Mesial Temporal Sclerosis and Creativity

How Neurodegenerative Disease Provides Insights into Human Creativity

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Abstract

This study explores the impact of Mesial Temporal Sclerosis (MTS) on human creativity by analyzing historical figures and creatives believed to have had MTS. It provides insights into the connection between MTS and creative abilities and

offers a comprehensive understanding of the implications of MTS on human cognitive function.

Introduction

Mesial Temporal Sclerosis (MTS) which is commonly regarded as hippocampal sclerosis (HS) is largely associated with temporal lobe epilepsy (TLE). Hippocampal sclerosis is a common cause of chronic epilepsy and is characterized by severe neuronal loss and gliosis (scarring) in one or more regions of the hippocampus. It is also known by various other names, including Ammon horn sclerosis, mesial temporal sclerosis, and incisural sclerosis. These terms are often used interchangeably to describe the same condition. The term "Ammon horn sclerosis" refers to the degeneration and scarring that occurs specifically in the Ammon horn region of the hippocampus, while "mesial temporal sclerosis" and "incisural sclerosis" refer to more general degeneration and scarring that can occur in other regions of the hippocampus as well. TLE is among the most commonly known localizations in relation to epilepsy syndrome. Majority of TLE cases have been linked to MTS which is detected through a decline in the hippocampus volume on the magnetic resonance imaging (MRI) and abnormal intensity in signal. Two studies by Otte et al. (2012) and Keller & Roberts (2008) found that alongside the mesial temporal abnormalities, patients who have been diagnosed with TLE have shown an elevation in white and gray matter abnormalities which are both ipsilateral and contralateral to seizure onset zone. A study by Keller and Roberts (2008) further confirmed that TLE patients with unilateral MTS showed atrophy in their gray matter in and beyond the ipsilateral temporal lobe. This included the limbic system, posterior temporal, inferior-medial, frontal regions, thalamus ipsilateral, insular, and basal ganglia. Keller and Roberts (2008) have, however, provided that contralateral to the seizure onset zone is uncommon among these patients. Keller and Roberts (2008) further demonstrate that abnormalities within the white matter have been shown using volumetry as well as in the voxel-based morphometry (VBM) and diffusion tensor imaging (DTI). Otte et al. (2012) has revealed that these abnormalities are common in the dorsal cingulum, anterior thalamic radiation, splenium of the corpus callosum, inferior fronto-occipital fasciculus, parahippocampal cingulum,

corticospinal tracts, superior/inferior longitudinal fasciculus, and fornix among persons with TLE. The study further revealed that MTLE-UHS patients demonstrated impairment in their decision-making under ambiguity. Additionally, this study found that impairment in decision making was associated with abnormal processing of feedback in patient's electroencephalographic (EEG) recordings (Otte et al., 2012). It has further been found that HS affects one's creative and writing ability due to its effect on the brain sections responsible for these functions. This study seeks to provide insight about MTS and its effect on human creativity. The paper further investigates historical figures and creatives believed to have had MTS when drawing insight on the impact that this condition on their creativity.

Overview of Mesial Temporal Sclerosis (MTS)

The earliest descriptions of hippocampal sclerosis date back nearly 200 years. In 1825, Bouchet and Cazauvieilh described the gross evidence of atrophy in the hippocampus of patients who had a long history of seizures. Then in 1880, Sommer coined the term "Ammon's horn sclerosis" to describe the gross atrophy and firmness of the Ammon's horn region of the hippocampus in patients with chronic epilepsy (Cendes, 2005). Since then, our understanding of the condition has improved, and it is now recognized as a common cause of temporal lobe epilepsy, with characteristic microscopic features of severe neuronal loss, gliosis, and sclerosis in one or more regions of the hippocampus. Histologically, sclerosis is a term used to imply neuronal loss which is associated with secondary astroglial proliferation which usually impacts different sections of the hippocampus in varying degrees. End folium are the most vulnerable hippocampus neurons to damage. However, granule cells which form part of the dentate gyrus, and the subiculum are among the most resistant sections of the hippocampus to the damage resulting from secondary astroglial proliferation (Cendes, 2005). When MTS is pronounced, it can appear in MRI scans as a reduction in the volume or shrinkage of the hippocampus, along with changes in signal intensity. However, MTS is a more comprehensive term than hippocampal sclerosis (HS) because it includes the involvement of other adjacent brain regions, such as the amygdala, uncus, and parahippocampal gyrus. While HS may be more appropriate when discussing histopathological findings from specimens that mainly include hippocampal tissue, the term MTS is more

appropriate when discussing the pathophysiological mechanisms, MRI findings, or clinical spectrum of the condition.

