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Original Article

The unified theory – Neurology of emotions and how to control them

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Abstract

Introduction

The major emotions such as fear, anger, joy and sadness are created through a complex mechanism in the temporal lobe combining data from all the sensory inputs to the brain. However, these emotions may turn into extreme manifestations when the hypothalamus and the autonomic nervous system transform these emotions to panic, rage, orgasm/laughter and grief. The Papez circuit which is at play for this "different turn" may be inactivated or could be over ridden by forebrain activity, that is, sequencing. This probably was the reason to the old adage of counting to ten when one is emotional. In this article, we hope to look at the basis and the neurology behind this and formulate a method to overcome panic.

Materials & Methods

A pilot study of 10 children aged 10 -16 was done on 16th October 2017. These children were shown pictures inducing fear and anger. A Visual Analogue Score (VAS) was used to determine the induced emotion. Next, the children were made to do sequencing tasks like mathematical calculations while viewing the similar graphics again. The new score was recorded and the data analyzed.

Results

The most frequently recorded VAS (n = 4) before sequencing was around 6.0, and between 3.0-3.5 post sequencing. The mean VAS without sequencing was 6.19 ± 0.91, which reduced to 3.65 ± 0.665. On comparing the individual VAS scores before and after sequencing, there was a general trend of a decreased VAS post-sequencing. The results were statistically significant with a p-value <0.05.

Conclusion

The study indicated that some form of sequencing while perceiving the fearful or any emotional stimuli might blunt the emotion and may not produce extreme emotions. This would be an extremely interesting and useful piece of information for many who are in cutting edge professions and competitive sports. However, much study needs to be performed to further validate this initial conclusion.

Key Words

Amygdala, Emotions, Fear, Inhibition (Psychology).

Introduction

Our emotions are the responses to the five senses our body perceives; and associates them with the stored memories from the past to bring about a pleasant or unpleasant behavior. A human being can experience four emotions including happiness, sadness, fear and anger. How

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these emotions can be projected upon us is the function of the limbic system, and most importantly, the amygdala, that plays a central part in acquisition of sight, hear, taste, smell and touch. The presumed role of the limbic structures connecting the hippocampal and para hippocampal region with the mammillary bodies, anterior thalamic nuclei, and the cingulated gyrus form the Papez circuit [1] The neuronal circuitry of the Papez Circuit processes all the information and relays it via the thalamus to the cortex and the hypothalamus and generates a series of changes in the hormonal and autonomic controls by the pituitary and the adrenal glands respectively. The "fight or flight" mechanism by the sympathetic stimulation is classic example of the body's response to fear.

It is not true that a particular sensory input will elicit a similar response each time and in each individual. This behavioral variability is the effect of both, the social and personal context in which a signal is perceived. For example, a girl who has been raped will recall her trauma every time she is touched, and this fear can occasionally transform into panic on being touched in a particular way. On the contrary, that similar touch might elicit a pleasant response in another girl who will associate this as a gesture of love and admiration. These differences in responses are a result of the preformed memories associated with the events, which take us back to react in accordance with our experiences from the past. The interesting fact remains that the same sensory inputs can emit different responses.

The uninhibited release of stimuli by the Papez circuit and the hypothalamus recruits continued autonomic and hormonal discharges. This results in unstoppable responses leading to extreme consequences. These, for example, if may turn happiness into ecstasy, sadness into grief, fear into panic and anger into rage. Uncontrolled "happiness" may result in early orgasm resulting in premature ejaculation. Uncontrolled "fear" can turn into panic resulting in a post-traumatic stress disorder experienced very frequently by survivors of physical or mental trauma.

The presence of a cognitive inhibitory control by the frontal lobe is essential for a flexible behavior. The fronto-basal-ganglia circuit initiates a stop signal task in the form of sequencing which is a serial order in behavior to bring about a stop to the continued discharge of autonomic responses. This can include counting numbers from 1 to 100, in forward or backward order; odds or evens; multiples and many more complex patterns. The goal is to achieve the sequencing needed to stop a behavior from being elicited too much. The more complex the sequence is, the better the control will be over inhibition of response. This mechanism is the basis of cognitive behavioral inhibition as seen in many experiments. The forebrain, and the usage of it, hence plays a crucial role in keeping a check on the levels of expressed emotions, and sequencing is one method to achieve this counter regulation.

Materials and Methods

A group of 10 children aged between 10 and 16 were asked to volunteer for the study on 16th October 2017. They were subjected to pictures & video clips that would make them angry, sad, happy or afraid. A Visual Analogue Score (VAS) was obtained on a scale of 1 to 9 and the results were charted for each participant without undergoing any form of sequencing or calculations being done at the time when the subject was visualizing the pictures. A second test was run on the same participants and this time, the Visual Analogue Score was obtained while undergoing sequencing patterns or calculations being done at the time when

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the subject was visualizing the pictures. The difference in the mean values of VAS before and after sequencing was calculated using a paired t-test keeping a 95% confidence interval.

Results

All the 10 participants were able to express emotion in response to stimulus as recorded by the VAS Scores obtained. [Figure 1] compares the frequency and the means of the obtained VAS. The most frequently recorded VAS (n=4) before sequencing was around 6.0, whereas after sequencing was between 3.0 and 3.5. The figure shows that the mean Visual Analogue score after emotional perception without sequencing was 6.19± 0.91, which significantly reduced to 3.65 ± 0.665. [Table 1] shows the results of a paired t-test in a tabular form. On comparing the individual VAS scores in each participant before and after sequencing, as in [Figure 2], we can clearly see a general trend ofa decreased VAS post-sequencing. There was a statistically significant difference between the two data sets; before and after sequencing, showing a p-value <0.05 (0.001).

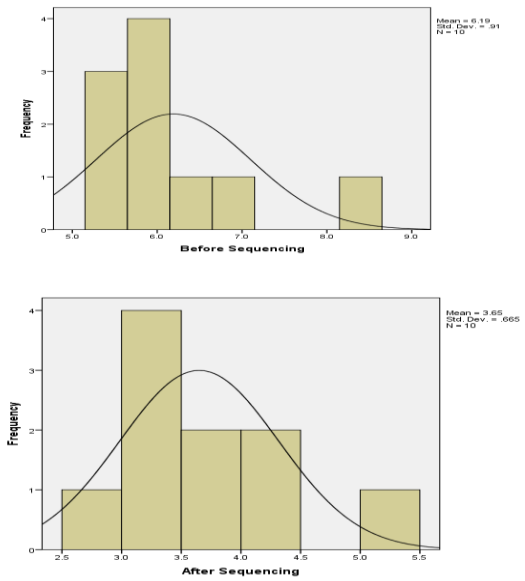

Figure 1: The frequency and mean Visual Analogue Score before & after sequencing

Table 1: Paired sample t-test to show the difference in mean and the standard deviations

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before Sequencing	6.190	10	.9098	.2877
	After Sequencing	3.650	10	.6654	.2104

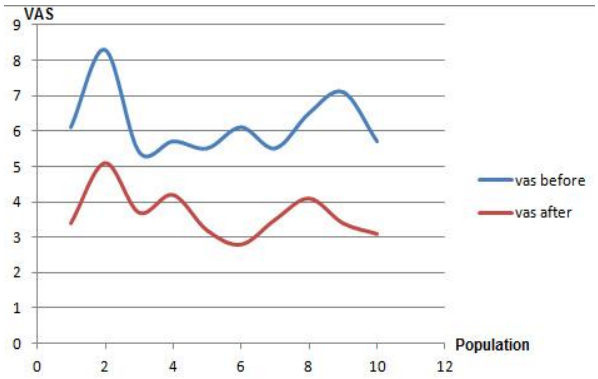

Figure 2: Difference between the individual Visual Analogue Scores before and after sequencing.

Discussion

It is quite often that many people find themselves in a situation of the red haze, panic, overwhelming impatience verging on panic and so on… One has to wonder how this has an impact on our motor skills. Cutting edge Neurosurgery, or complex sports at the highest level, is a function of skills and attitude. These skills can be attained by constant practice. However, attitude takes a long time of conditioning to change. For some, it never changes and this prevents them from joining the group of elites making them hesitant to taking up challenges. In this aspect, Neurosurgery can be compared to a Formula one racing or even a wing-suit jumper. If one looks at what can go wrong, these sports cannot

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even exist.... Yet, the beauty of an overtaking in F1 or witnessing the wing-suit jumper zooming past is a joy to behold. So, what exactly separates the ordinary from the elite in such cutting edge "walk on the high wire" jobs? It is fear, a very primal emotion associated with the amygdala, the Papez circuit and the hypothalamus. What is fear? The state evoked by threat. What is threat? That which causes fear!

The primitive nature of human emotion belongs to the mind that we share with animals as studied by Dr. Mac Curdy [2]. Hence, apart from the liability we as humans hold to fear, the fear of even being afraid is inevitable and the power to conquer this fear produces the feeling of excitement. Often fear of what can go wrong is what drives this anxiety, insecurity and anger. This is true in general atrocities like religious riots or coups and politicians are expert hands to make use of these fear/insecurities of the general public to incite them against certain sets of religions or individuals or parties. This manipulation has been done from time immemorial and forms an interesting part of political studies. From the viewpoint of an aneurysm surgeon, the fear of failure or the fear of imminent rupture of an aneurysm has to be kept in a different drawer of the mind. Fierce focus will help the surgeon to do this and bravery is not about doing foolish things but is rational about each step and achieves a little bit more towards clipping the aneurysm.

Neurobiology of Fear

To understand the neurobiology of this feeling one must know about the Papez circuit which conveys the information from amygdala to the hypothalamus resulting in the sympathetic reactions like increase in heart rate, perspiration and the urge to run away. This is the same circuit which causes your knees to buckle and your chest to burst when you would propose to your lady or do something out of the ordinary! The same circuitry is at use when a boxer or a cricketer sledges the opponent trying to get him mad and behave in an irrational manner ultimately losing his "cool" and his wicket or the boxing match. The same happens during an aneurysm repair or a very difficult tumor surgery during which the "red haze" of fear or impatience leads to degeneration of motor skills of the neurosurgeon, unnecessary hurry or an urge to finish things off as fast as possible leading to disasters.

