# General intelligence and specific abilities psychology essay

The development of meaningful artificial intelligence will require that machines acquire some variant of human consciousness. Systems that do not possess self-awareness and sentience will at best always be very brittle. Without these uniquely human characteristics, truly useful and powerful assistants will remain a goal to achieve. To be sure, advances in hardware, storage, and parallel processing architectures will enable ever greater leaps in functionality. But these systems will remain mechanistic zombies. Systems that are able to demonstrate conclusively that they possess self awareness, language skills, surface, shallow and deep knowledge about the world around them and their role within it will be needed going forward. However the field of artificial consciousness remains in its infancy. The early years of the 21st century should see dramatic strides forward in this area however.

During the early 2010's new services can be arise that will utilize large and very large arrays of processors. These networks of processors will be available on a purchase basis. They will be architected to form parallel processing . They will allow for reconfigurable topologies such as nearest neighbor based meshes, rings or trees. They will be available via an Internet or WIFI connection. A user will have access to systems whose power will rival that of governments in the 1980's or 1990's. Because of the nature of nearest neighbor topology, higher dimension hyper cubes (e. g. D10 or D20), can be assembled on an ad-hoc basis as necessary. A D10 ensemble, i. e. 1024 processors, is well within the grasp of today's technology. A D20, i. e. 2, 097, 152 processors is well wishing the reach of an ISP or a processor provider. Enterprising concerns will make these systems available using business models comparable to contracting with an ISP to have web space

for a web site. Application specific ensembles will gain early popularity because they will offer well defined and understood application software that can be recursively configured onto larger and larger ensembles. These larger ensembles will allow for increasingly fine grained computational modeling of real world problem domains. Over time, market awareness and sophistication will grow. With this grow will come the increasing need for more dedicated and specific types of computing ensembles.

Charles Spearman measured persons' performance on a battery of tests, with each test measuring a different mental ability. His statistical analysis showed that scores on each test were positively correlated with scores on each other test. This suggests that there is some common dimension contributing to the scores on each test. Spearman developed a statistical procedure called factor analysis, which can be used to discover the dimensions that cause the correlations among variables in a set. The results of his analysis led Spearman to conclude that there are two types of factor underlying scores on intelligence tests. One factor is g, general intelligence. Persons high in g will tend to score well on all of the tests of assorted mental abilities. The other factors are s, specific ability factors, for example, a specific ability to do well on tests of mental rotation.

Raymond Catell, who studied with Spearman, concluded that g is not one factor but two factors, fluid intelligence and crystallized intelligence. Both types of intelligence can be thought of as the mental ability to perceive relationships between object and/or events. The distinguishing characteristic between these two types of intelligence is whether or not the mental ability

is dependent on previous experience with a particular set of objects, events, and types of relationships.

Fluid intelligence is the ability to perceive relationships among objects and events that is independent of previous experience with those particular objects, events, or types of relationships. Unless you have had previous experience with this sort of problem, your performance on problems like this would be attributed to your fluid intelligence.

Crystallized intelligence, by contrast, does result from your experience with the specific objects, events, and relationships being perceived. For example, your performance on a vocabulary test is very dependent on your having been previously exposed to the words on the test. Crystallized intelligence generally increases through about age 50, presumably due to the accumulation of knowledge.

Intelligence as a Fixed Attribute of the Nervous System

Sir Francis Galton loved to measure things and correlate measures with one another. Among the things he measured were cognitive abilities of humans. Galton believed that individual differences in intelligence stem from relatively unchanging differences in the nervous systems of individuals. Galton was a bit of a snob too. For example, he concluded that persons who immigrated to America were genetically inferior to those who stayed in their home countries, that is, America was the dumping ground for all those genetically inferior persons who could not succeed in their home countries.

There has been some success in developing instruments that measure intelligence by measuring the time taken to perform some simple mental tasks. Such reaction times have even been physiologically measured, by looking for electrical changes in the brain that accompany the accomplishment of mental tasks. Such reaction time intelligence tests correlate moderately highly with traditional tests of fluid intelligence, but not as well with tests of crystallized intelligence.

