

Computational Methodologies in Psychometry and Mental Health

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Abstract

'Psychometry' the science of measuring human intelligence has evolved slowly over the last century. Today we have several theories for measuring this socially vital attribute of human beings at various stages of development. Many of these theories are often contradictory and the results are not conclusive. The measurement is done by administering mental ability tests. However, the search for a theory that yields good correlation is still ongoing.

Digital mental health by using a suite of digital technologies ranging from digital interventions to the application of artificial intelligence is a logical next step in this progress. Telepsychiatry and virtual reality in psychiatric treatment and rehabilitation are showing considerable progress.

This paper reports the research of the author using three of the six major theories of intelligence. The computational methodologies are generic and can be extended to any facet of human potential measurement and development. It is reliant on advances in computer and communication technologies such as high speed networking, multimedia and virtual reality.

If future generations are to remember us more with gratitude than sorrow, we must achieve more than just the miracles of technology. We must also leave them a glimpse of the world as it was created, not just as it looked when we got through with it.

- Lyndon B. Johnson, 36th president of the United States of America

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INTRODUCTION

Psychometry represented the singular success of scientific psychology. This branch of psychology concentrated on measuring human intelligence. Intelligence was perceived to be an all pervasive cognitive ability that enables a human being to solve any problem requiring the use of mental faculties. Some very special abilities such as rote memory, verbal, numerical, perceptual and so on were popularly recognized but they were found



to be far from “general intelligence”.

Traditionally intelligence was measured by administering a test that makes “*little or no call*” on the acquired knowledge of the candidate. If a specific aspect of knowledge is required then it was imperative to ensure that all candidates taking the test have acquired that aspect of knowledge. These tests are popularly known as “*Intelligent Quotient*” (IQ) tests and are designed typically for a specified age group or specified requirement. Studies to generalize the impact of factors such as Heredity, Gender, Twins, Physiological data (such as brain size and weight) and Brainwaves on the measured intelligence of a population have been exciting but also tended to be highly controversial. There are several classical theories of intelligence that gained respect all over the globe. Some of them that date back to as early as the beginning of the last century are mentioned as follows.

- Binet and Global Intelligence
- Terman's IQ Formula and the Stanford-Binet
- Spearman's Two-Factor Theory
- Thurstone and Primary Mental Abilities
- The Wechsler Compromise
- The Nature/Nurture Controversy

Gradually the basic notion of “*intelligence*” began to be referred to with a more generic term “mental ability”. Several theories have been propounded. Scientists have thrown up several pertinent issues related to the measurement of intelligence. We are currently witnessing a revolution in the conceptual framework for intelligence and its measurement.

The Six Key Theories of Intelligence

Six key theories stood the test of time over the last century. These theories are briefly summarized in the Table 1.

Table 1: Summary of the Six Key Theories of Intelligence

| - | Theory | Tests | Testability | Criticism |
|--|--|---|--|---|
| Psychometric Approach | There is one single figure of merit called "g factor" that accounts for intelligence. There is no universal definition of this 'g factor'. It is widely perceived to be undefinable. | Intelligence tests come in many forms, (Ex. Wechler, Stanford-Binet, IQ). The data is re-standardized to a mean of 100 with a standard deviation of 15. The tests measure scholastic aptitude, school achievement, special abilities, etc. with questions and performance exams testing familiar linguistics, logical-mathematics, and spatial abilities. | Candidates tend to do better on some types of questions. However the subsets of questions are generally positively correlated. The tests are correlated by factor analysis. The experience in taking such tests influences the performance. Also, the subjects can be trained for a finite number of possible patterns in formulating the questions. | Reducing all the factors and special aspects of intelligence into a hypothetical 'g factor' raises lot of questions about the end result. It is not possible to have a universal IQ test. A candidate has to take many tests in practice. |
| Gardner (1983) | There are multiple intelligences and no "g factor" | Logical-mathematical Intelligence, Linguistic Intelligence, Spatial Intelligence, Musical Intelligence, Bodily-kinesthetic Intelligence, Interpersonal Intelligence, Intrapersonal Intelligence, Naturalist Intelligence. There are no paper and pencil tests | There are many other observed factors that are perceived to be legitimate components of the basic notion of intelligence. | Critics say Gardner includes some "special talents" that are not normally found and hence they cannot be the 'least common denominator' for general human intelligence. |
| Steinberg's Triarchic Theory (1985) | There are three pertinent aspects of intelligence: analytic, creative and practical (tacit knowledge, action-oriented and self-taught) | Analytic intelligence is measured by mainstream "academic" tests. Creative intelligence is measured by and performance exams. Practical intelligence is measured by questionnaires that give scenarios and ask a person to choose how to handle the situation. | The three subsets identified explain many relationships between a) handicappers ability and b) school performance and psychometry based IQ tests. | |

