THE FIRST SCHOOL SHOOTER: EXAMINING MULTIPLE CAUSATION IN A CASE OF MASS MURDER

Honors Thesis

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Abstract

Violence in schools and in public settings is an unfortunately growing problem in modern society, and understanding why and how these crimes happen is an integral part to preventing future occurrences. This thesis is a case study of Charles Whitman, the person recognized as perpetrating the first mass shooting on a college campus. This case study examines multiple causation theory using Charles Whitman's case as an examine and guide for discussion. Areas of discussion include childhood abuse, drug use, self esteem, brain chemistry, social learning, locus of control, limbic system dysfunction, and cancer. It is argued through the case study that multiple causation theory provides the strongest, most encompassing explanation for why a person may end up committing a violent crime. Connections between sections, relation to the Whitman case, and discussion about how multiple causation theory is applicable to preventing similar cases are discussed.

Chapter 1: Childhood Maltreatment

Social Learning

Charles Whitman's life was continuously marked with aggression and abuse through his father's abuse of him, his brothers, and his mother as well as Charles' own abuse of his wife and personal violent ideations. The foundation of his later domestic abuse and perpetration of the mass shooting at the University of Austin, Texas may be attributed to social learning theory. Social learning theory argues that behavior is learned through modeling and observation, in that repetition and systems of punishment or reward reinforce certain behaviors that are acceptable or unacceptable in a given environment. (Brauer, Tittle 2012) In an abuse setting like the one Whitman grew up with, the behaviors being modeled were abusive and aggressive and the repetition and system of punishment would reinforce the behaviors being modeled. A study conducted by Gilbar et al. (2020) suggests male domination and control in interpersonal relationships influence or promote physical violence in domestic relationships; modeling control and violence based on gender in Whitman's case would influence the later abuse of his wife, Kathy.

Early research of the concept of social learning conducted by Bandura, Ross, and Ross (1961) examined its influence on aggressive behaviors through modeling. In this study, researchers presented a toy, a bobo doll, in front of a child and an adult researcher would demonstrate various methods of play. The play's methods were purposefully aggressive in nature; the adult would punch, kick, throw, and hit the bobo doll with a

hammer in front of the child as they watched. When later left alone with the doll, the children would imitate the behavior that was observed; the modeled methods of play demonstrated by the adult would be employed by the children participants. It was observed that the children would punch, kick, throw, and hit the bobo doll with a hammer, copying nearly perfectly the behaviors of the adult model. This classic early study provided the foundations of social learning and some of the first evidence that observing others perform certain behaviors influences the behaviors that are later performed by the observer.

Gender differences within the bobo doll study separated aggressive tendencies between male and female children. Bandura, Ross, and Ross (1961) found results that indicated higher levels of physical and verbal aggression amongst male children versus female children. The gender of the adult model was also found to have an influence on the child's copying behavior. Male child participants demonstrated higher levels of aggressive behaviors when the adult model was also male versus those who observed a female model. A study conducted by McEachern and Snyder (2011) observing relational and physical aggression among kindergarten children supports a gendered difference in aggressive behaviors. This study found significant differences in the frequency of aggressive behaviors between male and female children, a 4:1 ratio, as well as a positive correlation between early aggression and later displays of antisocial behaviors.

The bobo doll study demonstrates the immediate results of observational learning as imitation, however learned behavior through observation may have influences on future behavior. Increased sensitivity to stimuli during key developmental years influence the impact observed behaviors may have on the development of one's behavior. A study

conducted by Simpson et al. (2011) found that children encode observed behavior for immediate use as well as future use. This long term, multi-trial study found that observed behavior was first encoded for perfect imitation, then later reworked for practicality. Repeated modeling of the same behavior serves to "strengthen or weaken inhibitions of behaviors that observers previously learned". (Simpson et al 2011) The Bandura, Ross, and Ross (1961) bobo doll study demonstrates the initial imitation use while the long term Simpson et al (2011) study demonstrates the long term implication of social learning. The long term application of aggression in abuse settings is seen frequently when the abused becomes the abuser. In a study by Firoozabadi (2020) of 3,694 outpatients, 1,075 reported a history of childhood abuse with 209 also reporting perpetrating abusive behaviors against others (19.44%). This adult study further supports the long term application of observed behaviors modeled in childhood.

Research correlating abuse and future crime has connected specifically violent behavior in childhood to an increased likelihood of committing a violent crime of the same nature as the abuse. (Felson 2009) In a study conducted by Felson and Lane (2009) it was found that physical abuse most closely predicted later violent crimes, specifically assault and homicide. Another study by Wolff and Shi (2012) also found significant correlation between childhood abuse and trauma to later criminal offending. This study found that 44.7% of the sample (n=4,000) of incarcerated males had experienced physical abuse during childhood. Wolff and Shi also found that childhood abuse greatly impacted later adverse psychopathology compared to inmates who did not report abuse in childhood. These findings are supported by outside reviews as well, such as one conducted by McNulty and Watts (2013) that found a positive correlation between

childhood abuse, criminal behavior, and increased recidivism. The abuse suffered in childhood serves as the violent foundation on which the later criminal behaviors can develop upon. The modeling of domestic abuse seen in Whitman's father, reinforced by repetition and systematic punishment would strengthen aggressive behaviors as an appropriate response to adverse situations that threaten dominance or control. In the longer term, this is later modeled in Whitman's perpetration of domestic abuse as well the Austin tower shootings. Social learning theory does not solely drive one's behavior, however, and can be influenced by other environmental and biological factors.

