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ARTIFICIAL NEURAL DIGITAL TECHNIQUES FOR HUMAN MIND READING SYSTEM

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Abstract

A computer can, in a very real sense, read human minds. Although the dot's gyrations are directed by a computer, the machine was only carrying out the orders of the test subject. The computer mind-reading technique is far more than a laboratory stunt. Though computers can solve extraordinarily complex problems with incredible speed, Psychological tests are standardized measures of behaviour. Most psychological tests fall under two broad categories, mental ability tests and personality scales. Mental ability tests include intelligence tests, which are designed to measure general mental ability, and aptitude tests, which measure more specific mental abilities. Personality measures are usually called scales, rather than tests, as there are no rights or wrong answers. Personality tests measure a variety of motives, interests, values, and attitudes.

Keywords: IQ tests, Artificial Neural Content, MFC, Mental Retardation/Intellectual Disability, Stereotypes, Heredity, Cognitive Conceptualizations etc.

1.0 INTRODUCTION

People express their mental states, including emotions, thoughts, and desires, all the time through facial expressions, vocal nuances and gestures. This is true even when they are

interacting with machines. Our mental states shape the decisions that we make, govern how we communicate with others, and affect our performance. The ability to attribute mental states to others from their behaviour and to use that knowledge to guide our own actions and predict those of others is known as *theory of mind* or *mind-reading.*

Existing human-computer interfaces are mind-blind — oblivious to the user's mental states and intentions. A computer may wait indefinitely for input from a user who is no longer there, or decide to do irrelevant tasks while a user is frantically working towards an imminent deadline. As a result, existing computer technologies often frustrate the user, have little persuasive power and cannot initiate interactions with the user. Even if they do take the initiative, like the now retired Microsoft Paperclip, they are often misguided and irrelevant, and simply frustrate the user. With the increasing complexity of computer technologies and the ubiquity of mobile and wearable devices, there is a need for machines that are aware of the user's mental state and that adaptively respond to these mental states.

2. COMPUTATIONAL MODEL OF MIND-READING SYSTEM

Drawing inspiration from psychology, computer vision and machine learning, the team in the Computer Laboratory at the University of Cambridge has developed *mind-reading machines* — computers that implement a computational model of mind-reading to infer mental states of people from their facial signals. The goal is to enhance human-computer interaction through empathic responses, to improve the productivity of the user and to enable applications to initiate interactions with and on behalf of the user, without waiting for explicit input from that user. There are difficult challenges:

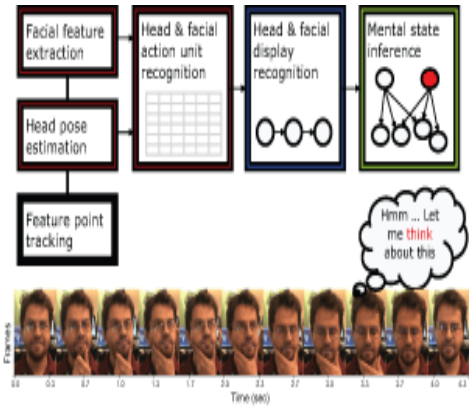

Figure 1: Processing Stages of Mind Reading System

Using a digital video camera, the mind-reading computer system analyzes a person's facial expressions in real time and infers that person's underlying mental state, such as whether he or she is agreeing or disagreeing, interested or bored, thinking or confused.

Prior knowledge of how particular mental states are expressed in the face is combined with analysis of facial expressions and head gestures occurring in real time. The model represents these at different granularities, starting with face and head movements and building those in time and in space to form a clearer model of what mental state is being represented. Software from Nevenvision identifies 24 feature points on the face and tracks them in real time. Movement, shape and colour are then analyzed to identify gestures like a smile or eyebrows being raised. Combinations of these occurring over time indicate mental states. For example, a combination of a head nod, with a smile and eyebrows raised might mean interest. The relationship between observable head and facial displays and the corresponding hidden mental states over time is modelled using Dynamic Bayesian Networks.

The mind reading actually involves measuring the volume and oxygen level of the blood around the subject's brain, using technology called functional near-infrared spectroscopy (fNIRS). The user wears a sort of futuristic headband that sends light in that spectrum into the tissues of the head where it is absorbed by active, blood-filled tissues. The headband then measures how much light was not absorbed, letting the computer gauge. The metabolic demands that the brain is making the system.

Figure 2: Structure of Futuristic Headband Mind

Preliminary results show that using button-sized sensors, which attach under the chin and on the side of the Adam's apple, it is possible to pick up and recognize nerve signals and patterns from the tongue and vocal cords that correspond to specific words.

