INTELLIGENCE – FROM THEORY AND EVALUATION TO METHODS FOR IMPROVEMENT

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ABSTRACT. The present paper analyses the best known theories regarding intelligence and retraces their origins and the way these evolved in time up to the present moment. A middle-way common sense approach was maintained by analyzing not only the bookish, textbook perspective on the subject, but also looking at the problem through the eyes of the non-specialist.

Some intelligence definitions are given, together with a brief discussion on the difficulties that one encounters when trying to define intelligence. A strong emphasis is placed on the idea that no perfect definition exists to this day.

A brief look at the problem of plant and animal intelligence follows, aimed at helping us appreciate how complex the problem really is. Modalities of analyzing and measuring intelligence are discussed next. The basic principles of measuring intelligence are covered and we follow the evolution of IQ testing from the start to modern days. The measurement discussion ends with bringing to attention the problems and imperfections of different intelligence tests and the critical remarks of researchers who argue against the use of intelligence testing. The paper ends with some practical applications of the ideas outlined so far such as the use of intelligence testing for detecting and helping people who are on the extremes of the intelligence quotient scale.

KEYWORDS: intelligence, tests, IQ, gifted.

1. INTRODUCTION

Although it is one of the subjects who are extremely debated in psychology and in society, although the studies focusing on understanding the mechanisms that generate human intelligence are numerous, many of them quite recent, although it represents a subject with huge implications both for psychology and for human society in general, intelligence does not have up to this point in time a clear, unique definition, agreed upon by the majority of researchers who have devoted their time to studying this fascinating domain.

As is the case with many important subjects in psychology, the answer to the question "What is intelligence?" seams simple, quite obvious for the majority of those questioned. That is, until we try to articulate it in a cursive manner, eventually to write it down – a moment when most of us come to acknowledge the difference between intuitive knowledge and discursive knowledge, based on ontological categories. We will step out of that dilemma in our study by bringing forward some definitions of intelligence which are currently accepted and in use:

"General mental ability, that amongst other things encompasses the ability to reason, plan and solve problems, to use abstract thinking, to understand complex ideas, to learn fast, to learn from past experience. Intelligence is not only the ability to learn from books and it is nor a purely academic ability, nor is it solely related to the results of a test. It represents a far larger ability to understand and adapt to the environment we live in".

"General mental capacity involved in calculating, reasoning, the perception of analogies and relationships, understanding, retaining and accessing information, fluent use of language, classification, generalization and adapting to new situations" (Columbia Encyclopaedia, 2006).

In order to understand the complexity of the problem, another attempt to define intelligence using the Report published in 1995 by a commission of the American Psychology Association (APA report) is presented: "Individuals differ in regard to their ability to understand complex ideas, to adapt efficiently to the environment, to learn from new experiences, to get involved in different forms of thinking, to try to overcome the obstacles they encounter using reason. Although these differences between individuals can be significant, they are not constants: a person's intellectual ability is variable depending on the moment, on the domain of study or on other different criteria. Different concepts of intelligence are attempts to clarify and organize this complex set of phenomena. Although in some domains a considerable level of clarity has been attained, no such conceptual arrangement has answered to all of our questions and none has met general agreement.

Thus, recently, when twenty prominent theorists of the field have been asked to define intelligence, they offered twenty somewhat different definitions".

Here are some of the "personal definitions" of the specialists:"Ability to judge, practical sense, ability to adapt to circumstances" (Alfred Binet); "The process of acquiring, storing in memory, recovering, combining and using information in new contexts" (Lloyd Humphreys); "The ability to face cognitive complexity" (Linda Gottfredson); "Adaptative behaviour aimed to reaching certain objectives" (Sternberg & Salter); "Propensity, unique to human beings, to modify or change the structure of their cognitive function in order to adapt to variable demands of a certain life situation" (Reuven Feuerstein) (Neisser et al., 1998).

The fact that a unique and exact definition is missing, underlines the complexity of the phenomenon called intelligence, but it does not keep us from analyzing it better. In this study, a shorter definition is used, that encompasses what is considered to be the fundamental element of all the definitions cited above:

Intelligence is the ability to understand simpler or more complex data from the environment people live in, to make them personal and to use them in an adaptative way, sometimes in completely different circumstances from those that were present when we received those data (Goh et al., 2003)..

2. THEORIES ABOUT INTELLIGENCE - ONE OR MULTIPLE INTELLIGENCES

There are currently two major schools of thought with different visions of the nature and attributes of human intelligence. The first point of view supported by psychologists such as Eysenck, Galton, Jensen or Spearman believes that any form of intelligence comes from a single source, a general intelligence factor named g (Neisser et al., 1998).

