Increase of human brain size through evolution

Introduction

The human brain is one of the most complex organs which is still to be understood better (Pugh, 2008). Considering the high amount of energy, it has, the brain only weighs around 1500 grams, accounting for only 2% of total body weight (Rosales-Reynoso, Juarez-Vazquez, & Barros-Nunez, 2018) . The human brain comprises of specific distinguished features, with several regions, each with specialised functions (Rosales-Reynoso et al., 2018). The evolution of the human brain has an extensive history; however, this topic focuses on the period after the diversion from common chimpanzees and the bonobo's (Enard, 2016). Since this split from our closest relatives, the human brain size has tripled and has gained the skills and abilities for cognitive and linguistical learning, along with language development and cooperation (Enard, 2016). According to a source, modern humans tend to have large and globular brains that distinguish them from their extinct *Homo* relatives (Neubauer, Hublin, & Gunz, 2018). To support this, it is stated that this increase in the brain size is part of the human evolution (Bastir et al., 2011). Furthermore, genetics and phenotypic changes that occurred after this split and that are common to all currently living humans can be defined as human specific. Fortunately, the human brain size growth can be tract because of the genome sequences from humans, chimps and other primates that have been extinct, which allowed humans to identify around 16 million genetic changes which occurred in the human lineage. Hence, the most obvious best measurable and most studied aspect of human brain evolution is its increase in size (Enard, 2016).

The brain is the source of all thoughts, emotion, decision and action that is made by an individual (Pugh, 2008). It was believed that the human brain reaches adult size at around the age of 10 and stops producing new cells. However, the results of researches in the past decade has demonstrated that the brain is constantly developing and making new cells even to old ages (Pugh, 2008). Although, it is true that the major period of growth and development of brain is during the first few years of life, which is by the age of 6 and even most neurons develop in the womb, but brain growth in structuring and function occurs throughout life. As we advance through society and technology, scientific knowledge on cognition behaviour has been growing. In relation to the development of the human brain, the initial sequence of brain configuration is largely programmed by one's genetic makeup when in the womb (Pugh, 2008). So, to understand the evolutionary process of the human brain size, this essay will be focused on the following topics:

- Morphology
- Genetic Effects
- Cognitive Behaviour

Morphology changes and effect

Humans are unique to other species in many ways and a common and increased interest is the increase in size of the human brain, which has contributed to structural changes that is different to other primates (Hill & Walsh, 2005). Today the human brain size is three times bigger than those of chimpanzee brains, which are the nearest living species to the humans diverged 7-8 million years ago. The brain size is also twice as bigger than pre-human hominids known as *Homo Sapiens* (*H. sapiens*) where the split occurred about 2. 5 million years ago (Hill & Walsh, 2005). This increase in size has affected the cerebral cortex which is the largest and main part of the brain, as most of the cognitive functions occur here (Hill & Walsh, 2005). Thus, over time, various regions of the brain have increased in size and among them the cerebral cortex has increased in size more (Bradbury, 2005). The cortex is comprised of larger cortices among with multiple layers of smooth sheet that is rodent and folded in mammals. This allowed more cortex to squeeze itself into a limited volume of the human head. Despite this, the enlarged cortex of apes, ponder upon a time of neuronal formation during the prenatal development, in order for every dividing progenitor cell going through more cell cycles prior to stopping cell division (Hill & Walsh, 2005). Moreover, the increase in human brain size is primarily due to the expansion of the neocortex, particularly heterometal association regions of the frontal, temporal, and parietal lobes (Verendeev & Sherwood, 2017).

The increase in size has also affected the shape of the human brain compared to other primates (Neubauer et al., 2018). Current human brain is globular in shape, having globular endocasts with steep frontal, bulging parietal and enlarged rounded cerebral area. Whereas, other *Homo* species and Neandertals have anterior-posteriorly elongated endocasts. Researches have shown that the globalization shape develops during prenatal or perinatal phase which is the period of high growth in the brain (Neubauer et al., 2018). In the study of Neubauer et al., (2018) computed tomography scans and geographic morphometric analysis of the endocranial shape of H. sapiens and humans' fossils reveals variations that have developed as a result of evolutionary shape changes. This evolutionary change in shape has led to the present human brain shape being globular due to the frontal are being taller, bulged parietal area, paralleled side walls, rounder occipital area and enlarged cerebellum (Neubauer et al., 2018). It is also stated that endocranial shape changes from different geologic groups is associated with increase in size in cerebellar and lateral parietotemporal area (Neubauer et al., 2018).