"Biological signals arise when reading or speaking to oneself with or without actual lip or facial movement," says Chuck Jorgensen, a neuro engineer at NASA's Ames Research Center in Moffett Field, California, in charge of the research. Just the slightest movement in the voice box and tongue is all it needs to work, it is based on the some psychological test.

3.0 PRINCIPLE TYPES OF PSYCHOLOGICAL TESTS

There are two types of psychological test.

1. Mental ability tests
   - Intelligence – general
   - Aptitude – specific
   - Achievement test
2. Personality scales
   - Measure motives, interests, values, and attitudes

Standardization refers to the uniform procedures used in the administration and scoring of a test. Test norms provide information about where a score on a psychological test ranks in relation to other scores on that test…allows a psychologist to determine how a person scores relative to other people. The standardization group is the sample of people that the norms are based on.

a. Reliability refers to a test's consistency; that is, repeated measurements should yield reasonably similar results.

b. Reliability estimates are based on the correlation coefficient.

Two sets of scores from two administrations of the same test are correlated; the closer the correlation comes to +1.00, the more reliable the test. Validity refers to the ability of a test to measure what it was designed to measure. Content validity is the degree to which the content of a test is representative of the domain it is supposed to cover (physics questions on a psychology test…poor content validity).Criterion-related validity is estimated by correlating subjects' scores on a test with their scores on an independent criterion…predictive ability.

Construct validity is the extent to which there is evidence that a test measures a particular hypothetical construct…are we really measuring intelligence with an IQ test?

3.1 KEY CONCEPTS IN PSYCHOLOGICAL TESTING

- Standardization
- Test norms
- Standardization group
- Reliability
- Correlation coefficient
- Validity
- Content validity
- Criterion-related validity
- Construct validity

