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# Teaching intelligence: Why, why it is hard and perhaps how to do it

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ABSTRACT

In spite of the documented importance of intelligence, surprisingly few colleges and universities offer courses on the topic. Three reasons are given; lack of personal experience with the range of variation of intelligence in the society (cognitive segregation), association of intelligence with elitism, and a belief that the study of intelligence is associated with racism. The most important goal of a course on intelligence is to provide evidence of the importance of the trait in society, thus combating a lack of knowledge due to cognitive segregation. The course should examine biological and social causes of intelligence. Student participation is encouraged rather than total reliance on lectures. This can be done by forming virtual discussion groups. Examples are given of topics that could be discussed by these groups. Finally, it is argued that discussions of racial, ethnic, and international differences in intelligence should be postponed to a second course or seminar, after students have acquired a reasonably sophisticated understanding of the causes and effects of intelligence. The reason for doing this is that while the study of group differences is important, superficial discussions of these issues can generate heat while producing remarkably little light.



## 1. Introductory remarks

### 1.1. The background of the discussion

This article, as with the other articles in this special issue, discusses the teaching of a course on intelligence. Such a discussion is more akin to an editorial than to a discussion of scientific evidence. Therefore, I shall adopt the style of writing appropriate to an Op-Ed section of a newspaper rather than the more dispassionate style of the typical scientific paper. The argument here is based on my personal opinions and beliefs, with no claim to scientific objectivity. That is the reason for frequent use of the pronouns "I" and "you."

My focus will be on undergraduate courses, although on occasion I will comment on graduate courses and seminars. I will first present reasons that I think led to the unfortunate demise of courses on intelligence. I then make some general comments on course goals and the manner of teaching, and finally consider specific topics.

My views on the teaching of intelligence have developed from my experience teaching this and related topics at the University of Washington, a large, research oriented urban university, from roughly 1970 until 2006. None of my courses ever conformed exactly to the recommendations to be made. These recommendations are based on "what worked" during my teaching career.

### 1.2. The disappearance of courses on intelligence

Should there be undergraduate and graduate courses on intelligence? The question may seem strange to anyone with knowledge of the literature. Across the population, measures of individual differences in cognitive capabilities, intelligence for short, are the most accurate predictors that we have of success in academic achievement, industrial and professional competence, and military performance. There are well established models of the multidimensional nature of psychometric measurements of

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intelligence, including the fact that a single large factor, general intelligence ($g$) often dominates the multidimensional space.

Going further, we certainly do not know everything about the source of intelligence, but we do know a lot. There are substantial, well documented findings about genetic contributions, the physiological basis for individual differences in cognition and increasingly, the complex interplay between environmental causes and effects.

There is also a great deal of information about group differences, both internationally and across demographic groups within national populations. Cause and effect are harder to unravel at the population level than at the individual level, but the data on correlations are clear. Indeed, we have a great deal of information about the relation of intelligence to that one demographic variable that influences us all; aging. Such information is of a great deal of social importance to the aging industrial societies, even if the reason for interest in the topic may evade many undergraduates.

Given what is known, one might expect that courses on intelligence would be taught widely. They are not, although at one time they were. Professors who themselves do research in the field offer courses in their specialty. A good many of these seem to be "graduate only." But what happens when we move outside of this fairly narrow group of scholars? In preparing this article I looked at the course list in six of the most prestigious universities in the United States; Stanford (as of 2013, the most selective university in the country in terms of the ratio of admissions to applicants) Harvard, Yale, the universities of California at Berkeley and Los Angeles, and the University of Michigan. None of these universities listed a course on intelligence in their undergraduate Psychology curriculum (Stanford did include a reference to intelligence in a course on expertise and its development).

The scarcity of courses in intelligence, both in universities in general, and in the elite universities in particular, is a serious issue. By and large, the social leaders of tomorrow are in the college and university classes of today. This is strikingly true at the highest levels of leadership. As of 2013, every member of the US Supreme Court and ten of the twenty presidents holding office since 1900 had earned at least one degree from either Harvard, Stanford, or Yale.[1] The association of education with influence spirals downward. As of 2010, 74% of the members of American state legislatures held at least a bachelor's degree. In the most populous state, California, the figure was 90%.[2] By contrast, nationwide 29% of the residents of the United States held college degrees.

The disappearance of intelligence from the curricula is serious, because this means that future social leaders will not receive information about an important trait in human variation during their formative early adult years. In addition, for the reasons given in the next section, they may have little personal experience with the range of human intelligence in their everyday life.

### 1.3. Why did the courses disappear?

Determining why the study of intelligence has become the academic equivalent of an endangered species would require an extended historical and sociological analysis. All I can do is offer some speculations, based largely on my own observations of trends in academia and American society since 1950. I do not claim to be a historian, so regard this as the notes of a 'participant observer'.

There has long been a streak of anti-intellectualism in American society. Any claim to superiority of intellect is derided as "putting on airs." Somewhat inconsistently, the proscription against display applies to mental but not to physical prowess. It is okay to demonstrate your physical superiority, in athletics if you are male and in displays of beauty if you are female, but flashing a Phi Beta Kappa key is proscribed for everyone.[3]

Behavioral evolutionists argue that the emphasis on body form is due to our Paleolithic heritage, where physical form was a signal of reproductive fitness. This does not explain the proscription of displays of intelligence. For that we have to look at the culture. The hero who fought off enemies with fist and gun is embedded our mythology. Millions of Americans will be able to identify Wyatt Earp and Daniel Boone. I suspect that very few can identify Robert Livingstone, the negotiator of the Louisiana Purchase, or William Seward, the negotiator of the Alaska Purchase.