It is likely that such reaction time tasks measure only one or a very few of the many brain processes involved in solving problems. Differences in intelligence may result more from differences in individuals' " cerebral central executive" than from differences in the more basic processes that accompany problem solving. The central executive is the part of the brain that organizes and controls all of the more basic processes involved in solving problems. The more efficient this central executive, the more rapidly one will be able to solve problems. With very difficult problems, it might require a very efficient central executive to be able to solve the problem in any amount of time.

It appears that our cerebral central executive is located in our frontal lobes. Solving problems that involve fluid intelligence produces strong activity in our frontal lobes. Individual differences in IQ are more strongly associated with the size of the frontal lobes than with the size of other parts of the cerebral cortex, and the age-related decline in fluid intelligence is associated with shrinkage in the frontal lobes.

# Cultural Differences in IQ

Different cultural groups perform differently on traditional tests of intelligence. For example, persons with roots in the Far East tend to score higher than persons with roots in Western Europe. Some would like to argue that these differences result from genetic differences in cultural groups. While the evidence is strong that individual differences in intelligence are to a great extent genetically determined, it does not follow that cultural differences in average intelligence are also genetically determined. Gray presents a nice explanation of how this can be so:

Imagine that we have two plots of land, one good, one lousy. The one plot is just perfect for growing corn — good soil, good drainage, few insect pests, full sunlight, and a farmer who takes good care of the crop. The other plot is lousy — poor soil, bad drainage, large populations of insects that feed on corn and diseases that infect corn, and a farmer that spends so much time drinking corn mash whiskey that he has little time to take care of the field. Assume that within each field the conditions are pretty much uniform. Now, we take a bin and throw into it several different types of corn seed, some known to produce good crops, other known to produce poor crops. We mix all this genetically diverse seed up and sow it in our two plots. Since the environmental conditions are uniform within each plot, the heritability is high within each plot — the good seed produces better yields than the poor seed. The two plots also differ with respect to yield, but not because of genetics, because of environment. Both plots got the same mixture of seeds. The good plot produced better yields than did the poor plot because it was a better environment for the growth of corn, not because it got seeds with different

genes. If we generalize this example to cultural differences in IQ, our babies are the corn seeds and the environments in babies from different cultures grow are our plots. You should not be surprised to learn that babies from different cultures experience different environments in our society.

Perhaps someday all cultural groups will have equal opportunity to all of those things that foster the development of high intelligence (good nutrition, good health care, good education, etc.). If there remained cultural differences in IQ at that point, then maybe a better case could be made that they are genetic — but even then there would be alternative explanations. For example, cultures may differ with respect to what sort of mental abilities they consider most important. Not surprisingly, those cultures which emphasize the importance of the sort of mental abilities that are tested by intelligence tests developed in Western European culture would be expected to score better on such tests than would individuals raised in cultures which emphasized other sorts of mental abilities.

## Specific Mental Abilities

If you were to gather a group of persons, all with about the same level of general intelligence, you would find that they differ with respect to how well they perform on tests of various specific mental abilities. For example, you would find that I do very well on tests of verbal ability and logical reasoning, but that I perform miserably with respect to tests of musical and visuospatial ability. One type of test that has always given me fits is test involving mental rotation. A three-dimensional figure is shown and you are asked what it would look like if you rotated it in space. You choose from several options shown. Some people solve these problems very quickly and with great ease.

Not I. Because of this deficit, I had to struggle just to get C's in mechanical drawing in high school and organic chemistry was a challenge for me in college (I went into the final with a C average but aced it an got an A for the course).

Some mental abilities seem to rely more heavily on the left cerebral hemisphere (those associated with language and verbal reasoning), while others rely more on the right cerebral hemisphere (the sort of visuospatial abilities on which I am deficient). Damage (such as that produced by a stroke) to the left cerebral hemisphere may cause drops in scores on tests of verbal ability, while damage to the right cerebral hemisphere produces drops in scores on tests of visuospatial ability.