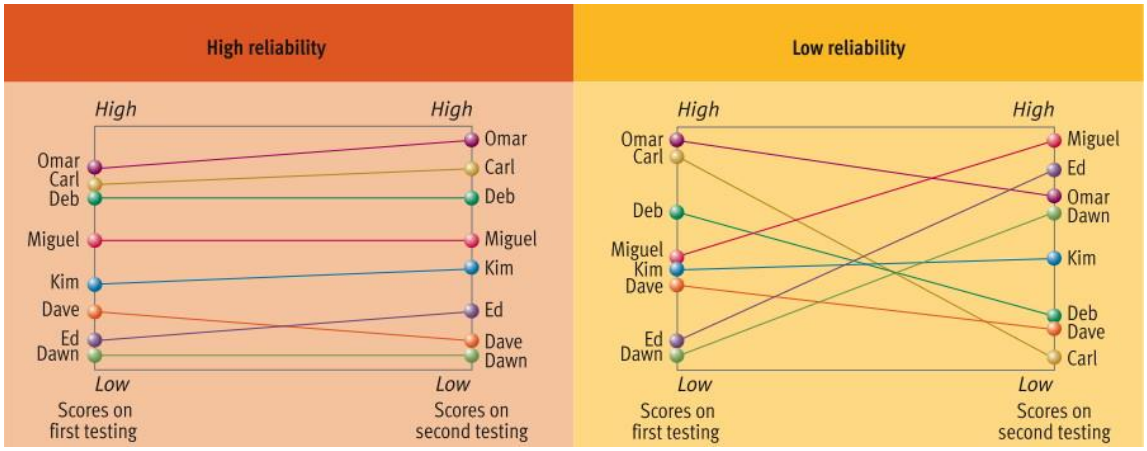

Figure: 3 Test-retest reliability

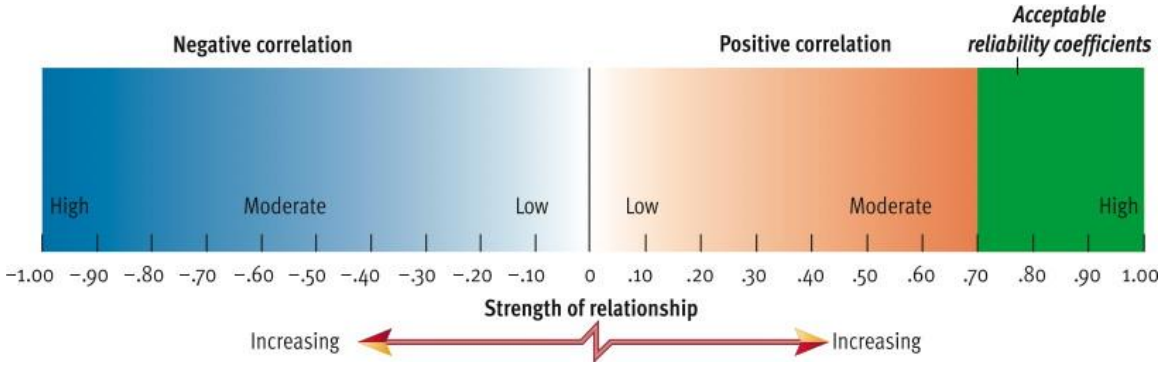

Figure: 4 Correlation and reliability

Figure: 5 Construct validity

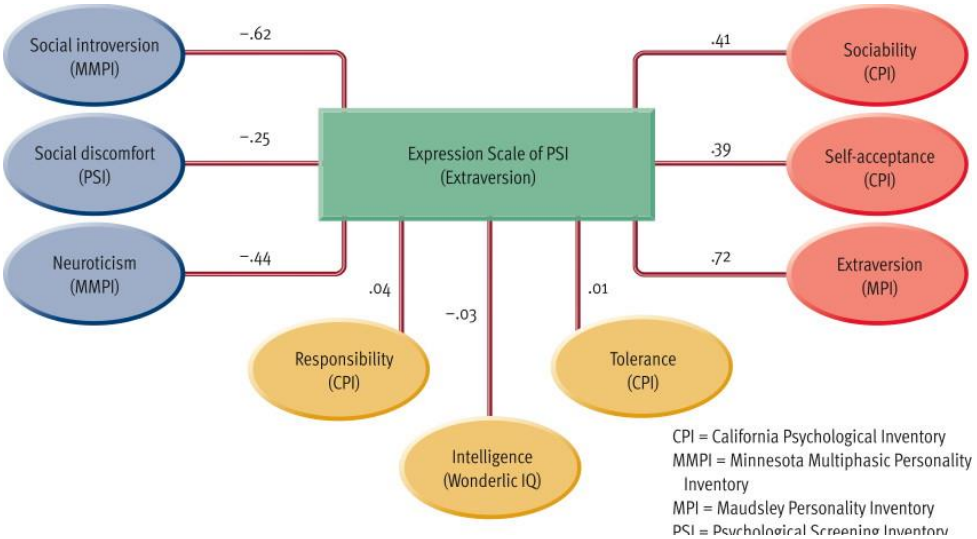

Figure: 5 Criterion-related validity

4.0 LITERATURE REVIEW

4.1 THE EVOLUTION OF INTELLIGENCE TESTING

Sir Francis Galton, 1869, published Hereditary Genius, in which he put forth the notion that success runs in families because intelligence is inherited. He developed a crude mental abilities test based on sensory acuity.Alfred Binet and Theodore Simon published the first intelligence test in 1905, a test designed to single out youngsters in need of special training…expressed a child's score in terms of mental age…for example, a 4 year-old child with a mental age of 6 performed like the average 6 year-old on the test. Lewis Terman, at Stanford University, revised Binet's test for use in the U.S….the Stanford-Binet. Terman used a new scoring scheme, the intelligence quotient, dividing a child's mental age by chronological age and multiplying by 100…this made it possible to compare children of different ages. David Wechsler was the first to devise an instrument to measure intelligence in adults. He later devised downward extensions of his scale for children. Wechsler is credited with two innovations in intelligence testing.

First, his scales give more emphasis to nonverbal reasoning, yielding a verbal IQ, a performance IQ, and a full-scale IQ. Second, Wechsler devised a new scoring system based

on the normal distribution…the deviation IQ. This scoring system is outlined on the next slide.

- Sir Francis Galton (1869)
- Hereditary Genius
- Alfred Binet and Theodore Simon (1905)
- Binet-Simon Intelligence Scale
- Mental age
- Lewis Terman (1916)
- Stanford-Binet Intelligence Scale
- Intelligence Quotient (IQ) = MA/CA x 100
- David Wechsler (1955)
- Wechsler Adult Intelligence Scale
- Sir Francis Galton (1869)
- Hereditary Genius
- Alfred Binet and Theodore Simon (1905)
- Binet-Simon Intelligence Scale
- Mental age
- Lewis Terman (1916)
- Stanford-Binet Intelligence Scale
- Intelligence Quotient (IQ) = MA/CA x 100