Anti-elitism has another root. Americans are uncomfortable with discussions of social class, even though the United States has a greater disparity in the distribution of wealth than do most comparable nations. The fact that intelligence test scores correlate positively with socioeconomic status (SES) can be used as an argument that elitism is a natural outcome of the distribution of intelligence (Herrnstein, 1973; Herrnstein & Murray, 1994). If we combine this with a (mistaken) belief that genetic contributions to intelligence, which undeniably do exist, imply that mental competence is fixed at birth, then an emphasis on the importance of intelligence is dissonant with the Horatio Alger "strive and succeed, work and win" attitude.

A second reason for the downgrading of intelligence is that Americans, and especially educated American families, move in social circles where there is a limited range of intelligence (Murray, 2012). The same thing is true of the coming generation of college students.

College entrance is substantially a cognitive screening process. Table 1 presents the interquartile ranges in SAT

[1] Five of the presidents; George W. and George H.W. Bush, Clinton, Ford and Taft received degrees from Yale. Four; Theodore and Franklin Roosevelt, Kennedy, and Obama received degrees from Harvard (George W. Bush received degrees from both Yale and Harvard). Hoover graduated from Stanford. Three others graduated from similarly elite private institutions; Wilson (Johns Hopkins), Coolidge (Amherst) and Nixon (Duke). Of the other seven, two were from the military academies (Eisenhower, Carter), three (Harding, Johnson and Reagan) graduated from small colleges, and two (McKinley and Truman) did not attend college.

[2] Chronicle of Higher Education, June 12, 2011.

[3] A glance at supermarket and airport newsstand magazine displays shows where popular culture puts its values. Occasionally there are copies of *The Economist* and *Discover*. There are always copies of *Sports Illustrated* (including, in season, the swimsuit issue) and several magazines offering, with illustrations, advice to both females and males on how to sculpt the body.

**Table 1**
Percentile scores and interquartile ranges for enrolled students in two University of California campuses and two nearby California State University campuses. Data in the first row within a cell represent SAT scores. Data in the second row (and in parentheses) are the percentiles corresponding to the scores, calculated over all applicants taking the SAT in 2011. Data downloaded from collegeaptsabout.com and mediacollegeboard.com, May 2013.

| Institution | 25th %tile Reading | 75th %tile Reading | Interquartile range Reading | 25th %tile Mathematics | 75th %tile Mathematics | Interquartile range Mathematics |
|---|---|---|---|---|---|---|
| UC Berkeley | 600 | 730 | 130 | 630 | 760 | 130 |
| | (81) | (97) | (16) | (82) | (97) | (15) |
| UC Los Angeles | 570 | 680 | 110 | 610 | 740 | 110 |
| | (73) | (90) | (17) | (78) | (96) | (18) |
| CSU East Bay | 400 | 500 | 100 | 410 | 530 | 120 |
| | (19) | (51) | (32) | (21) | (61) | (40) |
| CSU Long Beach | 440 | 560 | 120 | 460 | 590 | 130 |
| | (31) | (71) | (40) | (37) | (70) | (33) |

scores for four public universities; the University of California Berkeley and Los Angeles campuses (UCB, UCLA) two geographically nearby California State University campuses; Long Beach and East Bay (CSLB, CSEB). The interquartile ranges for the four institutions are roughly comparable. Across institutions, the 75 percentiles for the California State campuses are below the 25th percentiles for the University of California campuses in both reading and mathematics.

The table also shows the percentile scores for each score, based on the population of college applicants taking the SAT. As the table illustrates, the personal experiences of most college/university students is restricted to populations that have substantial range restrictions with respect to intelligence. To take just one of several contrasts based on the table, 75% of the students accepted to the University of California, Berkeley, had mathematical reasoning scores in the top 20% nationally. At nearby California State University, East Bay, 75% of the accepted students were in the bottom 60% nationally.

Illustrations like the one just given are easy to generate. They illustrate the segregation of students by intelligence level within the university setting. It follows that there is even greater segregation of young adults by intelligence level within the total society, for university students as a group will be selected based on cognitive screening tests.

By contrast, there is virtually no formal screening for personality traits and interests, except for the indirect screening for conscientiousness that occurs when high school grades are included in the screening process (conscientiousness generally comes in second place, behind intelligence, when various predictors of grade point average are compared). As for other personality traits? If you have ever proctored the final examination in a large undergraduate course you will almost certainly have observed behavior that can euphemistically be described as "group problem solving." More seriously, multiple surveys have shown that better than half of the students at colleges and universities cheat in some way, at least some of the time (Novotney, 2011). College students are screened for intelligence, not integrity.

Intellectual segregation has consequences. When it comes to comparing the relative importance of intelligence and personality variables upon success in modern America intelligence researchers have the data on their side, but those who question the value of intelligence have the anecdotes and personal experiences on their side. This remark applies both to students, alumni, and to the faculty, who represent an extreme of cognitive segregation. The fact that cognitive segregation is so prominent in the faculty is important, for they are the ones who decide upon the curriculum.