Shared Genetics

Whitman's behavior may be attributed to the observation and reinforcement of his father's actions, however there are also biological explanations that can supplement the explanation for his abuse and mass shooting. Much like how genetics can influence a person's eye color or their likelihood of developing certain medical conditions, genetics also plays a role in one's development on an emotional and psychological level. Aggression as a means of control serves as the key motivating factor behind Whitman and his father's actions and an explanation may be found within their shared genetics. Animal studies such as one conducted by Freudenberg et al. (2015) have examined the link between aggressive behaviors and genetics. The Freudenberg et al. (2015) study examined non-human vertebrates, zebrafish and mice, by comparing naturally occurring aggressive traits to increased aggression beyond practical use then later comparing individual behaviors to identified mutated genes. Over 140 different mutated genes identified in previous studies were combined and analyzed based on their impact on

changes in aggressive behavior. The three main neurotransmitters associated with genetic differences related to increased aggression in mice and zebrafish from this study include serotonin, dopamine, and adrenaline. Later studies of human aggression have also connected abnormal levels of dopamine and increased levels of serotonin to elevated aggression levels. (Waltes et al. 2015; Duke et al. 2013; Carrillo et al. 2019)

A twin study conducted by Tuvblad et al. (2009) examined heritability rates of two types of aggression, reactive and proactive aggression. Reactive aggression is characterized by "high emotional arousal, impulsivity, and the inability to regulate or control affect" while proactive aggression is characterized by "regulated, instrumental, and positive expectations relating to outcomes." (Tuvblad et al. 2009) This study analyzed 2,115 total sets of twins based on parental reported aggressive traits and found that levels of reactive aggression were most commonly attributed to environmental factors while proactive aggression was most commonly attributed to genetic heritability. In this study, reactive aggression is suggested to be motivated by frustration, anger, or a perceived threat. Looking at this in relation to the Whitman case, the shared genetics between himself and his father would foster proactive aggression while the observed reactive aggression demonstrated by his father would foster reactive behaviors.

Another twin study examining the differences in reactive and proactive aggression levels between monozygotic and dizygotic twins also scaled levels based on self report as well as parental report. (Baker et al. 2008) This study found that the mean levels of reported aggression were the highest among monozygotic twins for both reactive and proactive aggression. Gender differences in this study had little effect on the aggression levels between male and female monozygotic twins. These findings suggest that higher

similarities in genetic composition between two people influences the presentation of aggressive traits based on heritability. When looking at specific genes like those identified in the nonvertebrate studies, shared specific genes when equally expressed would yield the same behavioral results, in this case, aggression.

Adoption studies have also been a method used to examine a link between genetics and behaviors traits such as deviance and aggression. One adoption study conducted by Van Der Valk (1998) examined sets of adopted siblings, those biologically and non biologically related. This study compared behaviors related to aggression and deviance through self reports and completion of the Child Behavior Checklist (CBCL) and attributed environmental and biological influences based on observation. This assessment and report was conducted twice, with the second administration being given 3.2 years following the initial. Behaviors including aggression, externalizing, and attention and social problems were attributed to 50% of the variance found between sibling sets. In relation to the longitudinal aspect of the study, it was also found that levels of externalized, aggressive, and deviant behavior were more likely to persist among biologically related siblings compared to non biologically related siblings; 64% of reported deviant behavior amongst biologically related siblings was found to remain stable following the 3.2 year gap. These findings suggest a link between biologically relation and certain behavioral traits including aggression and other problem behaviors even when environmental factors are known to also have influence. This perspective can be applied to Whitman's relation to his father and the externalized, reactive behaviors that are suggested to be influenced genetically.

Epigenetics

The toll of Whitman's father's abuse was felt not only through his father, but indirectly through his mother as well. Diving deeper into the genetic influences, there are epigenetic factors that may predispose aggression; factors that can be traced back prenatally through stress hormones and postnatally through mental illness. The health and wellbeing of a mother is shown to have a direct influence on the development of a prenatal child, including hormone production within the mother's body. Animal studies examining the negative impacts of maternal stress during pregnancy such as the one conducted by Verstraeten et al. (2019) found negative results from increased maternal stress during pregnancy including birthing complications and offspring underdevelopment. Other studies have shown a correlation between maternal, prenatal stress and negative offspring symptoms, specifically underdevelopment of offspring and increased levels of cortisol production have been highlighted. (Cristina de Brito et al. 2018; Amugongo & Hlusko 2013)

Similar to animals, Repeated or prolonged production of stress hormones in a mother's body adversely affects a child's developing stress systems. Women who experience high levels of stress during pregnancy are reported to give birth to children with greatly increased likelihoods of developing a mental disorder. Increased cortisol production during pregnancy has been found to have adverse effects on the developing child including irregular heart beats or underdeveloped hearts, dysregulation of the hypothalamic-pituitary-adrenal, and certain cognitive impairments. (Labella, Masten 2017; Brunton 2015) One study conducted by Walsh et al. (2015) examined the neurodevelopment of prenatal fetuses whose mothers experienced elevated levels of

stress during pregnancy and the impacts of the stress on the child post birth. This study broke down stressors into categories including healthy, psychologically stressed, and physically stressed. Mothers who experienced individual stressors had a higher number of birth complications as well as developmental problems with their child, under development of the heart and central nervous system were primarily discussed, compared to healthy mothers. A small subgroup of mothers who experienced both psychical and psychological stress held the highest number of complications and adverse child developments including two fetal deaths. Whitman's mother who had been subjected to his father's abuse throughout her life, including through all three pregnancies would fall into the subgroup of mothers who experienced both psychical and psychological stressors. Her cortisol levels would be dramatically increased and would result in an increased likelihood of adverse development of her children.

Specific mechanisms influenced by genetics can prove to have a later impact on a predisposition towards aggressive behaviors that can in turn influence future violent behaviors. A study conducted by Jaworska and Rybakowski (2018) linked decreased serotonin transporter protein (SERT) activity, which is influenced by the FKBP5 gene, to increased impulsivity, episodic aggression, and increased chances of later developed mood disorders. Other adverse results from material stress during pregnancy discussed included irregular development of the central nervous system and brain structures including the hippocampus and amygdala and DNA methylation. When the mother is exposed to repeated or prolonged high-stress situations such as domestic abuse, the effects of this prolonged exposure also influences the SERT activity in the postnatal child. This exposure can result in increased sensitivity in one's stress response system

(Mastorci et al. 2009), causing the child to have increased difficulty processing and handling stressful situations. Whitman personally documented his struggle with controlling stress and anger towards small stressors. We also can follow a pattern of violent behavior both being witnessed and performed throughout Whitman's life. Further aggressive tendencies beyond stress sensitization and increased reactivity such as physical assault, domestic abuse, and homicide can also result, all of which we see later in Whitman's life.

Limbic System Dysfunction

As a result of his father's abuse of himself and his mother, Charels Whitman had a greatly increased likelihood of neurologically developing irregularly. Many of the structures in the body that are related to stress regulation and other emotional regulation reside within the limbic system. Dysfunction and sensitization within the limbic system has been connected to childhood maltreatment and adverse behaviors later in life. (Gunnar & Quevedo 2006) Structures of the limbic system that regulate fight, flight, or freeze responses to stimuli are typically associated with primitive behaviors including aggression. Witnessing traumatic events early in life have been found to have adverse effects on neural development as found in a study conducted by Choi et al. (2012) examining the negative developmental impacts of witnessing domestic violence as a child. A control group of participants who had not witnessed domestic violence as a child was compared to a group who had witnessed domestic violence in childhood using diffusion tensor imaging (DTI). It was found that those who had witnessed domestic violence during key developmental years produced the largest differences between

groups; lowered IQs, “limbic system irritability”, increased propensity towards mood disorders, and increased verbal aggression towards others were all correlated with witnessed early domestic violence.

Exposure to stress and adversity during key periods of development have also been shown to influence the development of limbic system structures. A study by Walker et al. (2018) with mice used MRI technology to examine brain structure differences among mice that had been exposed to stressors during peripubertal development. Findings from this study showed mice that had been exposed to various stressors had increased anxiety-like behaviors and structural changes in the amygdala and hippocampus. An interesting distinction made in this study was between affected mice who had hippocampus or amygdala changes and those that did not. Across all mice in the stressed group, increased anxiety-like behavior was documented, however a smaller subset of mice who also experienced changes in the hippocampus or amygdala also showed an increase in aggressive behavior. These findings suggest a correlation between limbic system structure abnormalities and the likelihood of later aggression resulting. Other rodent studies including a rat study by Cratty et al. (2000) has also connected limbic system structures, early stress, and later aggression. The study by Cratty et al. (2000) examined prenatal and early life stress in relation to Corticotropin-releasing factor (CRF). It was found that prenatal and early life stress increased exposure to CRF which regulates various emotional responses to stimuli including anxiety and stress. This finding was connected to hyperactivity in the amygdala which can increase stress sensitivity and hyper aggression.

Human research examining the connection between stress and childhood maltreatment and the limbic system have found similar results to animal studies. A study by Dackis et al. (2012) examined limbic system irritability, childhood maltreatment, and later development of psychiatric disorders. This study found that childhood maltreatment influenced depressive symptoms and increased limbic irritability. This irritability was characterized by somatic distortions, abnormal aggressive behavior, and dissociative symptoms. Another study by Sokolowski and Corbin (2012) also found correlations between early life stress and irregular development of limbic system structures and increased limbic irritability. This study focused specifically on the amygdala and hypothalamus and how dysfunction within these structures can result in adverse behaviors and abnormal psychopathology. With Whitman, there are innumerable examples of prenatal and early life stress that offered opportunity for abnormal development of the limbic system to occur.

The emotional dysregulation that can result from limbic system dysfunction can influence the development of mental illnesses beyond childhood. Early trauma and abuse may cause a child to develop dysregulated emotional control and increase their sensitivity to stressful events. Research conducted by DeBellis and Zisk (2014) examines the biological effects of childhood maltreatment focuses specifically on the adverse psychological disorders that may result. This study connects specifically the amygdala, hippocampus, and the HPA axis in regulating emotional responses to adverse stimuli as well as its role in the later development of mental illness. It is suggested that dysfunction of these areas contribute to the development and severity of "PTSD, depression, anxiety, antisocial behaviors, and substance abuse disorders." (DeBellis & Zisk 2014) Multimodal

MRI research has also been used to examine childhood maltreatment and its long term effects found progressive changes within the limbic system. Neuroimaging studies by Souza-Quieroz et al. (2016) found anatomical differences among participants who had experienced childhood trauma as a result of abuse compared to those who had not experienced trauma as a result of childhood abuse. This study found increased amygdala volume among participants with trauma from childhood abuse. Participants who showed variations in brain structure and reported trauma as the result of abuse in childhood also reported mental illnesses including anxiety disorders, depression, PTSD, and bipolar disorder. The findings in these studies suggest a connection between childhood abuse, increased stress sensitivity and aggression, and later development of psychological disorders. In Whitman's case we see high levels of stress, repeated stressor exposure throughout childhood, a genetic predisposition towards aggression, and the result of this in his later actions in Texas.