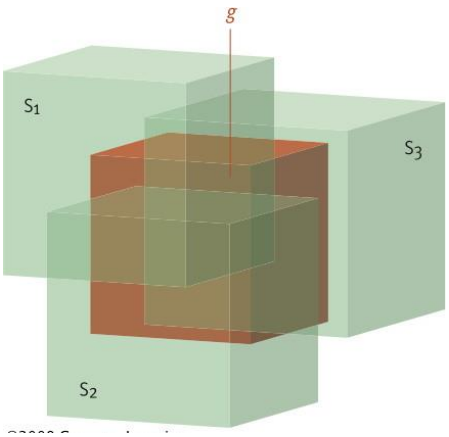

Figure: 6 Spearman's g

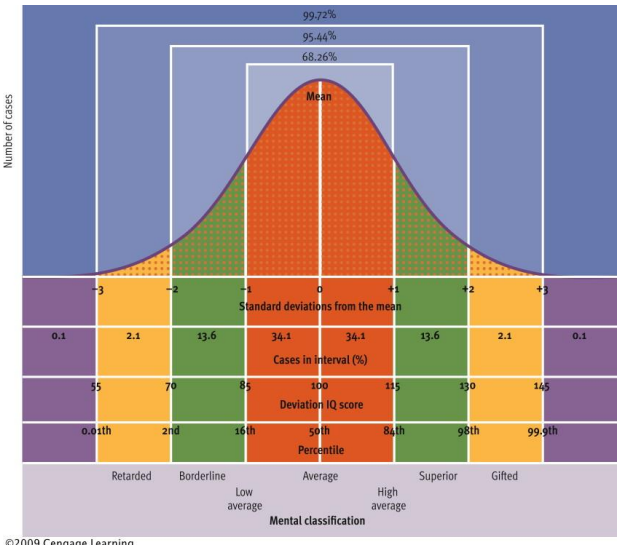

Figure: 7 The normal distribution

4.2 RELIABILITY AND VALIDITY OF IQ TESTS

Although they are intended to measure potential, IQ tests inevitably assess both knowledge and potential. IQ tests are, however, exceptionally reliable, with reliability coefficients into the .90s. IQ tests are reasonably valid indicators of academic intelligence, as they predict school success and number of years in school.

They are not good measures of social or practical intelligence and do not measure intelligence in a truly general sense. IQ scores are positively correlated with high status jobs; this may be related to the correlation with school success. There is conflicting evidence regarding whether IQ scores predict occupational performance. Court rulings and laws now require that tests used in selection of employees measure specific abilities related to job performance.

- Exceptionally reliable – correlations into the .90s
- Qualified validity – valid indicators of academic/verbal intelligence, not intelligence in a truly general sense
- Correlations:
- .40s–.50s with school success

- .60s–.80s with number of years in school
- Predictive of occupational attainment, debate about predictiveness of performance

4.3 EXTREMES OF INTELLIGENCE MENTAL RETARDATION / INTELLECTUAL DISABILITY

- Diagnosis based on IQ and adaptive testing
- IQ 2 or more SD below mean
- Adaptive skill deficits
- Origination before age 18
- 4 levels: mild, moderate, severe, profound
- Mild most common by far
- Causes:
- Environmental vs. Biological

New – concern about the term retardation, seen as demeaning, stigmatizing, and powerful; people diagnosed with retardation seem to be totally defined by it. The American Association on Mental Retardation (AAMR) changed its name in 2006 to the American Association on Intellectual and Developmental Disabilities (AAIDD) (Schalock et al., 2007). The next edition of its classification manual, due in 2009 or 2010, will use the term intellectual disability as a substitute for mental retardation.

Mental retardation is a diagnosis reserved for individuals with subaverage general mental ability accompanied by deficiencies in adaptive skills, originating before age 18.

The vast majority of people with mental retardation have mild mental retardation and are not easily distinguished from the rest of the population.

Origins of mental retardation may include organic syndromes, as 350 biological conditions that can cause mental retardation have been identified. Diagnosticians are, however, only able to pin down an organic cause in <25% of cases.

In fact, cases of mild mental retardation tend to involve unknown origin. Environmental theories hold that unfavorable environmental factors may contribute to the development of mild mental retardation; things like neglect, inadequate nutrition and medical care, and lower quality schooling.