A third reason for the demise of courses on intelligence is, unfortunately, academic politics. The liberal political views of many faculties, or to use the pejorative term, "political correctness," contributed to the dropping of courses on intelligence. Certain ethnic groups, notably African-Americans, on the average obtain lower test scores than White and Asian groups. This is well known. The causes and implications of these differences are hotly disputed, both as a scientific topic and as a political issue. Within many academic circles, any suggestion that these differences are (a) important facts to consider in understanding differences in socioeconomic status and (b) in any part genetically based is regarded as anathema.

Precisely such assertions were made in Arthur Jensen's (1969) now famous (or infamous, depending upon your social orientation) article discussing the disappointing results of attempts to improve the school performance of African-American students. Following the publication of Jensen's article, and then again following the publication of Herrnstein and Murray's (1994) *The Bell Curve*, which contained similar arguments, there was a steady drum of articles that, depending upon the attitudes of the writers, asserted that there are or are not genetically based differences in intelligence between races.[4] As Johnson (2012) has noted, in both Jensen's original article and in the many articles attacking or defending his position the writing is framed more in a debate style, assembling evidence for a particular position, than in the more appropriate style for scientific analysis, assembling the evidence for or against a proposition.

The result was that faculty and administrators who did not themselves study intelligence came to believe that classes on intelligence were at worst an echo of the spurious racism/eugenics arguments of the 1930s and at best a can of worms that should not be opened to avoid trouble on campus. The can of worms argument was strengthened by the fact that, due to cognitive segregation, the personal experiences of most faculty and administrators led them to believe that intelligence was not a very important topic anyway.

[4] The issue of gender is sometimes also broached, but there biologically induced differences, if they exist, are much smaller and more specialized, and hence less politically explosive.

As this issue is closely related to the issue of what should be in a course on intelligence, I should make my position clear at the outset. I believe that the facts concerning ethnic and gender differences can and should be discussed. However, I also believe that a superficial discussions of these issues can easily be misunderstood. Therefore, considerable care should be taken to avoid superficiality and to avoid overstating the strength of the evidence on one side or the other of the debate (Hunt & Carlson, 2007). Such care has not always been taken. The instructors of future courses on intelligence should not repeat this error.

## 2. Before the course begins

In this section, I discuss decisions that have to be made about the course as a whole. The next section will discuss the teaching of specific topics.

### *2.1. The goal of the course*

The first decision an instructor has to make is why the course is being taught at all. What should a course in intelligence do?

A course on intelligence should give students an understanding of the influence of individual differences in mental competence upon success (or failure) in modern life. They should further understand the dimensionality of these differences, including the dominance of the *g* dimension. Finally, they should understand the general nature of biological and social influences upon intelligence. Throughout it is important to stress places where the facts are firm and places on the frontiers of current research.

The first of these goals is by far the most important. Therefore instructors must avoid the trap of getting bogged down in discussions of, say, the relative merits of the Cattell–Horn–Carroll (CHC) model of fluid and crystallized intelligence (Gf and Gc), or the details of the P-FIT model of the neural circuitry underlying intelligence. Avoiding the trap is hard to do, because debates over the merits of different models and examinations of the details of neural circuits are what we specialists do. There is an understandable desire to talk about our own activities. In addition, we accept the importance of intelligence before the class begins. *Many undergraduate students do not start with the assumption that intelligence is as important in modern society as, in fact, it is*. The instructor must discipline his or her approach so that the main message is not lost in detail. For those students who become interested in the topic the details can come later, in seminars and graduate courses.

Having said this, it is of course important that students understand something of the issues relating to psychometric description, biological and social causes of intelligence, and some understanding of demographics. As for the latter, it is probably good to regard differences associated with age groups, at both the developmental and senior citizen level, as the most important demographic issue to be discussed. After all, everyone ages. Male–female differences come next. This is an area in which it is very important to distinguish between fact and opinion. It is also an area where an instructor wants to think carefully about how the facts are to be presented, and how unresolved issues are to be highlighted.

Ethnic, racial, and international differences should, in my opinion, either come last or be saved for a seminar. This is not because they are unimportant….I think the seminar or advanced course should exist. However, I think that the complexity of causal effects related to racial, ethnic and national differences are far best discussed after students have acquired some sophistication in understanding the nature of intelligence and the strengths and weaknesses of current intelligence tests.

### *2.2. Textbooks*

Two recent textbooks (Hunt, 2011; Macintosh, 2012) present potential curricula in much the same way. Both textbooks have received favorable reviews (Mayer, 2011; Sternberg, 2012, in press; Stoet, 2012; Widaman, 2012). As I authored one of the books anything I say should be taken with a grain of salt! On the whole, I agree with Sternberg, who reviewed both books, for different journals. What I see as the gist of his reviews is that Hunt (2011) presents a deeper treatment of individual topics, but of necessity, this means that my book requires more student effort than does the Macintosh text. I'd add that in my opinion Macintosh does a better job with the history of intelligence than I did! Anyone who is considering teaching a course on intelligence should examine both texts.