Table cont...

| | | | | |
|---------------------|---|--|--|--|
| Piaget | Piaget proposed a developmentally based model of intelligence. In all children, intelligence develops from a continually shifting balance between bringing new information into existing structures | To assess the understanding tests involving different containers with same quantity of liquid, shapes that can be illusive are deployed. | The tests must be specific to an individual. The test correlates well to psychometric tests. | The results are weak and highly personalized. |
| Vygotsky (1978) | This theory professes that intellectual abilities lie in social origin. Language and thought, learned from parents, begins the development process. Teachers and Mentors hasten the development. | Traditional psychometric tests ignore the "zone of proximal development" (increased performance with help from parents). Vygotsky's tests are dynamic. The tests give some idea of a child's potential instead of only testing the already developed intelligence. | It is very difficult to determine the evolving intelligence in a absolute manner. | Twin and adoptive studies are anti-theitic to this approach. |
| Biological Approach | The neuroanatomy, neurophysiology, neurotheology and neuropsychology are the key approaches. | Attempts to study the brain using PET's and MRI's are underway to find the links to human behaviour and intelligence. | Hardly 1-2% of the working of human brain is believed to be understood today. Neurotheology is in its nascent stage and tries to understand the spiritual nature of brain functioning. | The scan based tests are expensive and are not normally affordable by a large population. Computer simulations are also very primitive as much of the brain is not understood. |

Several IQ tests have been designed that are broadly based on one or many methodologies mentioned in the Table 1. Creating a test requires the designers to write a detailed definition of what the test is attempting to measure. A set of tasks that lend themselves to measure what the test aims at must be identified. A '*target group*' must be defined and the test must be administered to a pilot group. The above process is iterated over a span of time and a correlation between the tasks and the measured mental ability of the target group is established. Over the span of time '*reliability*' and '*validity*' of the results must be established.

Structure of the broad framework for Intelligence¹³

There are Five operations. They are

1. Cognition (aspects such as awareness, immediate or ability to assimilate new notions, discovery and recognition)
2. Memory (recall)
3. Divergent Production (inductive reasoning or ability to generate multiple possibilities of solutions)
4. Convergent Production (Deductive Reasoning or ability to freeze on a single or unique solution)

5. Evaluation (comparing and contrasting known and unknown aspects to make a logical decision)

The last three are vital for professions that thrive on analysis and design skills.

There are Six possible products or types of entities to manipulate. They are

1. Units of Objects
2. Classes of Objects
3. Relations amongst Objects
4. Structured Aggregates of Objects or Systems
5. Transformations that involve several Objects
6. Implications amongst the Objects

There are Four possible types of content in each of the above products. They are

1. Figural or Numeric
2. Symbolic or Encoded
3. Semantic
4. Behavioral

Psychometric tests or as a matter of fact any test that is administered to estimate the proficiency of an individual carves out the questions from

this framework. There are $5 \times 6 \times 4 = 120$ ways in which the above three aspects of the framework can be crossed. Thus, a given test draws from a possible maximum set of 120 patterns or types of abilities. These abilities are correlated to real life performance over a span of time and declared as standard components of a test aiming to measure corresponding mental abilities. A candidate is thus presented with a lot of practice tests that train the mind to quickly recognize the basic pattern in the question and locate the answer. After several practice tests the naturalness involved in answering the question is lost and the measure obtained may not be realistic. Even when the tests are administered for a large sample size of candidates over a credit worthy span of time (say three years) the results are wide open for criticism and doubt. Also, the patterns emerging out of the data gathered have been misused for political gains on many occasions in the past. After nearly a century of intense study by eminent psychologists there are many unresolved issues that are being hotly debated.

There are two popular Psychometrics that emphasize Cognition with only $1 \times 6 \times 4 = 24$ Patterns that are highlighted. These psychometrics are:

1. *Myers-Briggs Type Indicator [MBTI]*: Indices based on Extraversion-Introversion, Sensing-Intuition, Thinking-Feeling, and Judging-Perceiving.
2. *Kaufman Adolescent and Adult intelligence Test [KAIT]*: Fluid, Crystallized, and Composite Intelligence Quotients

It was hypothesized that individuals favoring Intuition and Thinking would be more intelligent and "*Mental Agility*" or more fluid in the mind either as individuals or in teams. Computerized adaptations of both MBTI and KAIT were used for selecting professionals primarily for the IT Industry. This was only for a few years and the follow-up correlations though not divulged did not appear convincing. Eventually, Cognition was associated more with the domain knowledge rather than generic patterns.