Some persons have amazing ability in one of two very specific areas but very limited ability in all other domains. Such persons are called retarded savants (or idiot savants). For example, consider a person who can give you the correct answer for the product of any two 6 digit numbers, but performs way below average on any other test of mental ability you can give him.

The sort of mental abilities that might serve one well in the world of work may well be different that those that serve one well in school, depending on what your type of work is. For me, it is clear that the abilities measured by traditional intelligence tests (designed to measure abilities needed for school work) serve me well in my work. I might not, however, be considered such a smart guy if I my work were carpentry (I would probably be out of work most of the time).

If you study those persons who have developed greatly superior ability in a single domain, such as music, art, chess, etc., the one thing you find in common is that they all practice longer and more intensely than do others in their field — but before you jump to the conclusion that the association between practice and expertise points just to an environmental/experiential determinant of superior ability, remember habitat selection — these person's drive to excel may be, at least in part, determined by the genes they inherited from their parents.

A heuristic (from the Greek word for " to discover") is a shortcut that may allow one to solve the problem with fewer steps. For example, for the above problem, consider this heuristic: Arrange the scores in ascending order and then determine whether the frequency distribution of scores is symmetric (it is for our scores). If so, just find the middle score.

## Language and Thought

Language appears to be more highly developed in humans than in any other species of animal. Language allows us to hook our brains together and create a thinking machine much more powerful than a single brain. Language also provides one way for us to think. When we are engaged in verbal thought, we are thinking in words, even though we are not communicating with anybody other than our self.

## Program Learning

An optimization problem may be defined as follows: a solution space S is specified, together with some scoring function on solutions, where " solving the problem" corresponds to discovering a solution in S with a sufficiently

high score. Let's define program learning as follows: given a program space P, a behavior space B, an execution function exec : P â†' B, and a scoring function on behaviors, " solving the problem" corresponds to discovering a program p in P whose corresponding behavior, exec(p), has a sufficiently high score.

This extended formalism can of course be entirely vacuous – the behavior space could be identical to the program space, and the execution function simply identity, allowing any optimization problem to be cast as a problem of program learning. The utility of this specification arises when we make interesting assumptions regarding the program and behavior spaces, and the execution and scoring functions:

Open-endedness – P has a natural " program size" measure – programs may be enumerated from smallest to largest, and there is no obvious problem-independent upper bound on program size.

Over-representation – exec often maps many programs to the same behavior.

Compositional hierarchy – programs themselves have an intrinsic hierarchical organization, and may contain subprograms which are themselves members of P or some related program space. This provides a natural family of distance measures on programs, in terms of the the number and type of compositions / decompositions needed to transform one program into another (i. e., edit distance).

Chaotic Execution – very similar programs may have very different behaviors.

Precise mathematical definitions could be given for all of these properties but would provide little insight – it is more instructive to simply note their ubiquity in symbolic representations; human programming languages (LISP, C, etc.), Boolean and real-valued formulae, pattern-matching systems, automata, and many more. The crux of this line of thought is that the combination of these four factors conspires to scramble scoring functions – even if the mapping from behaviors to scores is separable or nearly decomposable, the complex program space and chaotic execution function will often quickly lead to intractability as problem size grows. These properties are not superficial inconveniences that can be circumvented by some particularly clever encoding. On the contrary, they are the essential characteristics that give programs the power to compress knowledge and generalize correctly, in contrast to flat, inert representations such as lookup tables.

The consequences of this particular kind of complexity, together with the fact that most program spaces of interest are combinatorial very large, might lead one to believe that competent program evolution is impossible. Not so: program learning tasks of interest have a compact structure – they are not " needle in haystack" problems or uncorrelated fitness landscapes, although they can certainly be encoded as such. The most one can definitively state is that algorithm foo, methodology bar, or representation baz is unsuitable for expressing and exploiting the regularities that occur across interesting program spaces. Some of these regularities are as follows: