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GENERAL INTELLIGENCE

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ABSTRACT

Some do not have a more efficient brain development than others, such variations are determined by the type of intelligence of each one. But the logical intelligence determines the development of other intelligences because it leads to the improvement of other intelligences. Psychology considers two types of intelligence that together make up Spearman's g: crystallized and fluid intelligence. The first is related to previous knowledge and experience and reflects verbal cognition, whereas fluid intelligence requires adaptive reasoning in new hypotheses. Intelligence has a large genetic participation, and a percentage of genes that perform functional functions are involved in several neuronal functions, including synaptic function and plasticity, cell interactions and energy metabolism. There is an expression of genes associated with the main neurons of the cortex and midbrain. Studies indicate that there may be a relationship of pyramidal cell function and structure to human intelligence relative to dendritic size and speed of action potential and IQ.

Keywords: Intelligence. Brain. Neuroanatomy.

Introduction

Studies show that some individuals have a more efficient brain development than others, such variations are determined through the type of intelligence of each. However, logical intelligence is determinant for the development of other intelligences because it leads to the improvement of other intelligences (Haier *et al.,* 2004).

There are several resources to analyze an individual's intelligence, such as brain imaging that investigates the structure and macroscopic functions of the brain and genetic associations for identifying *genetic genes and loci* related to intelligence. When neuroimaging is observed, it is possible to identify better and greater connections in the white and gray region of the brain (Haier *et al.,* 2004).

Materials and Methods

Intelligence Quotient Test (I.Q.)

The Wechsler Adult Intelligent Scale (WAIS) is one of the most widely used tests today to estimate Spearman's overall intelligence (g factor). This factor describes intelligent behavior in any situation. Being subdivided into educational intelligence which is the ability to focus on new ideas/skills in certain situations, reproductive intelligence that is ability to recall information already learned. Through this it is possible to associate results of several cognitive tests, as well as a large-scale I.Q. score (Spearman, 1904). Such tests are related to specific personalities and corroborate studies in neuroimaging and genetics, as well as are related to the socioeconomic levels and age groups of the same tested individual (Foverskov *et al.,* 2017).

Even in an old age, intelligence remains stable. It was observed in a general intelligence test that evaluated the same individuals at 11 years and 90 years, demonstrating a high correlation in their results (Deary *et al.,* 2013). A study conducted with twins demonstrated that the heredity of intelligence is in the range of 50% to 80% and can reach 86% for verbal IQ this occurs due to the natural evolutionary process (Posthuma *et al.,* 2001).

An example of a natural evolutionary process is when a smarter species seeks an intelligent partner to procreate. This is because our genetic code acts with an instinct to survive. Intelligence was a determining factor for maintaining the species (Posthuma *et al.,* 2001). In the same sense, when we are sick, we activate our survival instinct, thus triggering the region of emotions in the brain, the same region related to feelings (Hulshoff *et al.,* 2006). Such feelings of love and passion involve cortical and subcortical structures: insular cortex, anterior cingulate cortex, hippocampus, parts of the striated cortex and *nucleus accumbens* (Hulshoff *et al.,* 2006).

The connections of these regions are realized through neurotransmitters that synthesize neurons and by hormones secreted in the neuroendocrine system. Oxytocin, for example, known as the love hormone, is produced in the localized pituitary anterior to the temporal lobe, region of the limbic system (Foverskov *et al.,* 2017). Oxytocin secretion has positive effects on the immune system, an example of this is when the body perceives a threat that may be real or fictitious, several mechanisms are triggered as a response that put the nervous, neuroendocrine, and immune systems to act together (Foverskov *et al.,* 2017).

When the individual has some pathology, the sympathetic nervous system sends orders to the medulla of the adrenal glands to secrete adrenaline, after this is activated the neuroendocrine system, of the hypothalamus-pituitary-adrenal axis that secrete hormones through the blood, reaching again in the adrenal glands, which when receiving the signal, secrete other substances, among those that stand out; corticosteroids and cortisol (Karama *et al.,* 2009).