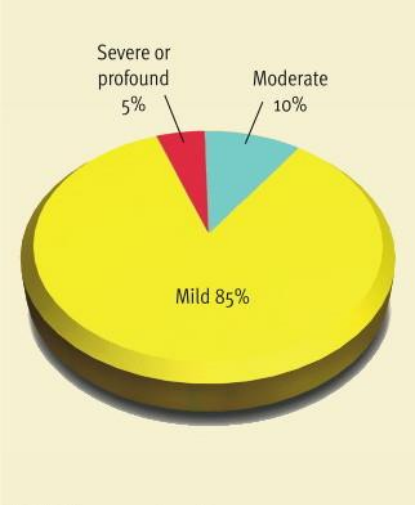

Figure: 8 The prevalence and severity of mental retardation

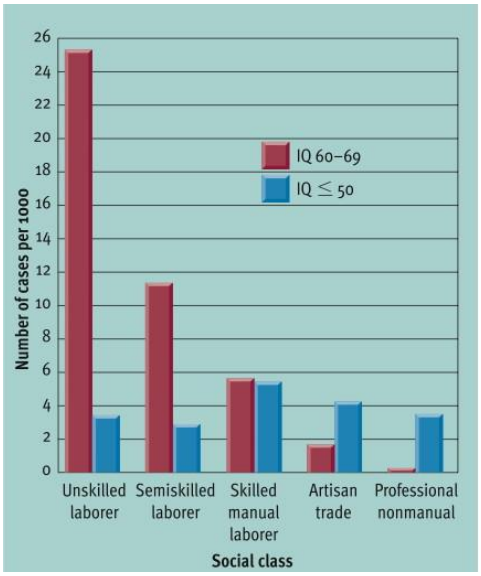

Figure 9: Social class and mental retardation

5.0 EXTREMES OF INTELLIGENCE

There are discrepancies between ideals and practice regarding how gifted children are identified in the U.S. Usually, identification occurs based on IQ of 130 or higher, although creativity, leadership, and special talents are recommended for use in identification as

well.Gifted individuals are often stereotyped as weak, sickly, socially inept, and emotionally troubled "bookworms."

Lewis Terman initiated a study in the early 1920's with 1500 children with IQs of 150 or higher. These children were followed throughout their lives. As a group, these subjects exhibited better than average physical health, emotional stability, and social satisfaction through their adult years.

Ellen Winner (1997) claims that a distinction needs to be made between moderately gifted (IQ 130-150) and profoundly gifted (IQ above 180) individuals, asserting that profoundly gifted children are often introverted and isolated.

- Identification issues – ideals vs. practice
- IQ 2 SD above mean standard
- Creativity, leadership, special talent?
- Stereotypes – weak, socially inept, emotionally troubled
- Lewis Terman (1925) – largely contradicted stereotypes
- Ellen Winner (1997) – moderately vs. profoundly gifted
- Giftedness and high achievement – beyond IQ
- Renzulli (2002) – intersection of three factors
- Simonton (2001) – drudge theory and inborn talent

5.1 INTELLIGENCE: HEREDITY OR ENVIRONMENT?

This issue has far-reaching sociopolitical implications and continues to be a complex controversy. Family studies determine only whether genetic influence on a trait is plausible, not whether it is certain. Family members also share environments. Twin studies provide evidence regarding the role of genetic factors. The basic rationale is that identical and fraternal twins develop under similar environmental conditions, but identical twins share more genes…if identical twins end up more similar on a given characteristic, it must be genetic. A heritability ratio is an estimate of the proportion of trait variability in a population that is determined by variations in genetic inheritance. A heritability estimate is a group statistic and cannot be meaningfully applied to individuals.

Adoption studies provide evidence that upbringing plays an important role in mental ability, as adopted children show some resemblance to their foster parents. Also, siblings reared together are more similar in IQ than siblings reared apart. In fact, entirely unrelated children who are reared together show resemblance in IQ. The cumulative deprivation hypothesis holds that children raised in deprived environments will experience a gradual decline in IQ as they grow older. Conversely, children removed from deprived environments and placed in homes that are more conducive for learning show IQ increases.

The Flynn effect is the trend, all over the developed world, for IQ scores to increase from one generation to the next. Hypotheses for why this occurs focus on environmental variables, as evolution does not operate in a generation. Clearly, heredity and environment both influence intelligence. Theorists use the term "reaction range" to refer to genetically determined limits on IQ. The environment determines whether a person will fall at the upper or lower end of their genetically determined range.