The sensory information from all the senses is conveyed to the amygdala and the entorhinal cortex, which is the primal centre for fear. The stria terminalis, a pathway leading from the amygdala to the hypothalamus, results in the manifestations of fears as all of us know. The three distinct sites responsible for provoking a fear response via electrical stimulation are the lateral and central zones of amygdala, the anterior and medial hypothalamus and some specifies regions of the PAG [3]. The most critical component comprising the central neural circuitry for fear learning is the amygdala [4]. Comprised of a heterogenous group of neurons, which are often subdivided into subnuclei each responsible to play separate but complementary roles in acquisition, expression and extinctinction of fear. These group of neurons share properties of the cortex and stratum. The Basolateral complex (BLA) made up of Lateral (LA), basolateral (BL) and basomedial (BM) nuclei, regulates conditioned fear. The intercalated cell masses comprise of the central nucleus (CeA), further divided into lateral (CeL) and Medial (CeM) sub nuclei [5]. The lateral/basolateral nucleus is the site of plasticity underlying the learned association between the Controlled and uncontrolled Stimulus. The medial nucleus plays a modulatory role in the process of predator odor-induced fear learning, these

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areas have been the subject of extensive research and multiple reviews. Recent research suggests that the CeA, while initially believed to be primarily a final common output pathway of the fear circuit to the behavioral and autonomic effectors regions of the brain, is also involved in the acquisition, expression, and consolidation of conditioned fear. The CeL receives input from many extra-amygdalar sources, including the mPFC, pPVT, auditory thalamus and cortex, and several brain stem areas with projections releasing neuromodulators onto CeA cells, such as glucocorticoids, estrogen, CRF, and oxytocin. This leads to the working hypothesis that fear-related information is gated by local inhibitory circuits in the CeL as it passes from the BLA to the CEm and the activities of these local circuits are tuned by the cortical and subcortical inputs onto the CeL using neuromodulators. However, it is not necessary that all sensory inputs trigger fear. This is because of the the specific pattern of environmental cues confronting the organism. The impulse transfer from LA to CeM is flexibily gated and the CeL and the ICMs fulfill receive glutamatergic inputs from BLA and send GABAergic projections to CeM resulting in a structured response [4,6].

Can we measure this?

Prior researches have indicated that visualizing the amygdala and the stria terminalis and then visualizing blocking off the inputs from the amygdala to the hypothalamus is difficult to a great extent in the author's experience as a surgeon as well as somebody who has played different competitive sports including martial arts! This may work for people who understand this circuit and would need the others to understand and then visualize the circuit as well as blocking it. Controlled response in humans is assessed via psycho physiological measures like skin conductance response (SCR), galvanic skin reflex, electromyography (EMG)and changes in heart rate. [7].

Functional magnetic resonance imaging (fMRI) is a powerful tool for investigating the emotional and cognitive brain responses. The use of a functional MRI enables the measurement of fear conditioning process during which one can see the difference in their way of functioning. It detects changes in the cerebral blood flow as a result of neuronal activation across the brain, while a cognitive task is performed.

The non-invasive nature of fMRI, proves to be an invaluable tool to delineate neural systems underlying sensory processing and higher cognitive functions. The technique is sensitive to changes in brain function due to neuropsychiatric disorders, pharmacological changes and genetic differences [8] hence representing a valuable research and clinical diagnostic tool. However, the limited correlations using only animal studies (eg: rodents) can reveal causal mechanisms providing the opportunity for translational preclinical studies into the influence of pharmacological, genetic and environmental manipulations on brain function, which would be rather difficult to conduct in human subjects [9-10].

For example, a study conducted on awake rodent models showed activation of the amygdala and related fear circuitry in response to a fear-conditioned stimulus and also concluded the linear correlation of magnitude of fear circuitry following early life stress [11-12]. Another study using fMRI on persistent and desistent subgroups of childhood-associated disruptive behavioral disorders (DBD) showed enhanced neural responses during fear conditioning [13].

Therefore, in order to understand the circuit- and cellular-level contributions of the CeA to fear learning, it is important to obtain sophisticated functional data

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superimposed onto the existing anatomical framework. Fortunately, an increasing number of genetically encoded fluorescent sensors [14-15] and actuators [16-17] for optical recording and control of neural populations respectively are becoming available. These approaches, in combination with intersectional genetic methods [18] the power to extract this critical information [5].

Conclusion

The above study clearly indicates that some form of sequencing or calculation whilst perceiving the fearful or for that matter, any emotional stimuli might blunt the emotion and may not produce extreme emotions. This would be an extremely interesting and useful piece of information for many who are in cutting edge professions and competitive sports. Where we have reviewed an extensive literature on the neuro physio biology of fear conditioning, it is equally important to know the mechanism behind fear extinction- an attempt to conquer our fears. Conditioning or repeated exposures to similar scenarios help to a great extent and this is why veterans of war and of large number of surgeries behave in a way that is patient and rational and is able to tackle the situation at hand.

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