Genetic effects on brain size

Furthermore, another key area that needs to be focused in understanding the evolution of human brain size is the genetic changes that have selectively occurred and adapted over time (Hill & Walsh, 2005). According to (Hill & Walsh, 2005), there are three major genetic evolutionary mechanism which includes, alteration in levels of pattern of gene expression, alteration in the coding sequence of genes and addition or subtraction of the entire gene to or from the genome. Although, genetic changes can occur at specific level or at individual level, but recent studies suggest that the evolution of human brain is specifically associated with gene expression changes specifically to the brain (Hill & Walsh, 2005). Studies have found out that in the human lineage compared to chimpanzee there is a subset of brain genes that shows increased expression. In addition, evidence suggest that some neural genes underwent important changes in their coding sequence over time which were targets for natural selection (Hill & Walsh, 2005). This has been investigated by comparison of ancient DNA changes occurring in several closely related species such as the *Homo* representatives and *H. sapiens* fossils (Simo et al, 2018). This study revealed that after the population split of *H. sapiens* from Neandertals more than 500, 000 years ago there were some genetic features that were fixed in *H. sapiens* . Thus, indicating a positive selection of important genes for brain function and behaviour within the human lineage (Neubauer et al., 2018).

A common example is the FOXP2 gene which is an important gene for speech and language development (Neubauer et al., 2018). In comparing the effect of this gene in humans and Neandertals, it has been seen that a substitution in an intron of the gene that affects a binding site for transcription factor which is likely to alter the regulation of FOXP2 expression and associated behaviour was absent in Neandertals ((Hill & Walsh, 2005). This indicates that the expression and regulation have been actively present in human brain which has led to benefits of language and speech. Whereas in Neandertals this might be due the brain size and not being able to regulate so many genes. This difference in FOXP2 sequence between humans and other species show evidence of positive evolutionary selection for language (Hill & Walsh, 2005).

In addition, molecular biologist has also been examining selective pressures like those of Dunbar and those before him on random gene mutation that might have led to evolution of human brain (Bradbury, 2005). It has been evident that the two genes that cause microcephaly (small cerebral cortex) in humans are strongly associated with human brain size evolution (Hill & Walsh, 2005). Microcephaly is an inherited disease in which the human brain is reduced to half of its normal size (Hill, 2005). According to(Bradbury, 2005), the founding of scientists confirms that mutations in the two genes involved in causing microcephaly are ASPM (abnormal spindle-like microcephaly associated). This is supported by the fact that during evolution of primates these two genes have been under selection pressure (Bradbury, 2005). These two genes show strong evidence that subtle sequence changes were subject to positive selection in the lineage leading to humans (Hill & Walsh, 2005). However, this is not confirmed by all and further research needs to be done to understand its role in brain evolution.

Development of Cognitive abilities

One of the distinguishing attributes of evolution of human brain size is the demonstration of highly advanced mental capacity. There are around 100 billion neurons in the human brain, which gives an idea that our cognitive abilities are almost without limit (Hofman, 2014). Considering the biological basis for this, this is assumed due to the large brain size of humans. This is evident particularly for the cerebral cortex which mostly involves high cognitive abilities (Enard, 2016). The evolution of the human brain is very relevant, as our bases is dependent on important cognitive features (Enard, 2016). The human beings have pride on the uniqueness of their brain (Bradbury, 2005). The remarkable properties of human brain make us a remarkable species (Enard, 2016).

In order to better understand the human cognitive abilities of how we acquire, process, store and act in response to the information from our environment, it is important to know our history and how selective pressures have shaped our ancestors (Verendeev & Sherwood, 2017). Relative to human body size, we have bigger brain compared to any other animal (Bradbury, 2005). The human brain is believed to have evolved through set of underlying structures which have shapes its size, and the level of information it can store and process. If the driving factor behind evolution is its ability to process information about its environment, then the greater information is received by the brain and the faster it processes it, the more effective it will be when responding to changes in environment and will have greater chances of survival (Hofman, 2014).

Ever since the split of lineage from the chimpanzee, there has been increase in the size of human brain and has enabled to acquire language, vocal learnings and intense cooperation (Enard, 2016). To understand this, one way is by comparing the similarities and differences of cognitive processes and neuroanatomical structures between extant species. Chimpanzees are considered as one of the closest existing species to modern human beings, and it makes them an important base for comparison.

There are number of exceptional cognitive and behavioural differences between humans and other species (Verendeev & Sherwood, 2017). The human intelligence and their ability to manipulate their environment may be due to the unique structures and patterns of human brain (Bradbury, 2005). It is important to recognise that these changes have occurred at different levels of brain structure, which has enabled the ability for complex human cognitive and behaviour (Verendeev & Sherwood, 2017). To test the hypotheses in relation to brain evolution in *H. sapiens* , there has been touch between the brain and its underlying skeletal base. It is evident that modern humans appear to have unique brain features such as larger olfactory bulbs, moderately wider orbitofrontal cortex and increase with forwarded projecting temporal lobe poles (Bastir et al., 2011).

Despite these, these is different argument in relation to the size of the frontal lobes and different prefrontal cortical parts of humans compared to other primate species (Verendeev & Sherwood, 2017). The area of the prefrontal cortex has an essential role in planning, decision-making, language, working memory and other cognitive abilities. Some believe that changes in prefrontal cortex is associated with consistent changes in other areas of the brain, while some analyses demonstrate that human prefrontal cortex is enlarged greater than what primate brain scaling trends predict (Verendeev & Sherwood, 2017) .

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