### *2.3. Student preparation*

The depth to which an instructor can go will depend upon the background of the students. Ideally, students entering a course on intelligence should have some understanding of statistical regression, including correlation, should be familiar with the basic concepts of modern genetics, and should have taken an introductory course on cognition. That ideal will seldom be met! At the outset of the course, an instructor should try to determine how much students already know about these topics. Depending upon the situation, it may be necessary to offer some supplementary instruction. The two textbooks cited both provide summaries of the necessary knowledge concerning statistics and genetics.

### *2.4. The manner of teaching*

Lecturing is an efficient way of delivering information to students' ears, but it is often not an effective way of placing information into the brain. Generations of research have shown that the more actively involved a student is, the more the student is likely to comprehend and retain the course material. On the other hand, the supervision of active student learning groups places much more demand on an instructor's time and talent than is required for the preparation and delivery of lectures.

Educators currently recommend the formation of student study groups, who meet outside of class. However this is difficult to arrange due to the students' own complex schedules. In urban universities it is virtually impossible, for many undergraduates have jobs off-campus. The internet to the rescue! Virtual discussion groups can be an effective way of gaining the benefits of study groups. In addition to the studying function, these groups can also be given assignments that are to be reported, in person, to the class as a whole.

Study groups can be initiated either by students or by the instructor. On the whole, I prefer a system where the instructor randomly creates groups of four or five students. The reason for this is that student-formed groups will be influenced by prior social contacts, including membership in "compatible" social groups, such as fraternities and sororities or other campus social groups. Within a university, and especially within a large urban public university, this can lead to the sort of social and cognitive self-segregation that many observers see as a worrisome trend in society (e.g. Murray, 2012).

Industrial experience with virtual groups suggests that the groups should not rely entirely on electronic communication. In-person meetings can be useful, especially at the start of the term. Whether or not the instructor should monitor group discussions is debatable. On the one hand, the instructor's input can be helpful in keeping a group on-track. On the other, it does smack of big-brotherism, and may be resented as such. In addition, as a sheer practical matter, monitoring as few as four or five groups can take a great deal of the instructor's time.

The issue of grading is a complex one. My remarks here apply to teaching junior and senior level undergraduate courses in general, for there is nothing special about the teaching of intelligence.

Frequent small quizzes are probably better teaching devices than an end-of-course examination. Indeed, the end of course examination is an exercise in certification, not instruction. However, someone has to read the quizzes and, hopefully, provide comments rather than checking off right and wrong answers. This again takes the instructor's time. Group reports should be evaluated, with feedback. The question of distributing credits is a knotty one. Giving every member of the group the same grade is probably the commonest practice, and certainly the easiest to execute. The only alternative that I know of is to have the members themselves indicate what the distribution of credit should be for a given project or report. Instructors can justify this by pointing out that this is essentially a version of the "360 evaluation" that is being increasingly used in industry and the Armed Forces. In a 360 evaluation a person's performance is simultaneously evaluated by the supervisor, peers, and (not relevant in the college setting) direct subordinates.

The bad news is that all of these methods of teaching require much more instructor involvement than giving a series of lectures, with a mid-term and end-of-course examination.

My experience and observations over my career were that university administrators exhort faculty to take the extra time to do good teaching, and then distribute money according to research output. B.F. Skinner would not have approved of this distribution of pellets. But, then, the administrators may be correct that the faculty are not quite as good at discriminating payoff rates as were Skinner's rats and pigeons. Everyone will have to consider his or her institution's overt and covert policies. Besides, good teaching is virtuous, and virtue its own reward.[5]

[5] This statement should be read with the same intonation that is used in a scene in the 1950s stage and film musical comedy *Kismet*, in which the Wazier's somewhat oversexed wife, Lalume, sings of the benefits of virtue as she seduces the hero.

## 3. The curriculum

### 3.1. General remarks

The trait of intelligence touches on so many aspects of modern life that any one quarter or one semester course cannot possibly present an adequate treatment of everything relevant. My belief is that it is far better to cover a few things well than to cover a large number of topics superficially. In this section I will describe some of the topics that I feel should be covered in a first course on intelligence. A graduate course would, of course, be both deeper and more specialized. However, every instructor will have to make his or her own choice. There is a guide that these instructors can follow. Examine the textbooks by Hunt (2011) and Macintosh (2012). If both authors spend a good deal of time on a topic it probably should be in the course.

### 3.2. The introductory section

This is probably the most important section of the course, for it is where students have to be convinced that intelligence is a topic worth knowing about.

### 3.3. The introductory sessions: The importance of intelligence in modern life

There is ample data showing how important intelligence is in a modern society. The relevant facts lend themselves to graphs and tables. Relying solely on such media to present the material is a good way to teach if (a) you want your students to have knowledge that lasts through the final exam but no more or (b) if you are teaching a course titled: Intelligence for Statistics and Mathematics Majors. Otherwise, the course should provide students with direct experience and memorable anecdotes about intelligence. The graphs and tables should be presented, after the students have been convinced that they ought to pay attention to them.

The first thing to do is to have students realize that in a very large society any one person's experiences very much reflect local situations, possibly at the expense of highlighting global differences. Cognitive stratification is a good example of this, and the students should be made to realize how deeply cognitive stratification is embedded in our society.