The main argument used by this school to uphold the ideas is represented by extremely strong correlation between results obtained by the same individual being tested at various tests that assess aspects that are independent of the cognitive function.

Thus, it was found that often, people who obtain very good results in tests that check mathematical skills also get superior results from tests that verify the language skills or three-dimensional thinking.

The conclusion drawn by the authors is a simple one: it's normal to be so since both types of problems are solved by making an appeal to the same information, the same informational tools, that so-called unique intelligence (Neisser et al., 1998).

The explanation provided seems simplistic, and its authors have received reproaches about that. Their attention was drawn to the fact that in solving some tasks like the correct use of language or mathematical calculation a large number of factors are involved.

Among them are economical factors (the access to education helps develop both of the components we mentioned), social factors (different environments that put greater emphasis on development of communication will mean important language development, sometimes at the expense of other cognitive abilities) or even emotional factors that relate to the testing or the conditions in which it takes place.

Another argument in favour of the theory of a single intelligence, created to respond to the criticisms mentioned above is the strong correlation between response time to occurrence of a stimulus and improved outcomes for an individual in intelligence tests.

Eysenck found a clear correlation, with strong statistical significance between the short reaction time to a light stimulus appearance and good results in various types of intelligence tests.

Since the response to a light stimulus is a conditioned reflex, easily executed, not dependent on environmental conditions or education, only dependent on the good functioning of the sense organs, the cortex, the neural pathways involved (afferent and efferent), the correlation observed between high levels of intelligence demonstrated by tests can only be explained by the existence of a single factor responsible for human intelligence (Eysenck, 1982).

This important current of thinking is opposed by those who believe there are many forms of intelligence. From their ranks we will only mention Gardner or Sternberg, which have the greatest merit in creating and sustaining this concept.

Gardner's theory, which is probably the best known plead for seven different forms of intelligence. They are: linguistic intelligence, logical-mathematical, bodily, spatial, musical, interpersonal and intra-personal intelligence (Gardner, 1983, 1993, 1999).

Two aspects regarding Gardner's theory must be understood from the start:

One of the premises is represented by psychometric tests used to measure intelligence only look at language skills, mathematical or spatial abilities and completely ignore extraordinary skills in areas such as art, music or sport.

The second important premise is the idea that intelligence has an important biological basis that depends on the way the brain is functioning. Studying people with different disabilities, Gardner identified

different brain areas responsible exclusively for the execution of one function only (speech, logic, spatial view, movement).
He concluded from that, that different cognitive tasks are performed exclusively in certain areas of the cortex, so that there are multiple forms of intelligence (Gardner, 1999).
The hypotheses from which Gardner started are correct and the conclusions which he drew are also correct if we think about the level of information he had access to (Gardner, 1983).
The development of neurosciences, particularly due to new imagery methods has offered access to a lot of new information in this direction and this new information is what allows us to say that the ideas presented above are in fact oversimplified. Thanks to magnetic resonance imaging we now know that although there cortical areas devoted to a particular type of information processing, cognitive thinking and solving tasks is done by integrating information from many such dedicated areas, which is done using specialized neural connections, dedicated to this purpose.
Another form of the theory which involves several forms of intelligence was proposed by Sternberg. Similar to Gardner's theory, it takes into account the existence of specific forms of intelligence that allow individuals to achieve incredible levels of performance in sport or art world.
What is new in Sternberg's theory is the idea that the whole spectrum of human intelligence can be divided into academic and practical intelligence. Academic intelligence would be in his view equal to analytical intelligence, represented mostly by theoretical problems, frequently formulated by people who are situated outside the problem.
Such problems are well defined, the problem containing all the data needed to solve it, and typically have a single solution. Opposite to that there is practical intelligence, seen in the problems that life confronts us with, where we do not have all the information at our disposal, the situations are ambiguous and the possible answers are many (Sternberg, 1997).
Although it sounds abstract, Sternberg's theory is highly influential, mainly because it has proved its utility. Everyone knows youngsters that understand enough mathematics to do small business on the streets with friends, but who are absolutely unable to pass a fourth grade maths test. Such evidence suggests the existence of a mathematical intelligence of an academic type that works parallel to and is not correlated with the practical type mathematical intelligence.