Hippocampal sclerosis is a common pathological finding in patients with medically refractory temporal lobe epilepsy, accounting for around 65-70% of cases (Michelle, Pierre & Charlotte, 2012). The exact incidence of hippocampal sclerosis is unknown, but it is strongly associated with early childhood and prolonged febrile seizures. It does not appear to have a gender predilection. Approximately 40-45% of patients with surgically resected hippocampal sclerosis have a history of febrile seizures (Cendes, 2005). Patients with hippocampal sclerosis typically experience complex partial seizures, which typically begin during the end of the first or second decade of life. These seizures often involve epigastric auras, accompanied by decreased behavioral activity, staring, slowly progressive clouding of consciousness, automatisms, and autonomic symptomatology. Some patients with hippocampal sclerosis may also develop secondary generalized tonic-clonic seizures (Michelle, Pierre & Charlotte, 2012). EEG studies commonly reveal unilateral slowing spikes with sharp waves in the temporal lobe, but bilateral temporal discharges are also present in some cases, indicating that the disease can be bilateral.

Recent studies have shed light on the complex pathophysiology of mesial temporal lobe epilepsy (MTLE) and mesial temporal sclerosis (MTS) (Michelle, Pierre & Charlotte, 2012). These studies have shown that prolonged and focal febrile seizures (FS) can produce acute hippocampal injury, which can evolve into hippocampal atrophy. In some children, complex FS can originate in the temporal lobe. MRI studies in familial MTLE have demonstrated that patients with benign epilepsy and seizure remission, or even individuals who had a single seizure, can have evidence of MTS (Cendes, 2005). This, therefore, suggests that the relationship between MTS and the severity of TLE might be more complex than previously thought. The development of MTS most likely involves complex interactions among genetic and environmental factors. Recent molecular neuropathological studies have revealed two intriguing findings in HS specimens of MTLE patients who underwent surgery. The persistence of Cajal-Retzius cells in HS patients points towards an early insult and an altered Reelin signaling pathway (Cendes, 2005). Increased neurogenesis and abnormal architectural organization of the dentate granule cell layer can also be observed in young patients with early hippocampal seizure onset, suggesting a developmental malformation of

the hippocampus (inherited or acquired) that in association with subsequent injury (e.g., trauma, infection, FS) could develop ongoing seizures, resulting in the full-blown neuropathological features of HS (Michelle, Pierre & Charlotte, 2012). Several mechanisms are likely involved in the development of HS, including genetic background, age, type of initial precipitating injury, and vulnerability related to programmed cell-death pathways.

White Matter Abnormalities in TLE

Previous studies have investigated the white matter abnormalities in patients with temporal lobe epilepsy (TLE) with and without unilateral mesial temporal sclerosis (uMTS). A study by Concha et al. (2009) found that patients with TLE + uMTS had widespread abnormalities of white matter tracts within and beyond the temporal lobe, while those with non-lesional TLE (nl-TLE) had fewer white matter abnormalities. These findings suggest that there is disruption of brain networks in TLE patients with and without MTS, although the affected network was more extensive in TLE + uMTS patients (Concha et al., 2009; Concha et al., 2005b). The study also found that TLE patients with right MTS showed more extensive bilateral changes than those with left MTS, despite similar ages of onset or disease durations. This suggests that the location of MTS within the temporal lobe may have a differential impact on white matter connectivity and highlights the importance of considering lateralization in TLE patients with MTS. Concha et al. (2009) further found that patients with TLE + uMTS had widespread abnormalities of white matter tracts within and beyond the temporal lobe, while those with non-lesional TLE (nl-TLE) had fewer white matter abnormalities. These findings suggest that there is disruption of brain networks in TLE patients with and without MTS, although the affected network is more extensive in TLE + uMTS patients.

A study by Knake et al. (2009) observed several diffusion abnormalities in the central section of the bcc. In previous studies on temporal lobe epilepsy (TLE), the corticospinal tract (CST) has not been measured or has been used as a control tract. However, in a study by Liu et al. (2012), the CST was found to have reduced anisotropy in adult TLE patients with unilateral mesial temporal sclerosis (uMTS). These findings are consistent with a previous study by Govindan et al. (2008) that found bilaterally decreased fractional anisotropy (FA) of CST in children with left TLE. Differences in methodology, such as measuring only the central part of the tract where the fiber orientation is most uniform, could explain

discrepancies between these findings and those of previous studies (McDonald et al., 2008). Additionally, previous MRI-based volumetric and voxel-based morphometry (VBM) studies have found reduced white matter volume in various brain regions in TLE + uMTS, including the ipsilateral temporal lobe and body of the corpus callosum, temporal pole, and ipsilateral frontal and parietal lobes and cerebellum (Muellller et al., 2012).

Mesial Temporal Sclerosis in Advanced Age

The reduction of fractional anisotropy (FA) observed in the study by Liu et al. (2012) was mainly driven by an increase in perpendicular diffusivity, which is consistent with previous reports (Concha et al., 2009; Lin et al., 2008). Some histopathological studies based on animal models have suggested that parallel and perpendicular diffusivities can be used as surrogate indices of axonal membrane and myelination status, respectively (Budde et al., 2009; Sun et al., 2006). Previous human in vivo diffusion tensor imaging (DTI) studies have also demonstrated increased perpendicular diffusivity with unchanged parallel diffusivity in the chronic stage of Wallerian degeneration, when myelin degradation is expected (Pierpaoli et al., 2001). These observations suggest that the observed increase in perpendicular diffusion in the study may reflect reduced myelin in the chronically degenerated fibers. However, the expected disruption of axonal membranes associated with degeneration could also impact perpendicular diffusivity.

The white matter findings in the posterior cingulate cortex (pCg) and tapetum in non-lesional temporal lobe epilepsy (nl-TLE) patients in the study performed by Liu et al. (2012) are consistent with a previous voxel-based morphometry (VBM) study byMcMillan et al. (2004) demonstrating white matter concentration/volume reduction in the ipsilateral temporal lobe of nl-TLE patients. However, a recent DTI study using voxel-based statistics detected more extensive and bilateral reduction of white matter FA in the temporal lobes, corpus callosum, and thalamus in a group of ten nl-TLE patients (Keller et al., 2011). The more extensive findings in the latter study could be attributed to qualitative methods used to classify subjects as non-lesional, which may have included some TLE + uMTS patients. Another recent voxel-based DTI study reported significant mean diffusivity (MD) elevation in the ipsilateral posterior fornix and posterior cingulum in ten left nl-TLE patients without changes in seven right nl-TLE

patients (Shon et al., 2010). However, left, and right nl-TLE patients were not looked at separately in the study due to a small sample size. Different patient selection criteria and methodologies used (voxel-based statistics for some studies and tractography for the current study) may also account for the discrepancy among the aforementioned DTI studies.

The distinct cognitive and structural differences between TLE + uMTS and nl-TLE patients suggest that these sub-syndromes may have different underlying pathophysiological mechanisms. One hypothesis is that TLE + uMTS patients have more widespread network dysfunction due to the involvement of multiple brain regions in the epileptogenic network. This could result in more extensive structural changes and cognitive dysfunction (Kaaden et al., 2011). In contrast, nl-TLE patients may have a more localized epileptogenic network, resulting in more limited structural and cognitive changes. However, further research is needed to fully understand the mechanisms underlying these differences between TLE sub-syndromes (Shon et al., 2010). The use of advanced neuroimaging techniques, such as DTI and functional connectivity MRI, may provide further insights into the pathophysiology of TLE and its subtypes. Several studies have found several differences between patients with left temporal lobe epilepsy (TLE) and those with right TLE. Specifically, patients with left TLE have been found to have greater impairment of learning and memory, as well as more widespread gray and white matter changes. DTI studies have also found differences in diffusion changes and fiber tracts in the two groups of patients (Focke et al., 2008). The underlying mechanism for these differences is not fully understood, but some researchers have suggested that seizure propagation may be more widespread in the language-dominant hemisphere (typically the left side) due to better connectivity (Powell et al., 2007). Others have speculated that the left hemisphere undergoes a more prolonged maturation process and is therefore more vulnerable to early brain insults. However, more research is needed to fully understand the asymmetry observed in patients with left and right TLE.

Hippocampal sclerosis is common among persons above the age of 85 years. Usually, this condition in older people is linked to a significant rise in ante-mortem cognitive dysfunction (Nelson et al., 2008). There is a lack of a specific nosology for HS-Ageing. Despite some progress, the clinical and pathological features related to HS-Ageing have not been definitively characterized. According to Nelson et al. (2008) a description of this

disease was provided a few decades ago, but its high prevalence in aged populations was only recently recognized. Josephs et al. (2008) has further revealed that brains from older individuals with hippocampal sclerosis pathology also show aberrant hippocampal TAR-DNA binding protein 43 (TDP-43) immunostaining, but the relationship between HS-Aging pathogenesis and TDP-43 proteinopathy is still unclear. HS-Ageing and Alzheimer's disease have overlapping clinical and radiographic features related to hippocampal atrophy, so improved clinical identification of patients with HS-Ageing would enable more specific management of both patients with HS-Ageing and patients with Alzheimer's disease.

Previous studies have reported the prevalence of hippocampal sclerosis pathology in elderly individuals. The prevalence ranges from 0.4% to 26% in different studies, with variability possibly attributed to cohort and study characteristics, such as patients' ages and dementia severity, tissue sampling thoroughness, and different diagnostic practices of neuropathologists involved in the studies (Schneider et al., 2009; Zarow et al., 2008). The epidemiological prevalence of HS-Ageing is not precisely known, but some large cohorts of aged individuals have reported a prevalence range of approximately 8-18% (Zarow et al., 2008). There is a lack of definite association between the presence of HS-Ageing on pathology and cerebrovascular disease or risk factors. Some prior autopsy series have reported agreement with this finding, while others have not. Both brain infarcts and HS-Aging pathologies increase in advanced age, and failing to use sufficiently aged comparison groups may lead to a spurious correlation (Hatanpaa et al., 2004). The authors of the study conclude that very few individuals in their datasets had hippocampal sclerosis pathology due to vascular factors.

The correlation between dementia prevalence and aging is well-established. However, specific neurodegenerative diseases tend to be most prevalent within particular age ranges. In advanced age, most brains show signs of vascular disease, Alzheimer's disease pathology, or synucleinopathies, which correspond to declining cognitive function. Cerebrovascular pathology is particularly prevalent in individuals over 90 years of age. Therefore, the finding that "pure" hippocampal sclerosis pathology is not common may be because individuals with Alzheimer's disease pathology tend to die younger and have less concomitant pathology (Nelson et al., 2007). The prevalence of HS-Ageing pathology increases dramatically in individuals who die beyond the age of 95, while

the prevalence of Alzheimer's disease-type pathology declines. This suggests that in extreme old age, vascular disease and HS-Ageing may be the primary drivers of dementia risk, rather than Alzheimer's disease.

Hippocampal sclerosis pathology is strongly associated with aberrant TDP-43 immunohistochemistry, with around 90% of patients with hippocampal sclerosis having such staining, compared to only about 10% in older controls regardless of other pathologies (Probst et al., 2007). However, the relationship between HS-Ageing and TDP-43-positive FTLD (frontotemporal lobar degeneration) has not been well defined. Cases with HS-Ageing do not fit neatly into existing FTLD classification. A study by Hatanpaa et al. (2004) has shown that individuals with hippocampal sclerosis pathology often met clinical diagnostic criteria for frontotemporal dementia (Takeuchi et al., 2016). It is currently unknown whether TDP-43 abnormalities are causally linked with HS-Ageing pathology, but a speculative hypothesis is that aberrant TDP-43 with hippocampal sclerosis pathology in advanced age may reflect physical wear and tear, similar to the association between TDP-43 pathology and chronic trauma-induced encephalopathy observed in some cases of blunt trauma.

There is a need for improved clinical detection of HS-Ageing to enable better management of patients with HS and Alzheimer's disease. A study by Dolan et al. (2010) found that individuals with incipient HS-Ageing had a different neuropsychological profile from those with advanced Alzheimer's disease pathology, with higher verbal fluency scores and lower word list delayed recall scores. This difference is informative because verbal fluency relies more on neocortical function, while word list delayed recall relies more directly on the hippocampal formation. However, Dolan et al. (2010) caution that these tests cannot currently discriminate between individuals with and without HS-Ageing due to too much overlap between groups, and further research is needed to develop more specific indicators. Additionally, Dolan et al. (2010) states that Alzheimer's disease and HS-Ageing may have different clinical trajectories over time, which could be a potential confounder in their analyses.

