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Aphasic Disorders: Broca's and Wernicke's Aphasia'

Overview

Language resides in two auditory areas of the human brain: the Broca's and Wernicke's areas. Once these areas are activated, further signals are then dispersed in sequence throughout the Arcuate Fasciculus. New imaging techniques reveal this terpsichore as language and thought actuate subsequent areas surrounding these auditory domains (TED, 2011). The theory being that language appears to wake the brain up. The Broca's area of the brain was discovered by the founder of the Anthropological Society of Paris (Teter, 2000) and noted surgeon, Pierre-Paul Broca in 1864 (Museum, 2016). The Wernicke's area was discovered by German neurologist Carl Wernicke's in 1874 (Britannica, 2016). If either one of these areas becomes damaged the production of language and/or motor skills can be adversely affected. This report focuses on fluent and non-fluent aphasia's resulting from damage to both the Broca's and Wernicke's areas. It discusses new radiographic technologies that are advancing the way that the brain can be examined, leading to a greater understanding of how the language centres of the human brain can adapt to often sudden lesions to these language areas.

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Figure 1: The above is a computer-generated recreation of an 1848 incident. A 3-foot pointed rod penetrated the skull of a railway worker, Phineas Gage. The rod entered through his face, into his brain, and exited his skull. Gage survived but suffered with behavioural problems after the event (National Institute of Neurological Disorders and Stroke, 2016).

Introduction

The Brain

The human brain is a highly functional adaptive processor, to which once was a mystery to be dissected post mortem preferably, to garner an understanding of what it is to be human. The human brain weighs approximately 1.4 Kilograms (Lewis, 2016). It is surrounded by Grey matter (BSc, 2014); a 2-6mm layer of fibres' known as 'bark', the Latin word for Cortex (Net, 2008). Grey matter is where information is presented, dissected and disseminated to the specific functions located in the brain area, whether they are the visual, auditory or language areas (BSc, 2014).

The Broca's and Wernicke's areas are situated in the left hemisphere and are specialised language regions in the brain (Dara Oliver Kavanagh, 2010). The Wernicke's area sits in the Brain between the Auditory Cortex (Robert J. Zatorre, 2002) and the Angular gyrus (Göbel S., Dec, 2001). Above the Auditory cortex is the Broca's area. The Broca's area is situated next to the Motor cortex region. The Wernicke's and auditory cortex are located in the Temporal lobe region just above the cerebellum (the little brain) within the brain (Dafny, 1997-present), and the Broca's is positioned within the left Frontal lobe. Between the two hemispheres rests a white matter bundle of fibres called: Arcuate Fasciculus, which connects the Wernicke's to the Broca's area (Johnson B. W., Introduction to Language in the Brain: Conduction Aphasia , 2015). Damage to these areas of the brain can lead to speech and motor deficiencies.

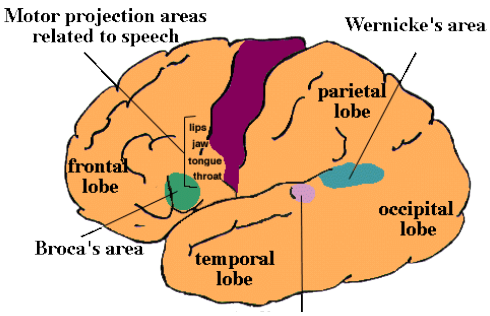

Figure 2: The two main language areas are Broca's area, which is located in the frontal lobe, and Wernicke's area, which is located in the temporal lobe. (Mary Louise Kean, 2016)

Language Theories

There are differing theories as to how language evolved for the human animal. Noam Chomsky, father of linguistics (FamousScientists.org, 2016), theorised that language evolved through a sudden, single mutation (Johnson B. W., Image and stimulation techniques for studying language in the brain: Introduction to Language in the Brain Part A: Genetics of language, 2015). Steven Pinker (Psychologists.Net, 2013) theorised that language was a gradual adaptation via the Darwinian 'Natural Selection' observational theory (FamousScientists.Org, 2015). Pinker's so called; 'continuity assumption' hypothesis recognises that basic linguistic representations are similar throughout all stages of language development, since language ultimately evolved from his 'single universal grammar' theory (Tomasello, 2003). Chomsky argued that 'the language by experience consists of nothing more than a series of individual utterances (Tomasello, 2003)'.