3. WAYS OF MEASURING INTELLIGENCE

If one takes into account the number and the complexity of the factors involved in generating intelligence we can understand at least intuitively the problems faced by researchers who developed the first intelligence tests.
From a historical point of view, the first attempts to measure human intelligence started from completely wrong premises. Sir Francis Galton (1822–1911), a known British scientist, proposed that intelligence be measured by analyzing the size and shape of a person's head. The idea was unfortunately accepted enthusiastically by several members of the scientific establishment of the time, some modified forms of it being still in use today (Bulmer, 1999).
Leaving aside the bad premises that started it, Galton's idea had a major fault: in the researcher's mind the conclusion was already drawn and the results only had the role to support it. Galton, a member of the British aristocracy, benefiting from an exemplar education for those times (limited to wealthy people) wanted to prove that intelligence is transmitted from one generation to the next inside the rich people's class, considered to be "superior", his logic being that the size of the cranium is genetically determined and it cannot be modified and the brain depends on the size of the cranium.
Numerous subsequent studies have disproved virtually every one of these assumptions: skull dimensions not only have nothing to do with intelligence, not even brain size can be correlated directly with it, so all that remains from Galton's theoretical framework is the idea that it is necessary and possible to do an objective measurement of human intelligence (Bulmer, 1999).
The first tests of intelligence that came close to what this term signifies nowadays were created by French psychologist Alfred Binet (1857-1911). In their development, he started from the idea that in general, an individual's performance in any given domain, whatever it may be, increases with age, which means that for a given age group, performance (of any kind) may be used to separate people into different groups of intelligences (Feides, 1972).
Based on this idea Binet conceived his first intelligence test. If Francis Galton aimed to put on scientific grounds the idea of genetic superiority of a particular social class, Binet had in mind a much nobler purpose when he designed his first test: he wanted to identify the students with the weakest educational performance so that they can be corrected in a timely manner.
Binet created his test step by step and he started with presenting different problems to be solved to students

who were already categorized by their teachers as "bright" or "not so intelligent". If the problem could be solved by intelligent children but not by those who were considered less gifted, it remained in the questionnaire, if it was solved by both groups it was removed and the next problem would be put forward for solving. Applying this algorithm, Binet was able to devise a first test which, according to him could differentiate between intelligent and non-intelligent children in the same age group (Freides, 1972).

The next step that was taken was introducing the concept of mental age. That meant that for every tested child a mental age was calculated. That mental age was defined as the age at which a certain level of performance is considered typical (to be more precise the median of the ages of all who were tested at the time when the test was conceived, who attained a particular level of performance) (Nicolas et al, 2013).

The possibility to attribute a mental age to every person who is tested offers information about the level of intellectual performance of that person. But we still have to deal with the problem of the impossibility of comparing persons pertaining to different age groups. For instance, if we were to use exclusively the concept of mental age to compare two persons of different age, we might reach the conclusion that a young man of 16 which has the mental age of 13 has the same intellectual capacity as an 8 year old child with a mental age of 5. The error in this way of reasoning in obvious for any psychologist familiarized with interpreting intelligence tests. It can be briefly explained by understanding that the relative distance of intellectual capacity is much higher in the 13-16 years old than in the 5-8 years old interval.

The solution devised to solve the problem was known as intelligence quotient. The idea behind it was to unite somehow in the same formula used to calculate the mental age, information about the biological age of the individual being tested (Nicolas et al, 2013). From a historical point of view, the first formula to calculate the IQ defined it as the result of dividing the mental age to the chronological age of the individual and multiplying the result by one hundred. Having in our formula the biological age of the individual being tested allows us, of course to compare the results between individuals with different ages. This first formula used to calculate IQ leads us to a simple conclusion: any subject with a mental age equal to his/her chronological age will have an IQ of 100. Increases or decreases of the mental age compared to the chronological one will lead to similar modifications in IQ.

Those basic principles for calculating IQ's are still valid today, although they have been vastly improved by using statistical tools that calculate each test's deviation from the test which is considered standard for a certain age group.

One of the tests that are extensively used today for evaluating intelligence is the Stanford-Binet scale, a seriously improved variant of the idea we presented earlier (Terman & Merrill, 1937). The latest edition of this test, number five, published in 2003 contains a large number of items that vary in accordance to the tested person's age (for children the test consists of images or simple questions about every day activities whilst for adults the test requires understanding analogies, deciphering the meaning of a saying or finding the common elements that belong to a specific set).

The test is administered orally starting from the mental age at which the candidate can answer correctly to all the questions and finishing with the age at which he cannot answer to any of these questions. Analyzing the answer the candidate has provided, one can calculate an intelligence quotient for that person. Even more, the test has a series of subsets of questions, grouped according to different domains of knowledge which allows the examiner to see the domains in which the candidate had the best or the worst score.

In the United States the Wechsler scale for measuring intelligence – IV is used more often. It was developed by psychologist David Wechsler and it has two different tests, one for adults and one for children. Both tests measure a fairly large area of intellectual abilities such as the level of language understanding, working memory, the ability to deduce something or to generalize knowledge (Zhou et al, 2010).