The "*Turing Machine Model*" which is the foundation for the modern day computation postulates that the concept of intelligence is "*behaviorist*" and hence aligned to thinking. This implies that there are only $5 \times 6 \times 1 = 30$ patterns or types of abilities that a computational model can effectively support psychometry. As a matter of

fact, Alan Turing argues that a program must be written that directs a computer to learn.

Is the assumed Computing Machinery reflecting/ mimicking/ replicating the Human Brain?

The most debatable "*Stanford Prison Experiment*" was a psychological experiment conducted in August 1971. It was a two-week simulation of a prison environment that examined the effects of situational variables on participants' reactions and behaviors. The implied parametric approach makes it amenable for computerization.

The Rorschach test is a projective psychological test in which subjects' perceptions of inkblots are recorded and then analyzed using psychological interpretation, complex computing algorithms, or both.

The reliability of both the "*Stanford Prison Experiment*" and the Inkblot tests even after computerizations has always been questioned.

Daniel Goleman's Emotional Intelligence is a proposition that better contrasts the 30 patterns-based conclusion using the "*Turing Machine Model*".

Emotional Intelligence^{2,3}

This notion attempts to provide a framework for attributes of a personality with measures for motivation, self-esteem, self-reliance, rule consciousness, empathy for others, ability to cope up with physical and mental stress and other related attributes. Daniel Goleman who made this idea popular has been widely criticized for misrepresenting and misinterpreting the core concepts in Emotional Intelligence. Today, there are several tests available to measure the Emotional Quotient of an individual. This is being projected as a complementary metric for IQ.

James Flynn discovered a systematic increase in test scores worldwide. "*Flynn effect*" indicates that there is an average gain of 3 IQ points over a span of a decade across all age groups. This implies that IQ tests for a specific age group must undergo constant up-gradation in terms of complexity.

The framework⁴ for emotional competence broadly comprises.

- *Personal Competence* [examples: emotional awareness, self-confidence, self-regulation, self-motivation]
- *Social Competence* [examples: empathy, service orientation, social skills such as conflict management, influence, team building]

The generalization of this methodology is proposed to be achieved by deploying “*Augmented Reality*” and “*Virtual Reality*” technologies.

There are two strong methodologies based on computing that function on the lines of Emotional Intelligence. They are:

1. *Captology*^{5,6}: Study of computers as persuasive technologies
2. *Emotion Machine*^{8,9}: Mind Over Matter

The technology tools for persuasion are categorized as Tunneling, Reduction, Tailoring, Suggestion, Self-Monitoring, Surveillance and Condition. Presently, Surveillance technologies are found in many public places and the associated Captology promises several pointers and working offsets to psychometrics and mental health in isolated cases.

The Emotion Machine aims to find more complex ways to depict mental events that seem simple at first. The approach is a blending of Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind. Complicated mental activities into simpler elements called “*Emotional States*” which are “not especially different from the processes that we call ‘thinking.’ Though functionally feasible but it is difficult to prove how the “*Emotional States*” relate to the Human Brain. Humanoid Robots are found in Science Fiction both as novels and films. They are beginning to appear in real world with very limited emotional quotient.

Detecting emotions from the face is a challenging idea that is being attempted by many algorithm designers with limited accuracy. More complex algorithms to detect emotions by analyzing data including gestures, tone of voice, force of keystrokes, and more such factors are expected to improve the accuracy. The claim of their functional value in auto-detection and correction of “*Mood Disorders*” is clinically being studied.

Neuro Linguistic Programming^{1,11,12}

Psychotherapy is founded on the principle that one person’s efforts can facilitate change in perception, attitudes, or behavior of another. The process of such therapeutic efforts remains individualistic and when it works, it appears to be sheer magic.

Neuro Linguistic Programming [NLP] is a concept that explores the connection between neurological processes, language and acquired

behavioral patterns. Psychotherapy based on NLP can change them to achieve specific goals in life. NLP first appeared in Richard Bandler and John Grinder's 1975 book titled *The Structure of Magic I*. However, NLP is not yet a scientific methodology.

NLP is believed to treat problems such as phobias, depression, tic disorders, psychosomatic illnesses, near-sightedness, allergy, the common cold, and learning disorders.