What is Aphasia?

Aphasia is an acquired language disorder resulting from damage to the parts of the brain that control language (Reinstein, 2010). Lesions in the Broca's and Wernicke's areas of the brain produce difficulties with speech and motor skills. These lesions can be due to a Traumatic brain injury (TBI) such as a Stroke, infection, tumour or surgery, and traumatic impact to the head, amongst other factors (National Institute of Neurological Disorders and Stroke, 2016). Aphasia is also used to describe speech and language disorders such as the developmental Landau-Kleffner Syndrome (Epilepsy) (Sonia Khan, 2012), the severe social and communications disorder, Autism (Eli S Neiman, Dec., 9th., 2015), and Dementia (Eric B. Larson, 2013), a progressive brain disease known as 'Progressive Aphasia (M.-Marsel Mesulam, 2003)'

Broca's Non-Fluent Aphasia

In the human brain, the Broca's area is located in the prefrontal cortex, at the bottom of the left frontal lobe, and is responsible for speech production (NeuroRehabilitation & Neuropsychological Services, 2016). Broca's non-fluent aphasia refers to a person's difficulty in speaking, but retains their aptitude for 'understanding both the spoken and heard language (Johnson A. P., 2016)'. It is known as non-fluent due to the lack of fluency in the spoken word (Jan Schnupp E. N., 2016).

Broca's aphasia is also known as motor aphasia (Jan Schnupp E. N., 2016). Broca's is described as Motor aphasia due to the ability of someone with lesions on the Brocas region of the brain, to maintain their cognitive ability for comprehension whilst suffering a disorder in their ability to articulate (Jan Schnupp E. N., 2016). For a person with Brocas lesions, their phonological cognition remains intact; however, 'their lexical syntactic knowledge' becomes aphasic (Tesan, 2015).

Wernicke's Fluent Aphasia

Also located in the left hemisphere of the human brain is the Wernicke's area. This area is responsible for comprehension (NeuroRehabilitation & Neuropsychological Services, 2016). Damage to this specialised language area can reveal 'problems in understanding speech (Johnson A. P., 2016)', but also, the lesions can affect a person's motor cortex, Angular gyrus, and the auditory cortex (Johnson A. P., 2016). These areas all perform different computations in the brain. Known as fluent aphasia, or receptive aphasia, there are lesions on the Wernicke's area, and people with this disorder speak quite fluently, however, much of that speech makes no sense to the hearer. The speaker does not recognise that they are speaking 'non-existent or irrelevant words (National Aphasia Association, 2015)'.

Angular gyrus

The Motor cortex, or M1, is one of the principal brain areas involved in motor function (Posit Science, 2014). Located in the frontal lobe, its role is to generate neural impulses to which control the implementation of movement (Posit Science, 2014). The Angular gyrus is one of nine major primary sensory areas known as 'somesthetics within the parietal lobe (Rhawn Joseph, 2000)'. The Angular gyrus maintains dynamic interconnections with the visual, auditory, and somesthetic association areas. Damage to the left angular gyrus, also known as anomia, effectuates severe word finding and confrontive naming difficulties (Rhawn Joseph, 2000).

Brain Lesions

A Brain lesion is any abnormal or damaged area of matter detected in the brain. Abnormalities can be seen as spots that are lighter or darker than normal brain matter. Magnetic Resonance Imaging (MRI) can reveal brain lesions. 'Lesions often trace back to causes such as tumour, infection, disease, injury, and stroke, and are also called cerebral lesions (Pam MS, 2012)'.

Technological Advancements

No-longer is statistical spiral performance by chi square and biserial correlations (Aaronson, 1958) the mainstay of statistical analysis and study into the function and functioning of the human brain. Although still vital statistical tools (Statistics Solutions, 2014), technological advancements have exceeded scientific expectations, with the ability to actually look into an active, functioning human brain of a living person.