Chapter 2: Amphetamines

Neurotoxicity

After complaining of chronic stress, headaches, and homicidal ideation to a doctor on campus, Charles Whitman was prescribed dexedrine, an amphetamine, to treat his concerns. Amphetamines, although can be prescribed for clincal purposes, can often produce adverse biological effects resulting from long term use and abuse including damage and alterations to the dopamine system in the brain. Amphetamines are synthetic stimulant drugs that act upon the central nervous system. They mainly increase catecholamine activity in the brain including increasing the production of neurotransmitters such as dopamine and norepinephrine. The lipid soluble nature of amphetamines allow for easy passage through the blood brain barrier. Fast access to the brain also allows fast access to synaptic clefts, the main area of action where dopamine concentration is increased and reuptake is decreased.

Long term exposure and high doses of amphetamines, causing prolonged dopamine alteration, can result in neurotoxic effects in the brain such as damage to dopamine nerve terminals. Animal studies such as one by Anderson and Itzhak (2006) examined the neurotoxic effects of amphetamines and methamphetamines on the brains of male Swiss Webster mice in a three day study where the mice were administered a constant dose of amphetamine every three hours. Using a monoaminergic marker, they were able to track concentrations of dopamine as well as amphetamine movement. Three days following the administration period the mice were sacrificed and an autopsy was performed. The highest concentrations of the amphetamine found were localized in the

frontal cortex, hippocampus, and amygdala, all of which positively correlated with depleted and damaged dopamine terminals in the same brain regions. Another study by Ricautre and McCann (1992) examined the effects of amphetamines administered to male spider monkeys over a four day period at twice a day. Similarly, upon autopsy, stained samples found concentrations of amphetamines centralized around areas that also showed depleted dopamine and damaged terminals as well as some nerve cell death. It was also suggested that primate studies produce results closer to those within human studies, allowing for results from these studies to be more easily applied to a human understanding of the effects of amphetamine use. (Ricaurte & McCann 1992) Cell damage, death, and the depletion of vital neurotransmitters in the brain following amphetamine use indicates its neurotoxicity. Although, there are further disruptions caused by amphetamine and methamphetamine use that go beyond the cellular level.

The neurotoxic effects of chronic amphetamine are easily identifiable in the short term and during active use, however prolonged periods of time, including during abstinence does not always equate to a decrease in neurotoxicity. Prolonged neural degeneration has been found to persist through long term use as well after use has ceased. Studies such as that of Ricaurte et al. (1984) administered consistent doses of amphetamines to rats for three days then examined dopamine, serotonin, and norepinephrine levels following a two week and four week period of abstinence. This study found considerable lasting depletion of dopamine, serotonin, and norepinephrine as well as continual nerve fiber degeneration. Similarly, another study by Ares-Santos et al. (2013), mice were administered a set dose of amphetamine, either a single 30mg, or period 5 or 10mg doses in a single day and then were not given another dose and left for

a 30 days. Upon examination through silver staining, there was also found to be considerable neurotransmitter depletion as well as evidence of dopamine cell body damage and nerve fiber degeneration. Results from these long term, abstinence based studies provide evidence that low dosages and periods in which amphetamines are not being consumed still produce lasting neurotoxic effects similar to those produced during active use.

Examining the impacts of amphetamines on rodents and primates provides important insight into how it affects brain chemistry and health, however not all animal examples are always transferable to a human understanding of the substance. Findings from past animal studies, however, are confirmed in human-based studies such as that of Ferdous et al. (2020) in which cultured human neuroblastoma cells were treated with set microdoses of amphetamine. Dopamine transport greatly decreased upon administration and was recorded to continue to either decrease or stay at a fixed decreased state for up to 50 hours, suggesting long term neurotoxic effects even upon a single dose of amphetamine. Cell damage, death, and the depletion of vital neurotransmitters in the brain following amphetamine use indicates its neurotoxicity. Although, there are further disruptions caused by amphetamine and methamphetamine use that go beyond the cellular level.

Beyond the cellular level, interactions between amphetamine and histone proteins can result in epigenetic modifications which may change gene expression and induce later behavioral changes. Amphetamine interactions with acetyltransferase and deacetylase, enzymes that moderate histones, can result in changes in the expression of genetic information. This change has been recorded during several animal studies such as

one conducted by Cadet et al. (2013) found changes in striatal gene expression following both acute and chronic administration of amphetamines to rats. Another study by Mychasiuk et al. (2013) found gene alterations and changes in DNA methylation in male Long-Evans rats following a two week period of consistent administration of either amphetamine or nicotine. Amphetamine administered rats were found to have experienced changes in the expression of 25 different genes as well as prolonged decreased myelination, even following a two week adistence period. Epigenetic modifications may explain the lasting cellular impacts of amphetamine use including beyond active use such as the lasting changes to the dopamine system in the brain. Changes in genetic expression and disruptions in the dopamine system can be connected to larger changes in behavior.

Aggression

A largely studied relationship within amphetamine use is a correlation between use and the development of aggressive behavior. Several studies have demonstrated a positive connection between amphetamine use and increased aggressive behavior. One study by Payer et al. (2011), for example, examined frequencies of aggressive behaviors in 39 amphetamine-dependant human participants in comparison to a 23 person, nonuse control group. With both self report and fMRI data, the levels of reported and observed aggressive behaviors was found to be higher for amphetamine dependent participants for both provoked and unprovoked situations. This finding of increased aggression independent of situation suggests a change in behavior as a result of amphetamine use. A meta-analysis by Scott et al. (2008) consolidates several findings that relate aggressive

and other antisocial behaviors to chronic amphetamine and methamphetamine use. Other suggested changes in behaviors as a result of amphetamine use include impulsivity, decreased empathy, and increased anxiety. (Corr & Kumari 2013)These behavior changes have all been found to contribute to a users likelihood of committing violent crimes; longitudinal studies and national crime surveys link amphetamines and other drugs to increase violent crime activity. (McKetin et al. 2020)(McKetin et al. 2014) Similarly, one four year study by McKetin et al. (2020) following 470 amphetamine using participants with monthly check-ins found that 75% of all participants had committed at least one type of crime within the four year span with 22% committing a violent crime once, and 9% committing a violent crime in each of the 48 months of the study. The results from all these studies provide evidence for a link between aggression or violence and amphetamine use, and in some cases, a propensity for crime including violent crime. While it is suggested that increased aggression can be individually determined and may be dose-related, in the case of Charles Whitman, his experience with abuse and violence in childhood, including a possible prenatal predisposition contributes to the likelihood that his use of amphetamines would increase his levels of aggression towards others.