Natural Language Processing (NLP) is a branch of computer science that deals with the interaction between humans and machines using natural language. It is powered by language models, which are trained on large datasets to learn patterns in human language. Computational Models using the NLP are widely used in Language Translation, Speech Recognition, Sentiment Analysis, Chatbots and Document Classification. The language models on combining with the advanced technologies associated with Captology and Humanoid Robots are promising to bolster the Neuro Linguistic Programming [NLP].

Neurolinguistic Computational Models that blend linguistics, psycholinguistics, and neuroscience are promising to lend credence to many controversial claims of therapeutic success using Neuro Linguistic Programming.

There are four pillars of Neuro Linguistic Programming, namely:

1. Outcomes
2. Sensory Acuity
3. Behavioral Flexibility
4. Rapport.

“If you cannot measure it, you cannot improve it.” – Lord Kelvin

Gardner’s theory of Multiple Intelligences¹³

Intelligence as a concept emerged as much more than a general “mental” ability. Howard Gardner’s view of Intelligence is akin to talents, personality, or ability to create an effective product or offer a service that is valued in a culture. It is a set of skills that make it possible for a person to solve problems in life. Intelligence in this theory is the potential for finding or creating solutions for problems, which involves gathering new knowledge.

Gardner’s theory of multiple intelligences appears to be a more reasonable framework for measuring human intelligence. Some interesting

Table 2: Some Interesting Observations based on Gardner's Theory of Multiple Intelligences

| Intelligence Area | Is strong in | Learns best through |
|--------------------|--|---|
| Verbal-Linguistic | Reading, writing, telling stories, memorizing dates, thinking in words | Reading, hearing and seeing words, speaking, writing, discussing and debating |
| Math-Logic | Math, reasoning, logic, problem-solving, patterns | Working with patterns and relationships, classifying, categorizing, working with the abstract |
| Spatial | Reading, maps, charts, drawing, solving puzzles and mazes, imaging things, visualization | Working with pictures and colors, visualizing, drawing |
| Bodily-Kinesthetic | Athletics, dancing, acting, crafts, using tools | Touching, moving, processing knowledge through bodily sensations |
| Musical | Singing, picking up sounds, remembering melodies, rhythms | Rhythm, melody, singing, listening to music and melodies |
| Interpersonal | Understanding people, leading, organizing, communicating, resolving conflicts, selling | Sharing, comparing, relating, interviewing, cooperating |
| Intrapersonal | Understanding self, recognizing strengths and weaknesses, setting goals | Working alone, doing self-paced projects, having space, reflecting |
| Naturalist | Understanding nature, making distinctions, identifying flora and fauna | Working in nature, exploring living things, learning about plants and natural events |

observations based on this theory are indicated in Table 2.

There are no pencil and paper tests. The tests are very often modeled as acting out a story, predicting the next chapter of the text, reading and writing stories, singing or responding to music, solving syllogisms of the form "if .. then ?". The emotional intelligence approach appears to be more comprehensive for measuring the interpersonal and intrapersonal intelligences identified by Gardner. The naturalist intelligence is a very recent addition in the list made by Gardner. It is measured through activities such as maintenance of scrap book of natural articles of nature. Software based assessment tools for "*Learning Styles*" provide the necessary measures related to the Multiple Intelligences.

"Students possess different kinds of minds and therefore learn, remember, perform, and understand in different ways." *Howard Gardner, 1983*

In fact many issues mentioned above are being hotly debated and in many cases there has been no finality of conclusion.

CONCLUSIONS

Computers have been in use in psychiatry since the early 1950s.^{7,10,14} In the recent years a rapid growth of using computational methodologies in mental health has been witnessed. Computers can perform standardized operations much faster and more accurately. The current interest in computer use is strongly associated with the availability of home, office, portable computers and mobile

technologies. Computers and communications technologies have become crucial due to the exponential growth in the information that has to be processed in order to deliver optimal mental health care. There are many tools and techniques based on computational methodologies that are operational.

Psychometric measures of ability, attitudes, perceptions, and beliefs are crucial for understanding user behavior in various contexts including health, security, e-commerce, and finance. Computerized estimates of these measures are proving to be useful and reliable. The same methodologies for psychometry can also be used for Mental Health with advanced technologies.

There are emerging measures for intelligence based on theories related to Existential Intelligence, Moral Intelligence and Spiritual Intelligence. This paper reports the research experiences of the author and some attempts towards Self-Discovery using computational methodologies.

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