EEG & MEG

Electrophysiological brain activity emits electrical fields that, as a consequence, produce magnetic emissions. Magnetoencephalography (MEG) signals are detected, usually with a cap that accommodates 306 tiny sensors known as ‘superconducting quantum interference devices (SQUIDs) (Aviv, 2008)’. These SQUIDs pick up the brains magnetic fields that change as the language centres begin to actuate (TED, 2011). This information, thanks to the MEG SQUID cap, has provided scientists with the first look at an active, human baby brain as it begins to think (TED, 2011).

Mr Leborgne (Tan tan)

Paul Broca discovered aphasia (1864) in lesions to an area of the prefrontal cortex that were found to be damaged in his severely aphasic patient, Mr Leborgne (Jan Schnupp E. N., 2016). Broca nicknamed Mr Leborgne "Tan tan" because ‘tan’ was the only word that Mr Leborgne could speak (Jan Schnupp E. N., 2016). Broca’s non-fluent aphasia can present in the brain after a Stroke or a traumatic brain injury, but can also develop in progressive aphasic disorders such as; Acquired Epileptic Aphasia, Autism, and Dementia. Broca’s aphasia is a language disorder that is both distressing and frustrating for patients. Persons with the disorder understand language, speech and the written word but cannot always articulate their own thoughts in a grammatically accurate manner. These patients are, for lack of a better description, prisoners in their own minds.

Carl Wernicke’s Stroke Patient

Wernicke's aphasia is generally associated with lesions to the Wernicke's area. Discovered by Carl Wernicke’s (1874), in a patient who had suffered a stroke. Although capable of speech, the patient could not understand either the spoken word or written language (Nicholas Wade, 2011-12). Wernicke’s is a much more invasive disorder than the Brocas, but relates to a lesser degree of distress in patients. Distress levels are limited because people with

Wernicke's aphasic disorder do not know that they are experiencing problems articulating speech. This is primarily due to the fact that Wernicke's is a fluent aphasic disorder and as such, patients speak fluently and it is only the hearer that recognises that most words are nonsensical.

Wernicke's aphasia patient video. (Jan Schnupp E. N., 2016)

Summary

The Broca's area and Wernicke's area are the two major language centres in the brain, situated in the left hemisphere. A person with a Broca's disorder has difficulty articulating sentences, but is able to remain on topic when in conversation. This reveals that although the person with Brocas is unable to accurately speak what they visualise in their mind, they are capable of understanding what they are hearing, and the brain has the ability to adapt to new ways of interpreting what they desire to say. A person suffering lesions to the Wernicke's area, although less distressing for patients ignorant to their fluent gibberish, suffers a greater degree of anguish when their disorder also affects the motor abilities.

- Broca's aphasia patient video
- A more recent Brocas aphasic patient, Sarah Scott. (Eli S Neiman, Dec., 9th., 2015)

Conclusion

The brain itself does not resemble any other object in the known world, with its complex structures and minute fibres. The fine layer of grey matter, that performs intricate and crucial computations and disseminations, filters information along its fibrous pathways actuating crucial functions within the brain. The Broca's and Wernicke's areas are connected via the fibrous tendrils of the Arcuate Fasciculus. Being that they are specialised language areas, damage to either domain can affect language and or motor skills. If the Arcuate Fasciculus cannot pass information between these areas, then the brain loses its ability to communicate with itself, resulting in loss of speech (Non-fluent), the ability to send messages to other parts of the body: such as the mouth and hands (Motor), and of course can result in a patients fluent, yet unwitting, gibberish (Fluent).

Even with today's technological advancements, the absoluteness of any theory concerning the evolution of language in humans, is negated by the fact that there are no absolute theories. A theory is a hypothesis; an ambiguous thought formed through experimentations or observations, it is an educated guess. The best we can hope for is, 'we are pretty sure that language resides in the brain because...' As technology advances, greater educated guesses will be revealed, yet absolute certainty is a long way off. Scientists, psychologists and linguists have found that damage to certain areas of the brain can affect the way a person speaks, hears and functions; however, causation does not prove actualities when it comes to the brain. If causation did prove scientific fact, then curatives could be formulated to not just treat the symptoms of TBI, dementia, and autism amongst other brain disorders, progressive and Aphasic, but actual cures would be available to treat the early stages of these disorders. Chomsky and Pinker have theorised about the evolution of language, and even with the MEG SQUIDS, language residing in the brain still remains theory, it is a solid theory, but theory none the less.

Table of Figures

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