The changes in the dopamine system that can result from substance use can have adverse effects on one's behavior depending on the substance being abused; in the case of stimulants such as amphetamines, the overproduction of dopamine can commonly result in increased levels of aggressive behavior. Aggression can manifest as either reactive or instrumental. Previously discussed studies examining neural degeneration, epigenetics, and neurotoxicity provides the mechanism with which amphetamines disrupt the dopamine system in the brain. The development of aggression in relation to dopamine has

been a widely studied topic in which positive correlations have been made in both animal and human studies. Several rodent studies have found an increase in dopamine positively correlates to an increase of aggressive behavior. Suzuki et al. (2010) found an increase in both dopamine and aggression when rats were chronically exposed to passive aggression, Van Erp, A. M., & Miczek, K. A. (2000) found the same correlation in rats who's dopamine levels were chemically manipulated using microdialysis, Anstrom et al. (2009) found increased dopamine signaling and increased social aggression in rats who experienced social defeat in dominance based fighting. Despite varying environments and situations, the results all demonstrate a positive correlation between increased dopamine and increased aggression in rats independent of several other variables. Similarly, a study by Schlüter et al. (2013) with healthy male participants also found increased dopamine with a sensitivity to aggression and an increased likelihood towards violent behavior. This study examined participants using positron emission tomography (PET) while they completed monetary, reward-related tasks. Participants who displayed a sensitivity to increased dopamine were positively correlated with an increased risk towards impulsivity and reactive aggression. This vulnerability presents risks for others as reactive aggression and a predisposition towards violence is a common precursor to future crime; in Whitman's case it is later manifested as mass homicide.

Changes in brain chemistry can have various adverse outcomes relating to behavior and crime, including a developed inclination for violent crime. In relation to homicide, several factors typically play a role in causing a person to commit this serious crime, one of them commonly being substance use. A study of the Nationwide Emergency Department Sample (NEDS) from the Healthcare Cost and Utilization Project

(HCUP) found that within a sample of 62,910 cases, the likelihood of a person experiencing homicidal ideation was greatly influenced by psychopathologies and substance use, including the likelihood to act upon these ideations. (Carbone et al. 2019) Severe psychopathologies including psychosis and antisocial personalities increased the likelihood of personal action amongst those who reported homicidal ideation by over 1,455% if homicidal ideation was present and persistent prior to the committing of the homicide. In a similar study conducted within the state of Florida, Maniaci et al. (2016) examined the connections between those medically detained after making homicidal threats and other psychiatric characteristics; suicidality, homicidal ideation, psychological disorders, and substance use. Of the 251 patients examined, it was found that accompanying the present threat to others or a specific person, 84.6% had a psychiatric disorder and 61.5% struggled with substance use. Although never formally diagnosed, Whitman does present several symptoms associated with various psychological disorders, and in combination with the prescribed dexedrine, both boxes are checked off in his scenario.

Chapter 3: Glioblastoma and the Amygdala

The Amygdala: Function, Subregions, and Malfunction

Located in the medial temporal lobe, the amygdala, also called the amygdaloid complex, is a brain structure commonly associated with the "fight or flight" response among several other emotional regulatory actions. The amygdala handels sensory input, emotional processing and regulates the responses to the stimuli and emotions. Reactions to situations and environments that cause feelings of fear and anxiety are typically associated with the amygdala. The brain develops an understanding of what inputs cause negative emotions through exposure and association, some researchers argue that through demonstration and learning the brain creates an association between what is and is not considered a threat. (Bear et al. 1996) Motivation, fear, and anger, or aggression are the most commonly associated emotions with the amygdala in terms of processing and general function, including anxiety. (Baxter & Croxton) The amygdala closely works with other brain structures including the hippocampus, using information stored in memories of past events to judge present situations. It has been suggested that specifically emotionally heavy memories may require more support from the amygdala than less emotionally intense emotions. (McGaugh et al. 1996) The amygdala, although typically discussed as a whole, comprises several interconnected segments that perform specialized functions.

Subregions of the amygdala serve separate functions, although cross-section communication allows for the amygdala to produce singular reactions to a large amount of stimuli. Three distinct regions have been identified within the amygdala, the

basolateral, cortical or cortical-like, and centromedial nuclei.Each subregion plays a role in a specific type of emotional regulation including modulating anxiety, fear, rewards, attention, and using previous experiences to judge present situations. The basolateral subregion has been identified as playing a major role in anxiety and the reward system in the brain (Sah et al. 2003)One study by Etkin, Prater, and Schatzberg (2017) found among 64 participants with generalized anxiety, who underwent an fMRI scan, significant differences within the amygdala complex compared to a group of healthy controls. Results demonstrated lower amygdala volume specifically in the basolateral region as well as reduced gray matter volume. The centromedial subregion has been identified as playing a role in allocating importance to stimuli and initiating responses depending on significance. One primate study by Mosher et al. (2010) using surgically implanted recording chambers distinguished centromedial neuron function from basolateral neuron function. Rhesus male monkeys completed various attention and orientation based tasks.It was found that CM neurons fired more frequently to stimuli within the events of the task such as presentation of images, while BM neurons were more likely to respond to the content of the images being displayed. Communication between both functional sets allows the amygdala to identify stimuli within an environment, make decisions about its significance, and then respond to the stimuli accordingly.