Their degree of accuracy is similar and his very high. Their main drawback is represented by the fact that administering them is difficult and costly, requiring a one on one interaction between the psychologist administering the test and the candidate.

From the moment they were introduced in practice, psychological tests had numerous adversaries. I have already mentioned some of the critiques directed towards different attempts to classify in any way intelligence.

Without insisting on them, I will stop for a moment on the analysis of the characteristics needed in order to be able to declare that a test – any kind of test, not only intelligence tests – is suited for studying a certain trait and can be used without the risk of obtaining errors instead of answers.

Summarizing, one can reduce the necessary conditions to a number of two: the test must have a high level of fidelity (it should measure correctly every time the variables we are interested in) and it should be valid (it should measure the characteristic

we are interested in and not other characteristics). Validity and fidelity are key elements without which any test is useless.

Both have to be present in order to obtain a scientifically correct answer and one cannot substitute the other. Leaving those two conditions aside, if we want to obtain results that we can compare with other studies we need to establish some rules that we will respect when interpreting the answers given by our subjects. In this manner, some rules are agreed upon and they establish the minimal standards of performance that a person must reach in order to receive a score.

If all three conditions are simultaneously satisfied we can talk about standardized tests.

At the end of this short presentation about intelligence testing one may ask some questions: what are the position and the role of intelligence tests at the moment? In other words, are they relevant? Can the information they offer be used in practice? Do intelligence tests have a future or do they represent a dream about measuring too complex elements and are we supposed to give up to this dream?

Practice shows us that intelligence tests are frequently used in present, although there are a lot of drawbacks and censures about it.

Their relevance seems to be obvious to the deciding factors from educational system, army and private companies. Their degree of validity is big enough, so the results from the tested subjects seem to be compatible with the scores from the tests.

As for the future of intelligence tests, it seems to be safe, although things should be analyzed separately. It is considered that as long as their design is correct (they have to take into account the age, the environment, the cultural features and possible disabilities), these studies offer valuable information about the cognitive capacity of tested individuals, the administration costs being low.

As for the individual tests, although their administration costs are high, they weren't replaced completely by group tests, because of the high amount of information that they can provide. Moreover, the new variants of these tests have items that allow the collection of important amount of information about personality profile or some behavioural features of a tested individual, and this information can bring a better understanding of the individual.

Far from being neglected, the field of intellectual capacity testing is blooming. Computerized programs have been already created to test the cognitive capacity; there are also interactive variants compatible with the intellectual level of the tested individual, with variation of questions difficulty depending on the number of correct answers.

We have to also take into consideration the fact that a human being doesn't refer only to intelligence. At the moment there are debates in civil societies and in professional associations about personnel employment on the basis of intelligence tests exclusively, or about children classification in different classes depending on the same parameters.

In addition, apart from intelligence, the capacity of a human being to adapt to the environment depends also on his/her emotional structure, motivation and creativity. There are situations in which the above mentioned variables can count more than IQ, but they are impossible to measure by far.

4. PRACTICAL APPLICATIONS

Although interesting, the above mentioned theoretical perspectives value nothing if they cannot be translated in actions meant to help us evolve. I have already mentioned some areas in which intelligence tests proved their utility. These tests are not compulsory. Further on, an analysis of other two directions with multiple much more serious implications and branches for the future of the human society is presented.

The first direction is represented by the management of people with intellectual disabilities. One of the situations in which intelligence tests are very good is represented by identification of people with low intellectual level. The general opinion related to mental retardation is that its frequency is not so high.

In reality, the incidence is estimated to be around 1-3% of general population, at global level. People presenting an impaired cognitive function may have a short decrease of the intelligence quotient (IQ between 55 and 69, the so-called forms of mild intellectual retardation), comprising of people with a low level of intelligence, but able to learn easy crafts, to respect social rules and to handle any situation by themselves or with minimal assistance, or a high decrease of the intelligence quotient (IQ under 25), at people with severe mental retardation, where most of the time it is necessary to institutionalize the subject or to offer personal assistance for the whole period of life. The majority of people with intellectual disabilities is represented by the first category (almost 90% of them have a mild or moderate level of intellectual retardation) (Campbell, 2006).

Why are IQ tests helpful for these people?

First of all, they help us understand that intelligence and adaptive behaviour don't always go together.

