Spearman on Intelligence

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This brief Note has been written to avoid what might be described as a deletion war in the Wikipedia entry on Charles Spearman's theory of intelligence. It does not set out to offer a comprehensive treatment of the subject, although it may be noted that the nominally more thorough treatments cited in the Wikipedia entry do not adequately represent Spearman's position.

The topic is of considerable importance in that Spearman was acutely aware of the limitations in the data fed into his analyses and thus the misuses to which the conclusions drawn from the research had been put. Nevertheless, it has to be said that, although he was aware of these limitations, the mindset, or paradigm, within which he was working prevented him surmounting them. In fact, many unethical practices and procedures deriving from (or perhaps simply reinforced by) his work have become ever more deeply embedded in current psychological research and theorising and "educational" practices and occupational selection.

The Wikipedia entry discusses Spearman's contributions to statistics at some length. These will not be discussed here.

As is well known, Spearman applied what was, in effect, a preliminary version of factor analysis to seek a structure in matrices of correlations between many tests. He noted, and this was something of a surprise at the time, that all these tests were mainly positively correlated. People who were good at one thing tended to be good at the others. In due course, he came to the conclusion that much of the variance in test scores could be explained, described, or accounted for if one posited a 3-factor model: A general factor which was tapped by all tests to a greater or lesser degree, some group factors which were tapped by certain clusters of tests, and some specific factors tapping abilities or processes unique to very few tests.

So far, so good.

How to interpret these findings? Spearman devotes three remarkable publications to this topic (Spearman 1904, 1923/27,1927) and to some extent shifts his position over time. He also highlights certain viewpoints at one time and others at other times.

The first thing to note is that he argued, stridently, that ***g*** was *not* to be equated with "intelligence" … although that is precisely what endless later workers *have* done.

He oscillates quite a bit about whether ***g*** is to be envisaged as a purely statistical convenience or construction which is helpful in making sense of the pattern of intercorrelations between tests or whether it is to be thought of as evidence of – and possibly, by calculating some kind of summative score, providing an index of – a basic psychological process or trait that is determining the network of correlations.

For a variety of reasons, which include the physical labour of calculating large numbers of correlations without the aid of calculating machines, let alone computers, and what might now be said to be the relatively unsophisticated methods he used to conduct his analyses, he nowhere publishes his correlation matrices with the tests ordered according to what would now be called their 'factor loadings' on the various factors. Had he done so, it might have been easier for readers to grasp what he was saying.

But, from the point of view of trying to understand how he viewed his findings, here is a quotation extracted from a transcript of what various participants said in the course of a number of meetings of an International Examinations Inquiry set up by Andrew Carnegie and held between 1931 and 1938. (See Deary et al, 2008 for selected aspects of the conversation between Spearman, Godfrey Thomson, and Edward Thorndike.)

Spearman says:

> One has to distinguish between the meanings of terms and the facts about things. G means a particular quantity derived from statistical operations. Under certain conditions the score of a person at a mental test can be divided into two factors, one of which is always the same in all tests, whereas the other varies from one test to another; the former is called the general factor or G, while the other is called the specific factor. This then is what the G term means, a score-factor and nothing more. But this meaning is sufficient to render the term well defined so that the underlying thing is susceptible to scientific investigation; we can proceed to find out facts about this score-factor, or G. We can ascertain the kind of mental operations in which it plays a dominant part as compared with the other or specific factor. And so the discovery has been made that G is dominant in such operations as reasoning, or learning Latin; whereas it plays a very small part indeed in such operation (sic) as distinguishing one tone from another. . . G tends to dominate according as the performance involves the perceiving of relations, or as it requires that relations seen in one situation should be transferred to another. . . . On weighing the evidence, many of us used to say that this G appears to measure some form of mental energy. But in the first place, such a suggestion is apt to invite needless controversy. This can be avoided by saying more cautiously that G behaves as if it measured an energy. In the second place, however, there seems to be good reason for changing the concept of energy to that of "power" (which, of course, is energy or work divided by time). In this way, one can talk about mind power in much the same manner as about horse power. . . . . .G is in the normal course of events determined innately; a person can no more be trained to have it in higher degree than he can be trained to be taller. (pp. 156 –157).

Clear though this may appear to be, one has to recognise that it comes from a rather polarised "discussion" between Spearman and others who appear to be trying to "measure" "intelligence" for an undefined purpose using a hodge-podge battery of tests. They don't seem to have understood what a general factor is, never mind what "intelligence" is or might

be. Still less to have thought through what role measurement of this factor might play in education.