Ask members of the audience, which I assume to be university students at the second year level or above, to think of their friends, people whom they might have as dinner guests or go with to social events. Then ask the students (or faculty, with whom the demonstration works even better) how many of these close friends do not attend or did not graduate from college. At this point, present data on the relative frequency of bachelor's degree holders in the population. According to the Bureau of the Census Current Population Survey, the 2012 figure for the US population was .29. Cognitive Stratification will have been demonstrated.[6]

[6] This demonstration may not work at an institution where a substantial number of students representing students who are the first generation of students to come from their families. In this case the question can be modified by asking how many of the adult generation (i.e. the student's families) have close friends who are an approximately equal mix of people who have and have not attended college.

Extra-class group exercises are also a good way to illustrate the importance of intelligence. One that I have used is to have groups of students visit public businesses, such as a fast food restaurant or a coffee shop, and observe what cognitive skills are required of the workers. In addition, the students should observe the design of the business and ask what cognitive skills are needed to design and manage the shop. A MacDonald's restaurant provides a particularly good example. It does not take much cognitive power to work at MacDonald's, but a lot of thought went into the design of the restaurant.[7]

### 3.4. First hand experience with the tests

Scientific arguments are based on data. Therefore, you cannot understand any science without having an understanding of its measuring instruments. The next thing to do is to have students look at some of the tests themselves.

I would offer a *brief* discussion of the history of testing, emphasizing what I consider to be the real message of Binet's work.[8] This is that it is possible to get a non-trivial estimate of a person's intelligence by what amounts to a structured interview that takes at most three hours. It might be useful to have selected students stage a “debate” based on the 1920s exchanges between Harvard Professor E.G. Boring and the (to become famous) journalist Walter Lippmann. The issues they raised are relevant today. See Hunt (2011) for comments.

I would then have students examine, first hand, some of the different tests that are used to evaluate cognitive competence (A great deal of information about specific tests, including sample questions, is available on websites). Particular interest should be paid to the variety of tests that, in spite of their superficial differences, appear to be measuring the same thing. The WAIS tests are obvious choices for discussion. I would also compare the SAT (with which most students will be familiar) to the Armed Forces Qualifying Test (AFQT), which is extensively described in its website. This contrast illustrates the difference between two tests that are intended to measure much the same skills, but in two different populations.

Two other tests are of interest because they are so different both from each other and other tests. These are progressive matrices tests, epitomized by the RAVEN series (which can also be used to illustrate how tests can be varied in difficulty within the same format) and the WONDERLIC test. Examining the WONDERLIC sets the stage for a subsequent discussion of the Working Memory–Control of Attention (WMCA) complex.

This is an area where the student groups and classroom reports can be used to good effect.

I would include in this section a discussion of the limits on testing as evaluations of traits that are clearly in the cognitive domain. There have been many discussions of (alleged) limits, notably by Howard Gardner (1993)) and by Robert Sternberg (1996). While these attacks on testing have been highly publicized, I find the points made by Keith Stanovich (2009) to be both more sophisticated and more constructive. This is a point where I would go to a lecture mode, perhaps by comparing Lippmann's concerns to those expressed by Gardner, Stanovich and Sternberg. Instructors using the Hunt text might consider the extent to which the causes for limits on testing discussed by Hunt inevitably lead to the effect of limited evaluations deplored by the critics of conventional testing.

### 3.5. Global views of testing and classification

Having discussed what the tests are, I would then present the evidence that test scores predict performance in a wide variety of settings, both in and out of academia. Here we can (finally!) turn to the presentation of data in conventional lecture format. This section can be concluded with a brief discussion of the problems associated with using imperfect predictors. It is important that students realize that in many situations selections have to be made, and that the issue is not whether or not a test is perfect, but whether it is a cost-effective technique for classification.

It is possible to have “in class” discussion or possibly guest lecturers offering two different views on testing. One is the view of the clinical or school psychologist, who uses the test to develop of a program for a particular individual, the other is the view of the personnel officer, who uses tests to select the best recruit(s) from a population of candidates. As an alternative to guest lecturers, have student groups role play the tasks of a clinician or school psychologist, who uses testing to plot a course of aid for an individual, and human resource specialist (aka University registrar?) who uses tests to select the best workforce or entering class. A fascinating, but certainly atypical case is provided by Santy's (1994) description of psychological testing in the US and Soviet astronaut/cosmonaut programs.

An alternative “in class” discussion could focus on behaviors at the upper and lower levels of the normal range of intelligence.

### 3.6. Psychometrics

Hopefully, the preceding section of the course will have driven home the point that intelligence is worth studying. The next thing to do is to introduce psychometric models.

Factor analysis can actually be discussed without algebra, although doing so requires some ingenious graphs. Students should also be shown how to interpret structural equation models (SEMs), as this skill will be needed later when discussing the causes of intelligence.

I would limit the discussion of psychometric models to two prominent ones; the general intelligence plus verbal, perceptual, and rotational dimensions (*g*-VPR) model proposed by Johnson and Bouchard (2005) and the older Fluid-Crystallized (Gf-Gc) model developed by Cattell and Horn, and then revised and amplified by Carroll (1993). These models are of interest because the *g*-VPR model is the best statistical summary of the psychometric data, but the Gf-Gc model may be the most useful model to use in educational and industrial settings. It may also be the most useful one to use when considering the effect of an aging workforce.