When functioning properly, all the subsections of the amygdala work to protect the body from harm by performing on the fly risk assessment and initiating emergency response tasks, this is not always the case, however, when a malfunction occurs. Adverse environments, situations, and experiences in early life during development can influence

the development and function of the amygdala. Adversities such as maltreatment and abuse in childhood have been correlated to malfunction Luo et. al (2022) found through fMRI data examining gray matter volume and resting-state functional connectivity (RSFC) decreased RSFC within the amygdala and decreased gray matter volume. Participants who experienced abuse in childhood or other maltreatments had significantly lower volumes and activity than non-abused participants, while also displaying higher levels of psychiatric disorders including depression and anxiety-related disorders. Decreased activity in the amygdala suggests decreased interactions with other structures commonly interacting with the amygdala such as the hippocampus and the frontal cortex. A study by Ikegame et al. (2020) examining amygdala volume and methylation found that participants who experienced psychiatric disorders, especially those with schizophrenia displayed hypomethylation and decreased left amygdala volume. Other studies confirm the correlation between childhood abuse, epigenetic changes, and increased vulnerability for psychiatric disorders later in life. (Cecil et al. 2016)(Sheridan & McLaughlin 2014) The influence of both childhood abuse as well as possible epigenetic changes in DNA methylation influence and activity amygdala and its connections to external brain structures.

Changes in the connections between the amygdala and other associated brain structures may contribute to adverse behavior and other undesirable outcomes. Abnormalities in function and connections to neural pathways within and traveling out of the amygdala have been shown to produce adverse consequences such as increased anxiety-like symptoms, social impairments, and sensitivity to fear-inducing situations. (Rizzo et al. 2018) Rizzo et al. (2018) demonstrated through MRI scans and structural

T1-MPRAGE scans, a correlation between abnormal amounts of gray matter and white matter, and a further correlation between abnormal levels of white matter in the amygdala and behavioral deficits including deficits in social interactions. Other areas of connections such as the prefrontal cortex, an area most commonly associated with decision making, impulse control, and other cognitive functions produce negative outputs when the connection between the amygdala is abnormal. A study by Liu et al. (2020) demonstrated positive correlations between heightened levels of anxiety and chronic stress and disrupted connections between the prefrontal cortex and the amygdala in a rodent based model using chronic stress exposure. Early life changes in development have also shown to influence later behavioral development. One long-term infant study by (Thomas et al. 2019) examining amygdala connectivity through fMRI found that disrupted connectivity between the amygdala and the prefrontal cortex positively correlated with the increase of fear responses at birth and continued to increase through two years. Possible deficits in decision making, forethought, and impulsivity coupled with heightened anxiety and increased sensitivity to perceived threat may act as modulators to someone like Whitman who is predisposed to acting aggressively and violently.

Glioblastoma and the Amygdala

In drastic situations, extreme abnormalities such as growths or tumors within the brain may contribute to changes in behavior or new developments; placement within the brain may further shape what these behavioral changes look like depending on the common functions of the structure being affected. Upon autopsy, a tumor was discovered

on Charles Whitman's amygdala, identified as a glioblastoma. A common yet aggressive brain tumor, glioblastomas result from point mutations and have a wide range of symptoms including seizures, headaches, memory loss, and other cognitive deficits. (Omuro & DeAngelis 2013) Common cognitive functions that are impacted by the development of gliomas include intellectual functioning, deficits in learning, memory, attention, and processing, as well as speech disruptions and declined emotional function. (Morshed et al. 2016) Abnormal growths in the brain can cause intracranial pressure that can restrict blood flow to the affected area. MRI studies have concluded that pressure from a resulting tumor on the brain can restrict blood flow to the location of the tumor as well as surrounding areas. (Waqar et al. 2021)(Server et al. 2011) A restriction in blood flow to certain areas would limit the amount of oxygen and glucose that would otherwise be delivered through normal cerebral blood flow.

Based on the typical function of the amygdala, restricted blood flow to this area following the development of a tumor would result in a decrease in the functioning capacities of the amygdala. Actions such as emotional processing, determining significance of events, or reacting to adverse situations with fear or anxiety would be suggested to decrease. Normal blood flow within the brain can be altered by other forces besides a physical tumor. PET scan studies examining cerebral blood flow and it's correlation to PTSD has found that those who suffer from PTSD experience increased blood flow to the amygdala among other brain structures. (Sempler et al. 2016) Pet scan data from cued and uncued fear-based situations have demonstrated increased cerebral blood flow to the amygdala during anticipation of unpleasant experiences such as a mild shock. (Hasler et al. 2007) Increased blood flow to one region in the brain may promote

increased activity in a given area; hyper activity in the amygdala from increased blood flow would suggest an explanation for anxious and aggressive behavior and increased sensitivity to incoming stimuli. In Whitman's case, it may be suggested that prior to development of the glioblastoma, the amygdala experienced hyperactivity resulting from alterations due to the abuse from his childhood. Following the development of the tumor, restricted blood flow, oxygen, and glucose to the amygdala would reduce it's functional capacity, contributing to decreases in emotional regulation as seen in the rapid development of aggression towards the end of Whitman's life.