The Role of Hippocampus and Default Network in Creative Thinking

The hippocampus is indeed a crucial structure in the brain for both memory formation and imagination. It works closely with other brain regions such as the prefrontal cortex to create mental simulations of possible future scenarios. This process is crucial for our ability to plan and make decisions, as well as for our creative thinking abilities. The use of fMRI has indeed revolutionized our understanding of the neural mechanisms underlying cognitive processes such as memory and imagination. Early studies involving amnesic patients clearly demonstrated the role of the hippocampus as imagining the future and remembering the past. Persons with damaged hippocampus may experience challenges with their cognitive processes of memory and imagination. Researchers have turned to the use of functional magnetic resonance imaging (fMRI) in studying reasoning and remembering processes in the brain (Beaty, 2020).

What is striking about the findings of these studies is the fact that certain brain regions activate whenever we recall the past and imagine the future. One sub region is the default network - a crucial brain network involved in these cognitive processes of memory and imagination, and it includes regions such as the medial prefrontal cortex, posterior cingulate cortex, and inferior parietal lobes, as well as the hippocampus (Beaty, 2020). The constructive episodic simultaneous hypothesis is also an important theory that explains how memory and imagination involve the flexible recombination of details from past experiences. This theory emphasizes the importance of reconstructing past experiences to imagine future scenarios, and it highlights the dynamic nature of our memory system, which is essential for creative thinking. Based on this theory, our past experiences demand that we reconstruct those experiences, which involve piecing together all relevant information about our past encounters such as people, places, actions, and objects (Beaty, 2020). Moreover, future imaginations based on this theory require that we construct experiences based on the details of what has happened in the past. The flexible nature of the episodic system is essential for our creative thinking.

The findings from studies on memory and creativity, which have been built using the episodic specificity induction where the participants are trained on how they can remember the episodic memories using large details shows that episodic specificity induction largely engages the default network. Thus, using episodic specificity induction can help improve creative thinking. The findings of a subsequent episodic research further

revealed that the episodic induction elevated activity in the left anterior hippocampus which connects creative performance to elevated activity in sections of the brain which are strongly linked to episodic memory (Madore et al., 2019). These findings, therefore, provide sufficient support for the role of the hippocampus in creating new ideas. This is also further proof that the brain sections involved with remembering are also responsible for imagining and creating.

One of the main questions in relation to creative research pertains to the brain's capacity to regulate our thoughts. Research has shown that by letting our brains relax the filter, a process that is governed by the default network and the hippocampus, it is possible for new ideas to develop in our minds. Usually, there is a need for us to redirect our thought processes from the things we might know or what we may think will work in our ideas. This underlines the important role of idea-generation and idea-evaluation in our thought processes. With regards to this, an fMRI study required visual artists to generate and evaluate ideas that were based on a short description of a book cover. The study found that during idea generation and evaluation, the visual artists experienced a rise in activities in both the hippocampus and default network (Ellamil et al., 2012). These findings suggested the engagement of the episodic system in this thought process. When evaluating the idea, the visual artists experienced activation of their hippocampal and default sections. Moreover, activation was further recorded in the frontal brain regions which have been associated with the role of cognitive control including the dorsolateral prefrontal cortex (Beaty, 2020). The studies further revealed an increased level of communication connectivity between these brain sections. This suggests that idea evaluation involves cooperation between the spontaneous/generative elements of the default network and the deliberate or evaluative element of the control network. The activity of these networks is usually co-inhibitory in nature - such that activation of one section leads to the deactivation of the other section. Usually, this is achieved without the need for focusing our attention via our control networks. Therefore, the findings from these studies suggest that creative thinking is a process that involves an elevation of communication and connectivity between these brain networks working distinctly.

Mesial Temporal Sclerosis and Creativity

To understand the impacts of MTS on creativity, it is important to understand creativity and writing in people with temporal lobe epilepsy (TLE) and other conditions that impact the temporal lobe. It is also important to understand the link between the temporal lobe and creativity because one of the most common findings in MTS is scarring in the temporal lobe. Understanding how TLE and other diseases impact the temporal lobe will offer insights into how MTS affects creativity. When looking into MTS, TLE, the temporal lobe and their association with creativity, it is important to also investigate cases of people with disorders that impact the temporal lobe, and those with TLE and MTS and identify the effects of the conditions on their creativity. Moreover, it is critical to understand the roles of the temporal lobe and its association with creativity.

The Temporal Lobe and its Functions

The temporal lobe is the second largest lobe and sits behind the ears. Every person has two temporal lobes where one lobe is located on the left-brain hemisphere while the other one is located on the right-brain hemisphere. The temporal lobes are named so because they are just behind the temples. The temporal lobe just like other organs does not function alone but receives inputs from other parts of the brain and sensory input from the surrounding environment (Stretton, and Thompson, 2012; Jeneson, and Squir, 2012). The temporal lobe does not control the mind but rather learns from the environment, where it creates a complex mind-body-environment interplay. The interplay alters one's subjective experiences constantly. In addition to its roles in auditory and visual processing, memory formation, and language recognition, the temporal lobe also plays a role in emotion regulation and social behavior. The amygdala, a structure within the temporal lobe, is involved in processing emotions such as fear and aggression, as well as in forming emotional memories. The ventromedial prefrontal cortex, which is adjacent to the temporal lobe, is involved in social cognition, decision making, and moral reasoning (Stretton, and Thompson, 2012; Jeneson, and Squir, 2012). Damage to the temporal lobe can result in a range of symptoms, depending on which areas are affected. For example, damage to the left temporal lobe can result in language deficits, while damage to the right temporal lobe can result in deficits in recognizing faces and emotions (Stretton, and Thompson, 2012).

Temporal Lobe Epilepsy and Creativity

Temporal lobe epilepsy (TLE) is one of the most common types of focal epilepsy and starts in the temporal lobe (Vinti et al., 2020). There are two types of TLE: mesial and lateral TLE, where mesial temporal lobe epilepsy (MTLE) is the most common. Research has identified a significant relationship between most (TLE) and mesial temporal sclerosis (MTS). According to Liu et al (2012), this is depicted in the abnormal signal intensity and low hippocampus volume on magnetic resonance imaging (MRI). To understand how MTS affects creativity, it is important first to investigate how epilepsy affects creativity. Epilepsy consists of different symptoms and impacts people in different ways. Epilepsy impacts the brain's chemistry and neural pathways and affects one's personality and ability to think based on the severity of the condition.

It is important to note that not all individuals with TLE or MTS experience an enhancement in their creativity. The effects of these conditions on creativity can vary from person to person, and some individuals may not experience any change at all. Additionally, while some individuals may attribute their creative output to their neurological condition, it is not always clear whether the condition is directly responsible for their creativity or if it simply alters their perception or processing of information in a way that leads to greater creativity. An example is a case that was depicted in a 1993 article in New York Times where a person who had no previous excitement in reading and arts developed a deep love for them upon being diagnosed with TLE (Angier, 1993). According to the victim, before the injury, there was no inclination towards being a reader on matters of God and the meaning of life. However, after the injury, the person became a very introspective person where he started reading philosophy, studying religions, and having a writing fever. Another similar case was depicted by an article in the Guardian written by Dan Mitchel (2014), who claimed that epilepsy enhanced his creative endeavors. The writer noted that after a seizure, he would wake up in what he claimed to be a brain fog, after which he felt as if he could make connections that he would not have made previously in a state of heightened creativity. It is also worth mentioning that while some individuals may experience an enhancement in creativity, TLE and MTS are serious medical conditions that can have a significant impact on a person's quality of life. It is important to seek appropriate medical treatment for these conditions to manage symptoms and prevent complications.

Numerous studies have also been undertaken to determine the link between epilepsy and creativity. Some of the studies have shown that epilepsy affects creativity positively while others depict that epilepsy harms creativity. Firstly, in a study by Cartwright et al (2004) to test the hypothesis that neural processes lined with TLE facilitate creativity, it was found that it is possible that some properties of TLE may impact creativity positively while others may harm creativity. In another study by Ghacibeh, and Heilman (2013) on the connection between creative innovation, TLE and lobectomy, the authors claimed that some people with left temporal degeneration develop artistic abilities. They further stated that the newly developed abilities may be linked with the visuospatial dominant right hemisphere. The Study findings refuted the claims as its results suggested that unilateral anterior temporal ablation did not improve the visual artistic ability given that their creative scores for RTS participants were higher than their verbal scores. The results, however, suggested that right hemispheric seizures caused changes in their right hemispheric networks that enhanced visual creativity.

In another study by Flaherty (2011), on the relationship between brain illness and creativity, the author notes that TLE is one of the disorders that are associated with increased creative drive. As the authors investigate the different disorders and how they affect creativity, the author notes that a tenth of patients with TLE depict a personality cluster that includes hypergraphia which is a compulsion to write. Additionally, the authors note that various prolific creative writers suffered from epilepsy. Moreover, the link between altered temporal lobe function and creativity comes from discoveries involving frontotemporal dementia (FTD) where variants of the condition stimulate de novo artistic output, where FTD patients can become significantly motivated to draw and paint. This is in contrast to those with Alzheimer's dementia, whose artistic talent deteriorates. According to Flaherty (2011), FTD can produce new artistic output in cases of relatively worse degeneration in patients' temporal lobes versus the front lobes.

Another disorder with links to temporal lobe atrophy is amyotrophic or primary lateral sclerosis, where neurodegeneration occurs in the temporal lobe(s) and sensorimotor areas. The patients increasingly manifested new artistic creativity as the neuronal death occurred. Geser et al (2021) also proved an increase in creativity associated with FTD, where the creativity spikes as the disease progresses. Artistic creativity rises and then declines where the decline is associated with eventual physical

impairment during the progression of the disorder. Emergent artistic prowess may happen however, in the early stages of the disease process.

Creative drive is significantly impacted by frontotemporal interactions. The temporal areas have an abundant role in the assignment of meaningfulness to ideas because of their function in the recognition of linguistic and social meaning. Temporal lobes are critical in the recognition of novelty. According to Flaherty (2011), the mutual inhibition of the temporal and frontal lobes impacts the altering verbal fluency and generation of linguistic ideas. There is a decrease in speech comprehension but an increase in talkativeness and motor activity in patients with temporal lobe lesions because the patients are less inhibited by the social consciousness of their mistakes. There is a parallel in mutually inhibitory networks caused by mutual inhibition of the temporal language reception area and the frontal language production area which impacts the generation of new ideas. According to Flaherty (2011), this explains why brainstorming when the social worry about judgment is temporarily muted produces more novel ideas.

Numerous brain disturbances are associated with artistic creation. Temporal lobe epilepsy is one of the conditions that is linked to artistic creativity. The temporal lobes are erratically seized by electrical hyperactivity chaotic storms, where the seizures prompt certain symptoms like hallucinations, fear, joy, and religious sensations, which is a blessing for people in art, where it can lead to a desire to write or draw where the desire persists even after the seizure in the postictal phase.

Creative and Historical Figures with MTS and TLE

There are various creative people involved in various creative works like art, music, drawing, and writing who had MTS or TLE. Some people have claimed that their disorders helped them to enhance their creativity while others are thought to have the disorders based on their work, the timeframe of their work, and accounts of their behavior. Emily Dickinson, a well-known American poet is a creative figure that is also believed to have suffered from TLE. As a result of this condition, it is believed that Emily Dickson produced much more poetry after she discovered that she suffered from epilepsy. Her neurodegenerative condition is believed to

have triggered a positive influence in her poetry work leading to increased production (Noble, 2021). A similar association was discovered in an examination of Robert Schumann's creative work. The majority of his compositions were written in hypomanic situations. Dostoevsky (1821-1881), a Russian writer, suffered from a rare form of temporal lobe epilepsy known as "ecstatic epilepsy." Dostoevsky based Prince Myshkin, the protagonist of *The Idiot*, on his epileptic experiences. Fyodor Dostoevsky, widely recognized as one of the greatest authors of all time, tackled topics of human psychology, philosophy, and religion in his writing (Lyer, 2020). Crime and Punishment, a novel about a student who murders his landlady, is the Russian's best-known work. Dostoevsky frequently wrote about his epileptic experience, and some of his characters had auras and seizures as well.

It is interesting to note how some of the greatest writers in history, including Edgar Allan Poe, Agatha Christie, Charles Dickens, Fyodor Dostoevsky, Gustave Flaubert, and Lewis Carroll, may have been influenced by their experiences with temporal lobe epilepsy. While the precise relationship between epilepsy and creativity is not fully understood, there is evidence to suggest that temporal lobe epilepsy can lead to altered states of consciousness, vivid hallucinations, and increased creativity in some individuals. These experiences may have influenced the writers' works, especially in the case of Carroll's *Alice's Adventures in Wonderland*, which some scholars believe was inspired by the author's own experiences with epilepsy. Additionally, Edgar Allen Poe, one of the most influential individuals in American literature, is best known for his short tales and poems. The Boston-born novelist is widely considered the creator of the detective fiction genre, as well as one of the earliest science fiction authors (Krämer, and Wolf, 2020). Poe frequently described states of unconsciousness and bewilderment, which some believed were caused by undetected complicated partial seizures. Because this type of seizure was poorly understood at the time, some people assumed Poe's unusual behavior was due to an alcohol problem, when he could have been suffering from confusion or postictal disturbance caused by seizures. Agatha Christie, the greatest-selling fiction writer of all time, is best renowned for her detective novels and characters such as *Hercule Poirot* and *Miss Marple* (Flaherty, 2005). Christie eventually developed the brain disease dementia, but also suffered epilepsy symptoms such as convulsions. Some of these writers were profoundly influenced by the hallucinations, seizures, and flood of memories associated with temporal lobe epilepsy. It is important to note that epilepsy is a complex

neurological disorder that affects individuals in different ways, and not all individuals with epilepsy will experience heightened creativity or altered states of consciousness. Nonetheless, the links between epilepsy and creativity provide a fascinating area of study for researchers and literary scholars alike.

Hypergraphia is another phenomenon that has been associated with epilepsy, as well as other neurological and psychiatric disorders. Hypergraphia is characterized by an overwhelming urge to write or draw, often resulting in the creation of large volumes of written or artistic works. The exact mechanisms behind hypergraphia are not fully understood, but it is believed to result from the hyperactivity of certain brain regions, particularly the temporal lobe. While hypergraphia can be disruptive and even debilitating for some individuals, it has also been associated with heightened creativity and productivity in others, including many famous artists and writers (Flaherty, 2005). Vincent van Gogh, who had epilepsy, is a notable example of an artist who produced an enormous amount of work despite his health challenges. The relationship between hypergraphia, epilepsy, and creativity remains an intriguing area of research, and may offer insights into the complex interplay between neurological and psychological factors that underlie human creativity.

Epilepsy and hypergraphia can be coupled with sadness, which can be a curse for some artists and a source of inspiration for others. However, depression, with its numerous potential causes, is unlikely to be a source of artistic talent. Instead, it frequently provides an excuse for people to deal with psychological problems through their art (Flaherty, 2005). Similarly, the appearance of hypergraphia does not imply ability. However, creative thought, particularly writing, appears to rely on the left temporal lobe, despite both sides of the brain playing important roles. In a study by Wu et al. (2015), hypergraphia was examined in patients with mesial temporal lobe epilepsy (MTLE). The study found that patients with MTLE exhibited increased hypergraphia compared to healthy controls, particularly in the left hemisphere of the brain. Interestingly, the study also found that hypergraphia was associated with a higher level of creativity in patients with MTLE, as measured by their performance on a divergent thinking task (Wu et al., 2015). However, it is important to note that this study only found a correlation between hypergraphia and creativity and does not prove that hypergraphia directly causes creativity.

Conclusion

Mesial temporal sclerosis (MTS) is a condition where the mesial temporal lobe is scarred and a condition that is most significant in people with temporal lobe epilepsy (TLE). As observed, the conditions are linked with the temporal lobe which plays critical functions in creativity. This work has investigated the links between MTS and creativity and writing. To understand the links, an investigation into the functioning of the temporal lobe has been investigated depicting how various functions of the temporal lobe in people with MST are affected which leads to ideas generation. Additionally, cases of historical creative people like writers, artists, and musicians with TLE have been investigated to determine whether and how TLE impacts creativity. Additionally, an investigation into other people who have suffered from the condition has been done to depict the influence of the disorder on their creativity. The investigation depicts that numerous prolific artists like poets, musicians, writers, and other artists were thought to have had TLE, whereas the artists and writers did most of their prolific works during the periods having TLE. Additionally, cases of people with hypergraphia and how it impacted their writing show that TLE can influence creativity in people positively. fMRI studies have shown that the hippocampus and default network are increasingly activated during the generation and evaluation of an idea. Therefore, MTS provides insights into human creativity by looking at the role of different parts of the brain, and how the pathology affects each of them as the disease worsens. The temporal lobe plays a critical part in creativity. However, further studies need to be conducted to depict how the temporal lobe works with other parts of the brain in the generation of ideas, and whether impacts on other areas affect creativity.

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