- Heredity
- Family and twin studies
- Heritability estimates

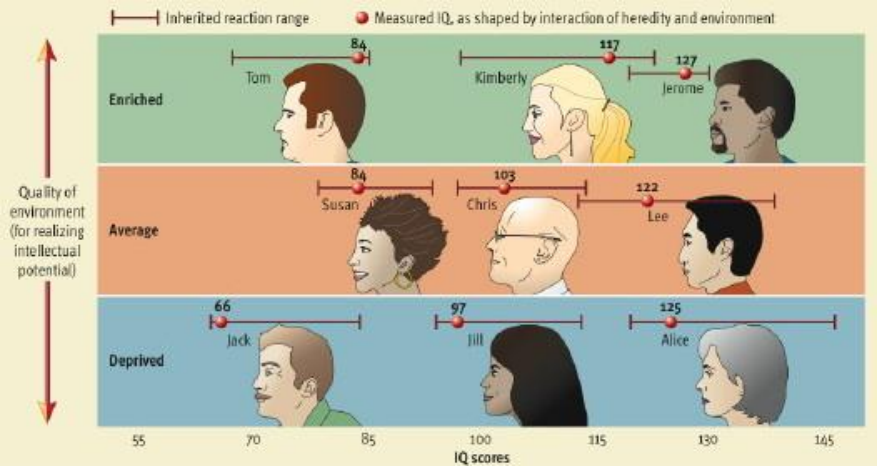

Figure: 10 Studies of IQ similarity

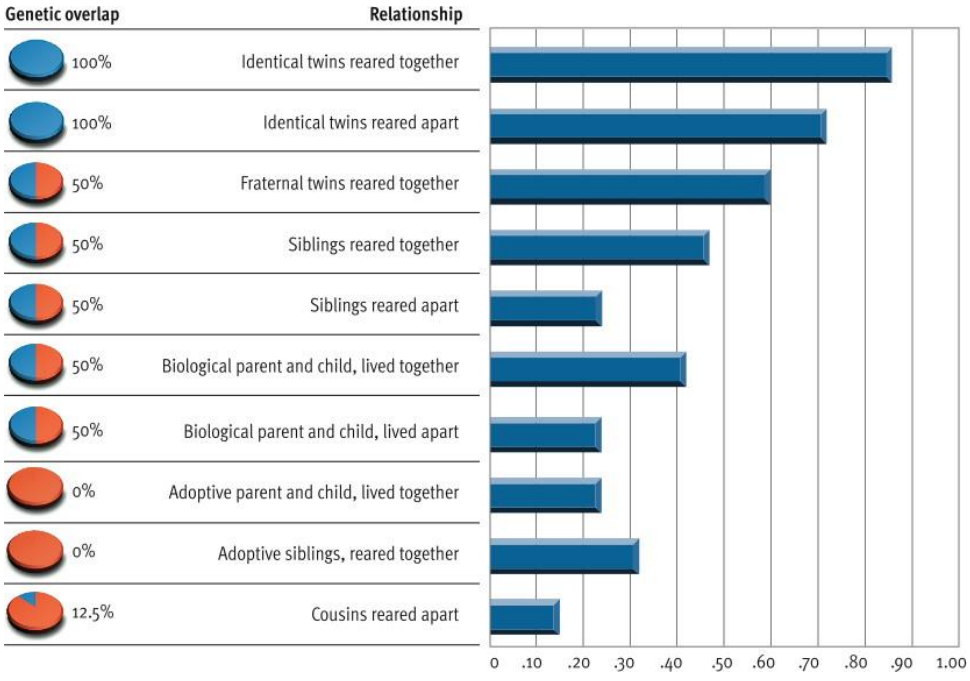

Figure: 11Mean Correlation of IQ

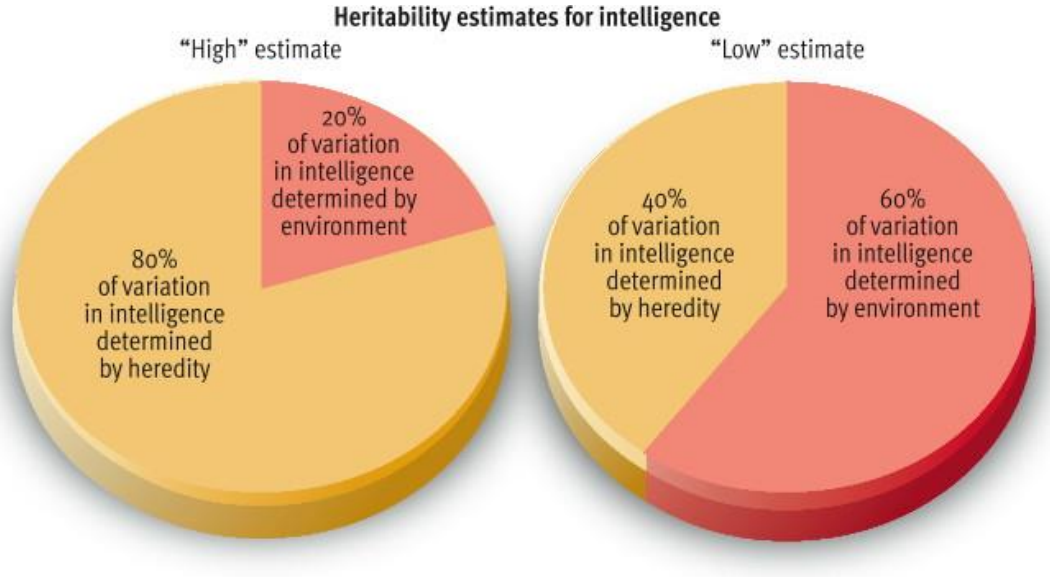

Figure: 12 Reaction range

5.2 CULTURAL DIFFERENCES IN IQ

Arthur Jensen argued that cultural differences in average IQ are largely due to heredity. The authors of The Bell Curve, by implying that we are moving toward a meritocracy based on intellect, ignited the same controversy. These arguments have been challenged on a number of grounds. First, even if IQ is largely due to heredity, group differences may not be. Social class and socioeconomic disadvantage are correlated with ethnicity, so environmental variables are not equal between groups. Kamin's cornfield analogy, presented on the next slide, depicts this issue. Claude Steele argues that derogatory stereotypes create feelings of vulnerability in the educational domain, undermining group members' achievement and performance on tests.

- Heritability as an Explanation
- Arthur Jensen (1969)
- Herrnstein and Murray (1994) – The Bell Curve
- Environment as an Explanation
- Kamin's cornfield analogy – socioeconomic disadvantage
- Steele (1997) - stereotype vulnerability

5.3 NEW DIRECTIONS IN THE STUDY OF INTELLIGENCE

Researchers such as Aurthur Jensen are searching for physiological indicators of general intelligence. Reaction time has been used in these studies, although the "fast is smart" idea is modest at best. Other measures studied include inspection time, which is an assessment of how long it takes to make simple perceptual discriminations that meet a certain criterion of accuracy. Higher correlations with IQ have been found with this measure, although much work remains to be done to discover why.

For over a century, intelligence was approached from a testing perspective. In contrast, the cognitive perspective focuses on how people use their intelligence. Robert Sternberg's triarchic theory of intelligence consists of three parts: the contextual, experiential, and componential sub theories. In more recent years (1999, 2000), Sternberg has asserted that

there are three aspects of what he calls "successful intelligence" – analytical intelligence, creative intelligence, and practical intelligence.

Other theorists propose an expansion of the concept of intelligence. Howard Gardner argues that IQ tests emphasize verbal and mathematical skills and exclude other important skills. He suggests the existence of a number of human intelligences, Daniel Goleman and others argue for the concept of emotional intelligence, which is the ability to perceive and express emotion, assimilate emotion in thought, understand and reason with emotion, and regulate emotion.

- Biological Indexes and Correlates of Intelligence
- Reaction time and inspection time
- Brain size
- Cognitive Conceptualizations of Intelligence
- Sternberg's triarchic theory and successful intelligence
- Expanding the Concept of Intelligence
- Gardner's multiple intelligences
- Goleman's emotional intelligence
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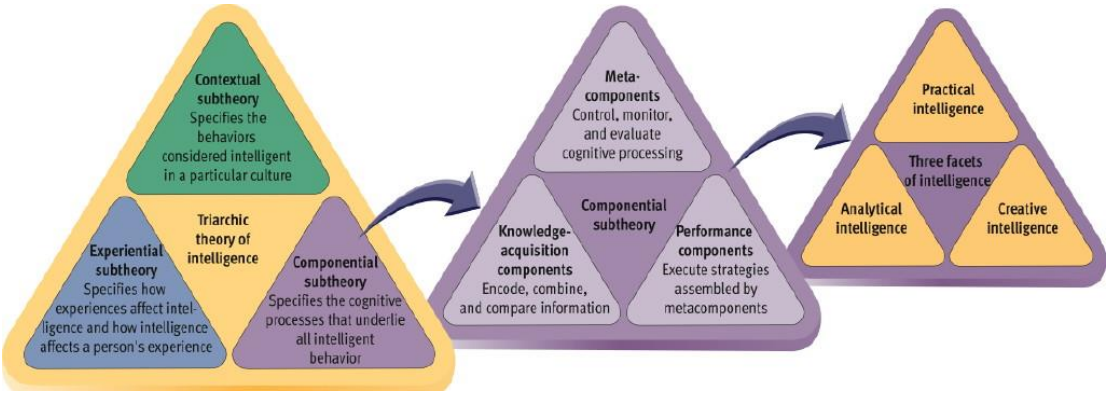

Figure: 13 Sternberg's Triarchic Theory of Intelligence

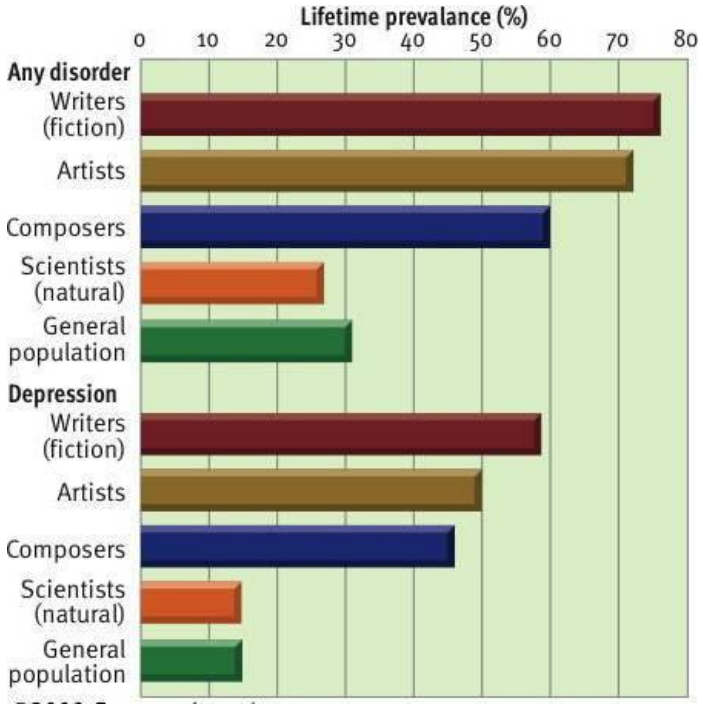

Figure: 14 Estimated prevalence of psychological disorders among people who achieved creative eminence.

6.0 TAPPING BRAINS FOR FUTURE CRIMES

Researchers from the Max Planck Institute for Human Cognitive and Brain Sciences, along with scientists from London and Tokyo, asked subjects to secretly decide in advance whether to add or subtract two numbers they would later are shown. Using computer algorithms and functional magnetic resonance imaging, or fMRI, the scientists were able to determine with 70 percent accuracy what the participants' intentions were, even before they were shown the numbers. The popular press tends to over-dramatize scientific advances in mind reading. FMRI results have to account for heart rate, respiration, motion and a number of other factors that might all cause variance in the signal. Also, individual brains differ, so scientists need to study a subject's patterns before they can train a computer to identify those patterns or make predictions.

While the details of this particular study are not yet published, the subjects' limited options of either adding or subtracting the numbers means the computer already had a 50/50 chance of guessing correctly. The researchers indisputably made physiological

Findings that are significant for future experiments, but we're still a long way from mind reading. It's a tempting thought. If there is no such thing as free will, then a system that punishes transgressive behavior as a matter of moral condemnation does not make a lot of sense. It's compelling to contemplate a system that manages and reduces the risk of criminal behavior in the first place.

Max Planck Institute, neuroscience and bioscience are not at a point where we can reliably predict human behavior. To me, that's the most powerful objection to a preventative justice system -- if we aren't particularly good at predicting future behavior, we risk criminalizing the innocent. We aren't particularly good at rehabilitation, either, so even if we were sufficiently accurate in identifying future offenders, we wouldn't really know what to do with them.

Nor is society ready to deal with the ethical and practical problems posed by a system that classifies and categorizes people based on oxygen flow, genetics and environmental factors that are correlated as much with poverty as with future criminality.

In time, neuroscience may produce reliable behavior predictions. But until then, we should take the lessons of science fiction to heart when deciding how to use new predictive techniques. The preliminary tests may have been successful because of the short lengths of the words and suggests the test be repeated on many different people to test the sensors work on everyone. The initial success "doesn't mean it will scale up", he told **New Scientist**. "Small-vocabulary, isolated word recognition is a quite different problem than conversational speech, not just in scale but in kind."

CONCLUSION

In this paper we have discussed the human mind reading system and IQ techniques based on some psychological factors, if successful, will allow computers to respond to the brain activity of the computer's user. Users wear futuristic-looking headbands to shine light on their foreheads, and then perform a series of increasingly difficult tasks while the device reads what parts of the brain are absorbing the light. That info is then transferred to the

computer, and from there the computer can adjust it's interface and functions to each individual. Hence if we get 100% accuracy these computers may find various applications in many fields of electronics where we have very less time to react.

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