Development of a glioma tumor requires space for the mass to grow, which may cause the tumor itself to shrink occasionally as a means of mobility. In order for a glioma to shrink and move freely, something consuming space must be released in order to allow for movement; potassium and chlorine ions as well as excess water are released. (McFerrin & Sontheimer 2006) MRI and spectroscopy studies have demonstrated and confirmed the release of potassium and chloride ions from glioma tumors into the surrounding areas of the tumor's locations. (Pacheco-Torres et al. 2015)(Sontheimer 2008) K+ and Cl- channels in the brain have been found to promote glioma growth as activity within these channels allow for free movement of cancerous cells that are easily permeable through the release of K and Cl ions. (Sontheimer 2008) Irregular influxes and decreases of ions in a certain area in the brain dysregulated the normal function by disrupting the normal activity of the natural potassium and chlorine ion channels. The combination of decreased blood flow, low oxygen and glucose, and disruptions in the ion channels in the brain contribute to dysregulated functioning of the afflicted brain structure following the development of a tumor such as a glioblastoma. As changes in

function occur, the resulting behavior may turn out to be as dysfunctional as the physical changes to the brain.

Dysfunction of the amygdala may be commonly associated with increased aggression, impulsivity, and anxiety-like behaviors, although a seemingly contradictory outcome that can occur may mask the externalization of these changes. First initially posited in 1939 by Henrich Kluver and Paul Bucy, a syndrome linked to trauma of certain limbic system structures, especially the amygdala and hippocampus, was discovered in monkeys following a temporal lobe lobectomy. (Kluver & Bucy 2006) Following a bilateral temporal lobe lobectomy on a rhesus monkey, Kluver and Bucy documented behavioral changes, however the first case of this syndrome, later denoted Kluver-Bucy syndrome, in humans was not recorded until 1955. (Kluver & Bucy 2006)(Terzain 1955) Modern understanding of Kluver-Bucy syndrome includes a list of behavioral characteristics including hypersexuality, insomnia, amnesia, lack of emotional display, and heightened sensitivity to visual stimuli among others. This syndrome exists exclusively as an affliction of the limbic system and can be triggered by numerous events with traumatic head injury, stroke, brain tumors, and herpes simplex being the most common causes. Other less common causes may include CNS tuberculosis, Alzheimers, Pakrinsons, temporal epilepsy, and methamphetamine withdrawal. (Das & Siddiqui 2021) (Clay et al. 2018) In Whitman's case, we see repeated traumatic head injuries resulting from ongoing childhood abuse, the later amphetamine use although may not have been severe or frequent enough to act as a trigger alone, rather it may be considered an influence on top of the injuries sustained from the abuse.

Severe brain injury resulting from childhood abuse results in multiple structural and chemical disruptions in the brain that promote the development of adverse outcomes such as Kluver-Bucy syndrome. ICP monitoring and microdialysis among a group of 97 participants who experienced childhood abuse performed by Timofeev et al. (2011) demonstrate the various changes seen within the brain following head injuries. The severity of the injuries sustained did influence the degree of change, however across the majority of participants, independent of severity, decreased levels of lactate and glycerol were found in the injured areas suggesting decreased norepinephrine production and progressive cell generation. Relative to the development of Kluver-Bucy syndrome, changes in the functionality of injured brain structures may produce symptoms that aline with Kluver-Bucy syndrome; heightened aggression, lack of emotional awareness, lack of fear, and overstimulation as symptoms also indicate a malfunctioning amygdala. Clinical studies examining signaling in the brain following a traumatic head injury have shown decreased presynaptic dopamine production (Fridman et al. 2019) and increased cerebrospinal fluid. (Paşaoğlu et al. 2004) Various changes and disruptions in the structure and functionality of the brain resulting from traumatic head injuries promote the external manifestations seen in Kluver-Bucy syndrome.

Changes in cognition and social behaviors have also been suggested outcomes of Kluver-Bucy syndrome. Changes in cognition, personality, and social behaviors are common in Kluver-Bucy syndrome, although the manifestation of the syndrome can be complete or partial and the display of symptoms is often individualized due to the rarity of the condition. (Lanska 2017) Partial kluver-bucy syndrome has been found to develop as a manifestation of head injuries, even following time gaps from the time of injury.

(Bhat, Pardal, & Das 2009) Bhat, Pardal, and Das's long term case study of an active duty soldier found symptoms and partial development of Kluver-Bucy syndrome following a head injury sustained two weeks prior. His symptoms included hypersxuality, increased aggression and impulsivity, deficits in facial recognition, and hyperfixations. Fully developed variations of the syndrome typically present a greater number of symptoms at a higher severity. Case studies of children with KBS by Bertoux, Resende, and Cruz de Souza (2018) found children diagnosed with full KBS displayed severe deficits in decision making, emotional recognition and regulation, facial recognition, learning, and creative thinking. Charles Whitman, although never formally diagnosed with KBS, did display symptoms such as heightened aggression, decreased emotional regulation, and impulsivity. His history of severe childhood abuse coupled with the glioblastoma found on his amygdala all contribute to the development of these symptoms and may suggest partial KBS.