Such changes can lead to good feelings, oscillating in their peaks, more pleasant sensations of situations that did not please on normal days, mixed with the feeling of malaise of the disease. In risk situations, neurotransmitters such as dopamine are activated, which is responsible for the sensation of reward, also produced in the *nucleus accumbens*, region related to passion (Karama *et al.,* 2009).

Neuroanatomy of intelligence

McDaniel (2005) analyzed 37 studies involving more than 1,500 individuals, with the objective of demonstrating a *relationship between cerebral* volume in vivo and intelligence and found a positive and significant correlation of 0.33. In another study, evaluating 88 studies with more than 8,000 individuals, a significant correlation coefficient, positive and slightly lower than 0.24 (Pietschnig *et al.,* 2015) was again found.

Brain imaging studies with individuals with high I.Q. showed a distributed pattern of several brain structures that were related to intracranial, cerebral, temporal lobe, hippocampal and cerebellar volumes (Andreasen *et al.,* 1993).

Voxel-based morphometry (VBM) demonstrated correlations between intelligence and cortical thickness that are in multiple areas of frontal and temporal lobe association (Hulshoff Pol *et al.,* 2006; Narr *et al.,* 2007; Choi *et al.,* 2008; Karama *et al.,* 2009). This model evolved into studies with results in the frontal ocular field, orbitofrontal area, large number of areas in the temporal lobe, inferior and middle temporal gyre, parahippocampal cortex and auditory association cortex (Narr *et al.,* 2007 hoi *et al.,* 2008; Colom *et al.,* 2009; hoi *et al.,* 2008; Colom *et al.,* 2009).

The gray matter changes its volume throughout childhood, until adulthood, where it is influenced by learning, hormonal differences, experience, and age. Such changes may reflect rearrangements of dendrites and synapses between neurons (Gogtay *et al.,* 2004).

When the individual acquires a new ability, several transient and selective structural changes occur in associated brain areas (Draganski *et al.,* 2004). Gender and age differences induce brain structures and may affect cortical areas associated with intelligence (Haier *et al.,* 2005). In relation to males, the frontoparietal gray matter is related to overall cognitive ability. In females, there are associations with the efficiency of the white matter and the total volume of the gray matter (Ryman *et al.,* 2016).

Thus, women demonstrate significant associations in the thickness of the gray matter in the cortices of prefrontal and temporal association, as well as men present associations, especially in the cortices of temporal-occipital association (Narr *et al.,* 2007). In a recent study where surface-based morphometry (BMS) was applied instead of VBM, substantial group differences occurred in brain structure, but cognitive performance was not related to brain structural variation within and between genders (Escorial *et al.,* 2015).

The increase in the volume of the initial gray matter in younger individuals can be observed with a sustained thinning in the puberty period (Bourgeois *et al.,* 1994). In children with higher IQ, it was reported that the cortex in the initial phase was accelerated and prolonged, followed by a cortical increase and equally vigorous cortical thinning in early adolescence (Shaw *et al.,* 2006).

Types of intelligence

Psychology considers two types of intelligence that together make up Spearman's g: crystallized and fluid intelligence. The first is related to previous knowledge and experience and reflects verbal cognition, while fluid intelligence requires adaptive reasoning in new situations (Carroll, 1993; Engle *et al.,* 1999). Crystallized intelligence, characterized by verbal ability, is influenced by cortical structure and cortical thickness in lateral areas of the temporal lobes and temporal pole (Choi *et al.,* 2008; Colom *et al.,* 2009). While the parietal areas (Brodman area 40) expose the overlap of their involvement in crystallized intelligence and other types of intelligence. Brodman 38's temporal area is only involved in crystallized intelligence (Gainotti, 2006).

The lateral frontal cortex is related to reasoning, attention, memory, being related to fluid intelligence, as well as the parietal lobe. In a study on fluid intelligence using Raven Advanced Progressive Matrices, it proved the activation of several areas in the left hemisphere, in particular the posterior cortex. People with a higher fluidic intelligence have neural activity in the prefrontal and lateral parietal regions (Gray *et al.,* 2003).