In a study group of people with the same IQ level, there was noted the existence of some people able to

function independently and to adapt to the social norms, as well as the existence of people unable to integrate socially and which are not able to take care by themselves. We have to take into account that a lot of people with low intellectual levels are never identified. Their cognitive function can be mildly or moderately decreased, but as long as they deal with daily challenges, most probably they won't ever be tested. Although that generally speaking these people can look after themselves, their lower intelligence quotient can make them victims of abuses from family members, potential employees or social entourage. Identifying these people allows targeted interventions, adapted from case to case, so the aimed subjects have an increased chance to recognize these situations and to obtain the necessary tools to defend themselves.

Secondly, the fast discovery of people with intellectual disabilities allows rapid intervention, which can lead sometimes to an important improvement of the cognitive level, but most of all to an increased chance to integrate socially as much as possible. We focus here on people of young age, pre-school or scholars. From this point, we describe two work directions.

Firstly, the global decrease of cognitive levels, recognized at the beginning of school, or even before school, allows the specialized intervention which can improve the child's cognitive profile. If the intellectual dysfunction is severe and there is no or insignificant improvement, than the option is to guide the child to a domain of activity compatible to his/her cognitive level and general abilities.

The benefits of such an approach are multiple, pointing the disabled child and also his/her family (higher chances to integrate socially and professionally may signify a material and psychological family relief), the group of children from which he/she is part of (most frequently, children with low IQ have a challenging behaviour towards the colleagues or the teachers) and his/her social environment.

Secondly, the modern versions of intelligence tests allow their assessment on different activity branches (abstract thinking, vocabulary and language, practical thinking etc). Cognitive impairment is frequently limited at one of these branches, affecting little or not affecting the rest of the intellectual activity of an individual. In such situations one can interfere with high chances of success, using adaptive mechanisms which compensate the lack of intellectual abilities.

The second direction in which the intelligence evaluation gets its practical applicability can be identified at the other extreme of intellectual endowment: exceptionally gifted people.

The standard to state an exceptionally gifted person from an intellectual point of view is variable. Most authors consider the intelligence quotient higher than 130. It is estimated globally that 2-4% of the population fall into this category. In order to understand this problem, it is necessary a short enunciation of the problem related to source of human intelligence. We reach this way the famous question: are genius people of the humankind the result of genetics or are they rather the result of a huge amount of work hours? This controversy is old, but still unsolved.

We mentioned at the beginning of this essay that sir Francis Galton would consider that the intelligence is totally inherited and if you don't have smart parents you have to resign yourself. Later in 1924, J.B.Watson, in an essay about behavioural psychology, set forth the theory that the environmental stimuli play a crucial role in intelligence development. There are a lot of opinions regarding these two extremes, in favour of one or another, but without denying the importance of both influences.

Unfortunately, neuroscience developments didn't contribute to solving this problem, but they actually made the controversy more difficult, by sharing arguments in both directions.

From the genetic point of view, there are many studies performed on monozygotic and dizygotic twins that clearly show a correlation between the genetic inheritance and the cognitive tests results. In 1991 Dr. Nancy Seagal published in Journal of Child Psychology the results of a study that compared the cognitive abilities in a group of monozygotic twins with the results in a group of dizygotic twins, trying to emphasize the role of genetic factors in setting the intelligence quotient. Since then numerous studies showed repeatedly that monozygotic twins have very similar performances at intelligence tests, with a degree of correlation between them of 84-88%, much bigger than the correlation degree in the group of dizygotic twins (54%) (Segal & Russel, 1991).

On the other hand, the same author analyzed the role played by the environment on intellectual development of monozygotic and dizygotic twins. The study compared the intelligence tests results of 48 pairs of monozygotic twins grown up separately with 40 pairs of monozygotic twins grown up together. The results, published in Science in October 1990 showed that the correlation quotient between the results in the first case was 69%, whereas in the second case it was 88%.

In conclusion we got from the same author some results difficult to analyze: on one hand there is the clear proof of genetic inheritance of intelligence, on

the other hand there are also arguments for the role played by the environment.

Recent studies make a whole frame of the role played by genetics in intelligence development. Monozygotic twins, even grown up in separate environments, prove a correlation of 74% of the intelligence tests results. Dizygotic twins, grown up together show a correlation quotient of 60%, non-twins show a correlation of 31%, adoptive brothers show a correlation between 28 and 33%, nonrelated children of the same age show a correlation of 28% (Segal & Russel, 1991).

This is an enumeration of numbers that cannot be explained but through genetics. But genetics can be taken into account only if we rule out the rest of the factors. Obviously, it is impossible to rule out all the variables that influence intelligence development (most probably we don't even know all these variables), but the author of the study emphasized from the beginning an extremely important aspect: the numbers above mentioned are valid only within the families with at least a medium socio-economical status. They lose their applicability if we take into consideration starving, sick or neglected children.

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