[7] Your institution's IRB should be consulted beforehand. It's also worth noting that, with the exception of certain police and security functions, observation of public officials performing their duty is always permissible. Sitting in the back of a low level magistrate's court, such as traffic court, where defendants speak for themselves rather than through attorneys, can provide illustrations of varying intelligence.

[8] This is one of the few places where Hunt (2011) and Macintosh (2012) differ in their coverage. Macintosh spends much more time on history than does Hunt.

This can lead to an interesting debate between groups of students charged with defending either model. With luck, the debate could get students to consider two different uses of scientific models; as summaries of data and as guides to action.

While *g* and the closely related Gf dimension are likely to dominate the discussion of psychometric models, some attention should be paid to the separate verbal (V) and two perceptual (PR) dimensions of the Johnson & Bouchard model. I have often used the following in-class exercise to illustrate (a) one of the practical aspects of the R dimension and (b) how much variance college students may show on a dimension that is not part of the admissions screening process.

Ask students to close their eyes and then point to some prominent campus landmark that is not visible from the classroom. Keeping their hands pointed to the landmark, the students should then open their eyes and look about them. Every time I have tried this exercise there has been a great deal of variety in the directions people point, and if there are more than a dozen people in the room there is a good chance that at least two students will be pointing at each other.

A discussion of the V and R dimensions also provides an opportunity to introduce the topic of gender differences, which are negligible with respect to general intelligence, but do occur on tests that have high loadings on either the verbal (V) or rotational (R) dimensions of the Johnson & Bouchard model.

An interesting topic for group reports is a discussion of how society demands different aspects of intelligence. Hunt and Madhyastha (2012), in a journal that is probably not often read by intelligence researchers, show that factor analysis of the cognitive demands of occupations, not people, produces a dimension that looks very much like *g*. Further discussions of the cognitive demands of specific occupations can be found on the US Department of Labor's O*NET Web Page.[9] It can also be useful to make comparisons of the demands placed on verbal intelligence (and crystallized knowledge) by publications addressed to different audiences, for instance contrasting the style of writing used by the *New York Times* to that in *USA Today*. Another interesting example of cognitive demands on both verbal and spatial–visual reading is offered by a cognitive analysis of instruction manuals for assembling furniture and machinery.

### *3.7. The causes of intelligence*

A discussion of the causes of intelligence poses problems for the instructor, for two reasons. The first is that the best teaching technique, proceeding from the concrete to the abstract, is opposed by the fact that some of the most important things students should take away from this section of the course are, in fact, abstract concepts needed to understand arguments about causality. Most of these concepts will be as relevant years from now as they are today, while research yet to be done will in all probability give us a more specific understanding of specific biological and social causes of intelligence. I suggest that discussions of causation should be broken down into three sections; general issues, biological issues, and social–educational issues.

#### *3.7.1. General issues*

The first thing to do is to establish the distinction between *proximal* and *distal* causes. This should be tied into a general discussion of the relation between genetic and environmental causes of intelligence. Students should understand that (a) there is no genetic inheritance that dictates a person's intelligence but (b) genetic inheritance exerts a substantial influence upon how intelligence develops in different environments. Understanding the concept of *reaction range* is important. Students should also understand that the heritability coefficient, *h*, is a measure of the relative importance of genetic variation compared to the sum of genetic and environmental variation, and therefore can be changed either by changing the range of genetic and environmental effects. A line that will be useful as long as students are familiar with the *Star War* films is that

> In the Imperial Army h was zero, because all the soldiers were clones, and so there was no genetic variance.

Then point out that there is an analogous argument for the environment. Schooling affects intelligence. Therefore:

> If all children were given exactly equal educational opportunities, the value of h would increase because the environmental variance would decrease.

#### *3.7.2. Biological influences*

Students should accept that behavior is, ultimately, controlled by the brain, and hence is biological. Therefore in addition to genetic effects, both physical events (e.g. drug use) or social events (e.g. education) produce their effects by changing the brain. These changes may be either structural or they may be the result of reorganization of neural networks, which implies neural plasticity.

There are three important, well established research findings about the biology of intelligence that students should know. The first finding is that within the normal range intelligence is polygenetic, and that no one gene accounts for a great deal of the variation. This is somewhat paradoxical, given that there are a large number of syndromes that are largely due to anomalies associated with a small number of genes. The second finding is that the abilities associated with the control of attention and maintenance of working memory, which are central to general intelligence, depend largely upon the dorso-lateral prefrontal and the parietal cortex, as described in Jung and Haier's (2008) P-FIT model. The third finding is that intelligence is associated with the development of neural networks that process information efficiently, so that the intelligent (and the practiced) brain uses less metabolic energy to process a problem than does the less intelligent (or less practiced) brain. This carries with it the added implication that neural plasticity is important in establishing intelligence.

The topic of biological influences naturally lends itself to a number of group projects and reports. One of the easiest ways to illustrate genetic effects is to examine the results from twin studies, including the several reports that we now have of twins raised apart. These are discussed in both the

[9] www.onetonline.org.

suggested textbooks, which provide good starting points for students interested in developing the topic further.

Discussions of the effect of direct injuries to the brain can be useful at this point. For instance, one group could report on studies of the centrality of working memory, followed by a second group discussing some case studies associated with injury to some component of the P-FIT circuit. The case of Phineas Gage (Damasio, Grabowski, Randall, Galaburda, & Damasio, 1994) is a natural. This can be supplemented by discussions of more modern cases of forebrain damage. Sadly, these often occur as a result of concussions that can cause the brain to bounce when an athletic or military helmet receives a severe blow. Students might look at descriptions of the types of behavior that are associated with such injuries.

Students often find it interesting to examine (and debunk) advertising claims. There are a number of commercial companies that claim, aggressively, that their procedures or products will "train the brain." One writer of such programs even claimed (without offering any evidence) that mental functioning could be improved by brushing teeth with the non-dominant hand, on the grounds that this would exercise unused brain circuits![10] Other commercial brain-training programs are more closely tied to experimental studies of the effects of training working memory–control of attention functions. A group presentation describing and evaluating these program could be especially useful.

Note that the same thing could be said for advertisements claiming to improve the brain by either dietary or pharmacological intervention. What mechanisms are supposed to be affected, and what evidence is offered that the agents actually work?

This is a point at which some discussions of the normal development and deterioration of the brain can be discussed. Student can find well documented studies showing that the P-FIT circuit is not completely connected until (in most cases) latter adolescence, and that the prefrontal region is susceptible to the ravages associated with aging, disease, and alcoholism.

Parenthetically, a similar case can be made for discussions of plasticity in and damage to the hippocampus and related structures associated with the establishment of declarative memories. Most students will have some familiarity with total amnesias associated with hippocampal destruction, such as the famous HM case. They will be less familiar with the reduced memory capabilities associated with alcoholism and extreme vitamin deficiency, as in Korsakoff's syndrome, or demonstrations of neural plasticity in the adult hippocampus. The discussion of increased hippocampal volume in London taxicab driver (Maguire et al., 2000) provides an interesting example.

This is also a point in the course where discussions of aging are appropriate. Three things can be stressed, each of which is appropriate for a discussion group report. They are (a) the stability of a person's relative intelligence in the population, in spite of considerable changes in level of absolute competence, (b) the pattern of change in performance evidenced by the Gc-Gf distinction, and (c) changes in brain structure and function associated with advancing age.

[10] This surprising claim was featured on the XFINITY website in May of 2013.

### 3.7.3. Environmental influences

A useful way to begin the study of environmental influences is to present students with the evidence for changes in the level of intelligence over the 20th century, the "Flynn Effect" (Flynn, 2012). Point out that this effect is analogous to the measurement of *h* in behavioral genetics, the changes tell us that the environment is important (as *h* tells us that the genes are) but do not tell us what is important. Then go into the specifics.

Environmental influences can be divided into two classes; environmental influences that affect the brain as an information processing machine, regardless of the external referent of the information being processed, and environmental influences that determine what the mind knows about the world. For brevity, I will refer to these as "physical" and "information" influences.

Students should learn that there are a substantial number of physical agents that can influence intelligence. These run the gamut from good (or poor) infant nutrition to the excessive ingestion of alcohol (bad), maintaining a healthy cardiovascular system (good, because the brain gets an adequate supply of blood) and exposure to environmental pollutants such as lead (not as bad as things were but still a problem).

The student also needs to appreciate the fact that a great deal of human thinking depends upon the use of 'cognitive artifacts' that have been developed over the last 6000 years, starting with the writing and number systems. The development continues to this day, through the development of logical and mathematical reasoning and, very recently, such things as electronic information processing systems. Throughout history intelligence has been associated with the ability to use these artifacts to advantage. One or more groups might consider how changes in the technology used to assist in cognition may change the demands on intelligence. For instance, what does the advent of "robotic" (technically, teleoperated) surgical devices do to the demands on a surgeon's visual–spatial reasoning?

Students should learn that intelligence is associated with increased schooling, as this is where we learn to use the cognitive artifacts of our culture. They should also learn about the benefits of home environments and the efficacy of adequate, intensive pre-school instruction. They should also realize that most "Head Start" and similar programs fall far short of the intensity of the programs that have been shown to have an influence. Issues involving the benefits of maintaining intelligence through mental activity in the retirement years should also be introduced.

At this point, a discussion of the influence of socioeconomic status can be inserted. Note that, like *h* and the Flynn effect, SES correlations with intelligence test scores tell us that something is happening, but do not specify just how it is happening.

As in the case of biological influences, there are a large number of topics for group analysis and reports.

The story of attempts to reduce lead pollution is fascinating. The deleterious effects were noted over 2000 years ago, which began a fight between proponents of public health and proponents of industrial efficiency (and profit). A group of students could review this fight, and then ask what other pollutants might be present in our own environment… including the environments of "3rd world" countries who provide cheap labor for the industrially advanced nations.

A good place to start is a discussion of the recycling process for consumer electronics.

Similar discussions can be offered about the effects of nutrition. Here it is useful to make a distinction between extreme, prolonged malnutrition, such as may be observed in third world countries racked by war, brief periods of malnutrition, and the (alleged) effects of poor dietary practices within the advanced countries.

A group might report a fascinating, if not ultimately successful, attempt to increase intelligence. In the 1980s the government of Venezuela embarked on an effort to increase the intelligence of all school children in the nation (Herrnstein, Nickerson, de Sanchez, & Swets, 1986). While the project was ultimately abandoned due to political changes, the idea is certainly interesting. A discussion of this project could serve as a lead-in for a discussion of how schools ought to be organized to improve intelligence. A point to make here is that a good education both instills knowledge, and provides students with a way of recognizing when that knowledge is to be used. There are interesting examples in the literature on medicine and physics where it is clear that students have acquired relevant knowledge, but fail to exercise it outside the classroom.

## 4. Wrapping it up

At this point, it is highly likely that the term will be at an end. This is the point at which students can, indirectly, give an instructor feedback. Have students discuss, openly and with each other (but with the instructor looking on, mouth shut) what they think are the most important lessons of the course.

## 5. What has not been said

I have excluded from my discussion three topics that are sometimes introduced into classes on intelligence. These omissions should be, if not justified, at least commented upon.

I have not discussed mental retardation. I regard this as a topic for another course, for two reasons. The first is causation. A great deal has been learned about the biological causes of many of the commoner forms of mental retardation. Using some of this knowledge as an illustration is worthwhile; for instance using Down's syndrome or Huntington's syndrome as illustrations of effects that can be produced by chromosomal or genetic anomalies. The second reason is amelioration. A discussion of support systems required by those unfortunate people who require some form of assisted living is important, but is simply too much for an undergraduate course on intelligence.

Another omission is any discussion of the evolution of intelligence. If it can be worked in during an introductory lecture, I would spend a few minutes discussing brain size and encephalization ratios, and what the fossil record tells us about the evolution of *Homo sapiens*. I would not go into any elaborate discussion of the evolution of behavior prior to the historic period (roughly, the point at which writing and mathematical systems were first developed) on the simple grounds that, because behavior does not leave fossil records, we have only a general idea of the social organization and cognitive capabilities of early *H. sapiens*, let alone the predecessor hominids. There is enough solid information about intelligence in the modern world so that there is no need to take course time recounting stories about how things might have happened.

The third omission, which I am sure that many readers will have noticed, is that I have not discussed racial, ethnic, or national differences in intelligence.

Differences in intelligence associated with racial, ethnic and national groups do exist, and they have important social implications. However, the distinctions themselves are “fuzzy” concepts, a person may be in one or more of these groups to some degree (Barack Obama, the 44th President of the United States, illustrates this. He is conventionally referred to as the first “Black” or “Afro-American” president. This is only half right; Mr. Obama's mother was an American Mid-West White, his father was a Kenyan African). Nations come and go, and are often non-comparable (Tonga and the People's Republic of China are both members of the United Nations!). Because of immigration, many nations have shifting population characteristics. Therefore, any discussion of differences in intelligence across such fluid demographic groups will, of necessity, involve discussions of definitions of intelligence across groups, genetic, physical and social environmental differences, and the influence of social policies. It is extremely difficult to separate the scientific discussion of group differences from a discussion of policy issues.

For these reasons, I do not believe that discussions of racial, ethnic, and national differences can be discussed adequately in a first course on intelligence. Furthermore, and I think the historical record shows this, inadequate discussions and off-the-cuff remarks have produced a great deal of heat and very little light. Not everyone realizes this. When I appeared as a guest lecturer in a course on cognition, taught in a major university, the instructor asked me, at the end of my talk, “What's the three minute answer on racial differences?” She was surprised when I declined to answer. However, this is exactly what an intelligent researcher on intelligence should do.

I encourage the development of seminars and specialized courses discussing group difference in intelligence. When such courses are offered every attempt should be made to require that participants first take a course on intelligence, such as the one described here. Both Hunt (2011) and Macintosh (2012) do provide discussions of racial, ethnic, and national differences in intelligence. These discussions could serve as take-off points for a seminar on group differences.

My ideal course mentions, but does not stress, male–female differences. These do exist, although with the exception of the Rotation (R) dimension of intelligence, they are not large in the industrially developed societies. The differences are partly associated with biological differences, but very much more associated with social variables. These have different force in different segments of society, and even more so across ethnic groups and national boundaries. For instance, we know that individual differences in cognitive competence are influenced by education, and if, as a matter of national policy, a country restricts education for women, those aspects of intelligence that are associated with education will not be developed in the female population. This is a social fact, not a scientific inevitability. Because of the complexity of the topic, I advise postponing detailed discussion for a seminar on gender differences in cognition.

## 6. Summary

The frequency of courses on intelligence has dropped over the past fifty years. This is so in spite of considerable research showing the importance of intelligence in modern society, the psychometric structure of the trait, and many of the causes of individual differences in intelligence. The drop appears to have been due to three reasons; cognitive segregation in the society, the unpopularity of overt elitism in the United States, and animosity within academia towards discussions of differences between racial and ethnic groups. Any course on intelligence has to address the first two of these two concerns by appropriate instruction. The third issue, though real, is at its heart a political issue rather than a scientific one. Carefully worked out discussions of group differences may serve to inform the political debate. Brief, shallow discussions of this topic will merely inflame it.

The contents of a first course on intelligence have been described here. The goals of this course are, first and foremost, to establish the importance of intelligence in modern life, and secondarily to provide information about the structure of intelligence and some of its causes. Emphasis has been placed on ways in which to encourage active student participation through the formation of virtual discussion groups.

I hope that these observations and suggestions will assist future instructors in preparing ever better courses on intelligence.

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