Ohtani et al. (2014) demonstrated that measurements of gray matter volume from two frontal areas, orbitofrontal (OFC) and rostrals foremost cingulate cortices (rACC), were complemented by white matter connectivity between these regions. Associated with this, the volume of the left gray matter and white matter connectivity between the left posterior orbitofrontal and rACC demonstrated that up to 50% of the variance in general intelligence mainly in the prefrontal cortex in relation to its structure, function and connectivity are related to general intelligence, specifically reasoning capacity and memory (Ohtani *et al.,* 2014).

Influence of DNA and genes

The GWAS that are studies of association between phenotypes and genotypes used for intelligence analyses, demonstrate that single nucleotide polymorphisms (SNPs) when associated with intelligence are inserted in 51.3% in the intronic areas and in 33.4% in the intergenic ones, but only 1.4% are exonic (Savage *et al.,* 2018).

Corroborating this, the studies evaluated the same associations, but in regions of non-coding genes, thus making the genome to be responsible for influencing changes in synaptic activity and can develop a huge force in evolution in relation to cognitive ability (Hardingham *et al.,* 2018).

White substance

The white matter consists of myelinated axons that transport information from one brain region to another, with the integrity of the white matter tracts, being essential for normal cognitive function. Specific patterns of white matter dysconnectivity are associated with hereditary general cognitive and psychopathological factors (Alnæs *et al.,* 2018).

Throughout the process of brain maturation in children, the structure of the white matter demonstrates associations with intelligence. In a study with a population sample of 778 children, aged 6 to 10 years, the microstructure of the white matter was associated with nonverbal intelligence and spatial vision capacity, despite age (Muetzel *et al.,* 2015).

Results and Discussion

Not only the volume and thickness of the gray matter of the brain, are the bodies of neurons, as the integrity and function of the white matter in the temporal, frontal, parietal, myelinated axons, is related to intelligence.

Intelligence has a large genetic participation, being a percentage of genes that produce functional proteins implicated in several neuronal functions, including synaptic function and plasticity, cellular interactions, and energy metabolism. There is an expression of genes associated with the main neurons of the cortex and midbrain. Haier et. al., 2014, conducted a study with cells of the temporal lobe region (responsible for memory, recognition of signals and languages, which are associated with intelligence) of 35 individuals, who had performed IQ test and obtained a high score, and demonstrated a relationship between the function and structure of the pyramidal cell and human intelligence related to the dendritic size and speed of the action potential and the IQ.

Thus, the integrity of multiple white matter tracts in the right lancinado fascicle that connects parts of the temporal lobe with the frontal lobe areas is crucial to define intelligence, and damage in this passage is proven in individuals with mental retardation and good connection in individuals with high IQ.

According to Souza et al. (2002), general intelligence cannot be attributed to a specific region, this statement is made through functional and structural neuroimaging studies. The same includes a network of regions such as the dorsolateral prefrontal cortex, parietal lobe and the anterior cingulate cortex, multiple regions within the temporal and occipital lobes and the main white matter tracts.

Frontal and parietal areas are related to fluid intelligence, ability to think and reason abstractly and solve problems, temporal lobes in crystallized intelligence, which involves knowledge that comes from previous learning and past experiences, and the integrity of the white matter at the processing speed that defines the volume of the gray matter.

As defined in DWRI intelligence (Rodrigues, 2021), the region on the left side of the prefrontal cortex, related to logical capacity, regardless of acquired knowledge, is related to I.Q. tests, is a precursor to general cognitive development and intelligence is also the result of integrity in the participation of neurons, synapses, and their genetic composition.

The prefrontal cortex acts as a data distribution center where it monitors and influences other regions of the brain, the ability to solve logic problems in unusual situations regardless of the knowledge acquired already defines this region as an intellectual leader and manager of all intelligence.

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