn, 1970) is, of course, only in its beginnings at the moment and, as such, is beset, like all revolutionary theories, by anomalies and problems. As Barnes (1982) has pointed out, the acceptance of a new paradigm indicates *problems for research,* as well as serving a resource for the scientist. This happens because of the perceived inadequacy of a paradigm as it is initially formulated and accepted, its crudity, its unsatisfactory predictive power, and its limited scope which may in some cases amount to but a single application. In agreeing upon a paradigm, scientists do not accept the finished product; rather, they agree to accept a basis for future work and to treat as illusory or eliminable all its apparent inadequacies and defects. Paradigms are refined and elaborated in normal science, and they are used in the development of further problem–solutions, thus extending the scope of scientific competence and procedures.

Thus, we should now be in the era of normal science, which is a process of extending and filling out the realm of the known. It is thus suggested that the revolution has produced a new paradigm or perhaps a return to the Galton–Spearman paradigm in new guise. There can be little doubt that the paradigm that had become traditional in the last 50 years is so faulty that it cannot explain existing phenomena, and that a new paradigm is needed. Whether the one here suggested will fill this role is, of course, a question that only the future can answer.

But, surely, a paradigm needs a theory, as well as new facts incapable of being assimilated by existing theories. Such a theory has been suggested originally by Eysenck (1953) and Furneaux (1961) and elaborated more recently in *A Model For Intelligence* (Eysenck, 1982). This theory regards speed of cognitive processing as the fundamental variable underlying differences in general intelligence, and the theory has been developed more recently by Eysenck (1987a). There is no space here to outline this theory or to discuss it in any detail; clearly, this cannot be the purpose of a paper of this kind. Nor can we discuss a possible relationship between this theory and the recent revival of Spearman's theory by Weiss (1986) and Eysenck (1987b). Theories of this kind go beyond psychological and physiological theories of speed and cognitive processing to even more fundamental biological aspects of cortical activity. That these activities are relevant to intellectual functioning and to differences in intellectual functioning seems well established; whether or not they can readily be integrated into a general psychological theory of intelligence remains to be seen.

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