Here is another apparently clear statement

> This factor is no process of intelligence of any sort. Nor, by itself, does it even furnish any sort (sic) with a measurement. (Spearman, 1927)

So that's it: ***g*** is a hypothetical construct which has emerged from factor analysis. A person's score on this general factor is always the same whatever the collection of tests used to measure it, but different tests tap it to different extents. The question of the relationship between scores on this general factor, whatever "intelligence" may be taken to be, and other variables has to be explored separately.

Maybe this is indeed the kernel of what he has to say. But let us back up.

In 1904 Spearman had reported on an amazing programme of research largely carried out in the previous century. This dealt with (1) the correlations between measures of sensory discrimination – touch, hearing, music, sound, and visual discrimination; (2) the correlations between scores on school tests of such things as Latin, Greek, English, and Mathematics ; (3) the correlations between a number of ratings of such things as "brightness" and "common sense"; (4) the correlations between the school ability tests and these, more general, ability ratings; and (4) the correlations between the sensory discrimination measures and all the others.

He writes:

> …we reach the profoundly important conclusion that *there really exists a something that we may provisionally term "General Sensory Discrimination" and similarly a "General Intelligence" and further that the functional correspondence between these two is not appreciably less than absolute.* (Italics in the original.) (Spearman, 1904)

And, by God, he means it! The correlation between the two, when corrected for measurement error, is 1.0!

In contrast,

> the specific factor seems to be in every instance new and wholly different from that in all the others

and, in accounting for the pattern of correlations between tests, is responsible for anything between 25% of the variance attributable to the general ability to 15 times as much.

He says that

> (a test of) discrimination has unrivalled advantages for investigating and diagnosing the central Function (ie General Intelligence in the terminology he was using at the time)

He asserts that a test with a monochord lasting a few minutes is sufficient to yield a reliable index of the general function. WOW! Yet

> The Central Function almost entirely controls the relative position of children at school … and is nine parts out of ten responsible for success in such a simple act as discrimination of pitch.

On the other hand, the contributions from specifics form a uniform hierarchy with Classics at the top and descending through French, English, Mathematics, and musical ability.

He notes that, whatever the basis of the general Function may be

> it does not appear to be of any loosely connected or auxiliary character (such as willingness to make an effort, readiness in adaptation to unfamiliar tests, or dexterity in the fashion of executing them) but rather to be intimately bound up in the very essence of the process.

He is here clearly talking about some specifically psychological process or ability, not merely a statistical construction.

Later, (Spearman, 1927) he elaborates on this. He comes to see ***g*** (which he has, by that time stridently declined to call "intelligence") as being made up of two distinct psychological processes which nevertheless normally work closely together.

One of these processes he refers to as "eductive" ability and the other as "reproductive" ability. Eductive ability is the ability to see – draw out – relationships. The term comes from the Latin root *educere*, which means "to draw out". Reproduction, on the other hand, is the ability to bring to bear information, not usually verbalised, which has been made explicit in the past.

He writes (Spearman, 1927):

> To understand the respective natures of eduction and reproduction – in their trenchant contrast, in their ubiquitous co-operation and in their genetic inter-linkage – to do this would appear to be for the psychology of individual abilities, and even for that of cognition in general the very beginning of wisdom.

Note that he is not talking about two *factors,* still less *independent* factors. Rather these are two distinct *psychological processes* which normally work closely together.

Spearman's position is to be sharply distinguished from the original Cattell-Horn (1966) notion of "fluid" and "crystallised" intelligence. One is *not* a crystallised form of the other. They are different at birth, have different genetic origins, and predict different things in life. And they are not separate *factors* anyway.

As it happens, this is exactly the position Horn (1994) later adopts. And, in a statement made at a later meeting of the International Test Commission, Horn made the final leap that Spearman failed to task.

Here is what Spearman had to say

> Every normal man, woman, and child is … a genius at something … It remains to discover at what … This must be a most difficult matter, owing to the very fact that it occurs in only a minute proportion of all possible abilities. It certainly cannot be detected by any of the testing procedures at present in current usage. But these procedures are capable, I believe, of vast improvement. (Spearman, 1924)

Reading between the lines of what he said at the meetings of the International Examinations Inquiry, we catch a glimpse of this position. There he refers to the diversity of "aptitudes" which (unlike the "General Intelligence" his colleagues are so preoccupied with assessing for no clear purpose and in what Spearman takes to be an inappropriate way) can be, and should be, be capitalised upon, and nurtured, by schools. Unfortunately, although he makes it clear that "aptitudes" – better termed "motivational predispositions" – are not to be confused with the specific factors which have emerged from his other work, he then falls into the trap of saying that these aptitudes need to be reduced to a smaller number through the application of factor analysis.

But, whatever about that, in his 1924 address to the British Association for the Advancement of Science, Spearman is quite clear about the implications of what he has said for schools and testing.

He declares that conventional ability tests – ie the tests from which his ***g*** had emerged – "have no place in schools" since they *deflect* teachers', pupils', parents', and politicians' attention from primary purpose of education which is – as the term itself implies – to "draw out" the diverse talents of the students. (The word "education" comes from same the Latin root as his "eductive" ability thereby implying that the objective of education is to draw out the diverse talents of the pupils - and neither to put knowledge *in* nor to arrange pupils in a hierarchy of what may be considered to be a more or less unalterable "ability".) Furthermore, he notes, the tests used in schools generally do not merit the names assigned to them. Thus, for example, the typical test of "scientific ability" cannot validly be so described because it does not measure the competencies required to advance scientific understanding. It is, rather, a test of the ability to regurgitate briefly remembered arbitrary snippets of received wisdom in the area.

Spearman's injunction to undertake further work on the *nature* of eduction and reproduction has received scant attention, although some might have expected the factorial work summarised by Carroll (1993) to have contributed to this. (The outcome – that measures of speeded things like reaction time (as distinct from sensory discrimination) contribute hardly at all to ***g*** – was anticipated in Spearman's 1904 paper.)

On the other hand, Spearman's former student, John C. Raven (see *Wikipedia* entry), set about developing tests that would provide simple, clear, and directly interpretable measures of these two abilities for use in research (in place of what both he and Spearman considered to be the uninterpretable hodge-podge tests being used by others). The two tests were the *Progressive Matrices* and *Mill Hill Vocabulary* tests (see Wikipedia entry for *Raven's Progressive Matrices* for a description). Although mainly for reasons associated with their non verbal nature and simplicity of administration, these rapidly found worldwide practical application and look-alikes were developed by others. (Incredibly, many of their authors appear not to understand basic matrix principles … such that the logic controlling progression in the elements of a matrix should replicate in both the columns and rows, thereby enabling

the person taking the test to, on checking his or her reasoning, be *absolutely certain* that the chosen answer was the correct one.)

The significance of these matrix designs from the point of view of facilitating the development of theoretical understanding of the nature of eductive ability has been less widely appreciated. In fact, as the author has shown elsewhere (Raven, J. 2008), an examination of the processes required to solve the Raven Progressive Matrices items *does* throw considerable light on the *nature* of eductive ability. It turns out to be a complex activity having major affective and conative components that are overlooked in the theorising of many researchers.

Interestingly, it was the *vocabulary* test that J.C.Raven was able to use to better understand the workings of the mind. The results are expressed in a framework entitled the "Coordinates of Conduct". This was initially published in an extended *Guide* to the use of the Mill Hill Vocabulary test (now incorporated into the MHV Section of the Manual [Raven, Court and Raven, 2000, updated 2004]) and later summarised in *Psychological Principles* (Raven, J.C. 1966)

Throughout his life, J.C.Raven also sought to advance understanding of the multiple talents behind Spearman's wider statement about genius. One of the tests he produced for work in the area was *Controlled Projection* (Raven 1951) and work with this test contributed to the development of the *Coordinates of Conduct* framework already mentioned.

But it was David McClelland and his colleagues (1958) who stumbled on the developments actually required to move psychometric thinking forward … although McClelland himself never fully appreciated the significance of what he had done.

As interpreted by the author (Raven 1984/1997), what McClelland's work shows is that one needs a two *stage* (*not* a two *factor*) framework to think about human abilities or competencies. One first needs to identify an individual's specific motivational predisposition and then, and only then, which of a number of cumulative and substitutable components of competence he or she brings to bear to undertake those activities effectively. (Because they are all difficult and demanding activities which no one will carry out unless they are strongly predisposed to engage in the overall activity, one cannot meaningfully assess someone's ability to execute these components of competence – such as the ability to seek out and act on feedback (ie self-monitor performance), self-confidence, or creativity) unless one has first identified an activity they are strongly predisposed to undertake).

In other words, one needs a paradigm shift in the way one thinks about abilities. One needs a *descriptive framework* of the kind used in chemistry or biology, not a *variable* oriented framework of the kind used in physics and pursued by psychologists in the past.

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