Chapter 4: Chronic Stress

Dopaminergic and Hormonal changes

Situations and environments that produce a stress response are common in daily life and are not typically harmful in singular episodes, however negative consequences may result from chronic stress exposure. Acute stress responses work as coping mechanisms or methods of adaptation and in these single situations function in a positive manner. Chronic stress can be marked by increased cortisol levels and changes in the mesolimbic dopamine system in the brain, measurable through saliva and body hair as demonstrated by Lee, Kim, and Choi (2020), as well as several other human and animal studies. (Karailiev et al. 2020) A rat study demonstrating the effects of stress by Karailiev et al. (2020) found chronic stress exposure increased cortisol levels and decreased dopamine D1 gene expression in the amygdala following a 9 week stress provoked isolation period. In cats, Contreras et al. (2021) also found cortisol concentrations within hair and nail samples to serve as suitable measures of chronic stress, also indicating that higher concentrations of cortisol in the samples were found to be higher among cats who were adult owned compared to street-cats. Using hair, nail,and skin samples to measure cortisol levels as a biomarker or chronic stress also translates to human studies. One study of medical students by Mayer et al. (2018) found traumatic stress increases following stressor triggers such as beginning of new medical internships; stress levels were determined through hair cortisol concentration. Alongside the onset of stress, depressive symptoms were also found to dramatically increase following the stressor

trigger, suggesting a correlation between chronic stress and the development of depressive symptoms.

Newly stressful environments have been shown to influence biological changes such as increases in cortisol and decreases in dopamine activity, although prolonged stress and previous experience with chronic stress may have more severe consequences. Although it is suggested that previous experience with acute stress may promote resilience and adaptation for future similar experiences (McEwan et al. 2007) past experience with chronic stress episodes may predispose future episodes to become increasingly harmful. Multiple periods of chronic stress have been shown to have maladaptive results including accelerated cell aging, increased oxidative damage, and increased cortisol levels. Imbalances in the production and accumulation of oxygen reactive species (ORS), causing cell tissue decay and death is recognized as oxidative stress. (Betteridge 2007) One mice study by Codeluppi et al (2021) exposed healthy lab mice to long term restraint stress, measuring biological changes at 7, 21, and 35 days, finding atrophy among astroglial cells and dramatic increases in anxiety-like behaviors. Aschbacher et al. (2013) demonstrated the negative effects of chronic stress within a sample of 48 healthy participants, measuring levels of stress using the Perceived Stress Scale (PSS) (Cohen, Kamrack, Mermelstein 1093), stress, tasks, blood draws, and collections of saliva and hair samples. It was found that those who scored high on the PSS produced higher levels of cortisol and experienced more oxidative stress than those who had moderate or low scores. As demonstrated by multiple human and animal studies, long term exposure to surplus cortisol can produce psychotic-like symptoms and can dysregulate several other internal systems.

Changes in production and chronic exposure to excess cortisol can produce adverse, psychiatric-like symptoms as well as disrupt the reward system in the brain. Changes in dopamine production while experiencing an acute period of stress is necessary for adaptation and for coping with the current stressor. When the acute exposure becomes continuous or repetitive, the results become maladaptive. In rats, chronic stress exposure through predator scent tests has been shown by Drememncov et al (2019) to decrease dopamine concentration in the hypothalamus and increase cortisol production. Following these changes, rats who were placed in predator scented environments for fifteen days showed dramatic increases in anxiety-like behaviors. Other rodent studies are consistent with these findings, producing similar results of decreased dopamine as a result of chronic stress from various sources including repeated unanticipated stress (Parul et al. 2021) social stress through fighting defeat, and long term food restriction (Ball et al. 2017). Bloomfield et al. (2019) demonstrated the effects of psychological stress on the dopamine system, utilizing PET, and MRI technology among a group of participants taking the Montreal Imaging Stress Test, examining both acute and long term stress exposure. Their study found decreased dopaminergic functioning in the long term group as well as increased vulnerability to negative reactions to future stressors. Past stressors explored in this study focused mainly on childhood abuse, suggesting a connection between stress experienced during childhood abuse predisposes one to be increasingly sensitive to future stressful events. Whitman's case provides multiple sources of continued stress from school and work stress to financial troubles, as written about in his personal journals, as well as years of severe childhood abuse.

Aggression

Disruption in neurotransmitter and hormone activity can produce various adverse behavioral and psychiatric-like consequences including changes in aggression and aggressive and homicidal ideation. A number of internal and external factors can influence the chemical changes in the brain that may produce unwanted psychological and behavioral changes. Several animal and human studies have demonstrated a strong correlation between dopaminergic disruption and adverse psychological and behavioral changes Increased anxiety-like and depressive symptoms (Nestler & Carlezon 2006), changes in memory and other cognitive functioning (Lee et al. 2021), and increased aggression have all been connected to dysregulated dopamine functioning. (Carbone et al. 2019)(Schlüter et al. 2013) Changes in the dopaminergic system disrupts the reward system in the brain and can sensitize the amygdala. Furman, Tsoory, and Chen (2019) demonstrated amygdalar sensitization in male and female mice, finding that mice exposed to chronic social stress, independent of sex, showed decreased resilience to future exposure to stress induced situations and increased depressive symptoms, increased anxiety-like behaviors, and increased aggression towards other mice. Similar models of sensitization as a result of chronic stress have been demonstrated by Weissman et al. (2020) in a long term study of 149 people who experienced abuse during childhood. MRI scans and self report data at a two year follow-up showed a correlation between childhood abuse, reduced hippocampal volume, increased likelihood of depression, and increased sensitivity to stress tasks compared to a control group of 74 participants who did not experience childhood abuse. Increased amygdala sensitivity resulting from

chronic stress and traumatic events such as severe abuse increase the frequency in which acutely or mildly stressful events are perceived as a larger threat.

Inclinations to perceive non threatening or mildly stressful situations as threatening can increase the likelihood of an aggressive, defensive reaction. Triggers as small as changes in facial expression have been shown to be enough to provoke a fear-related response in an overly active amygdala, prompting reactive aggression. Cunha-Bang et al. (2017) examined impulsive aggression through self reported data collected about trait aggression, impulsivity, and anger, finding that after MRI scanning the same participants, those who reported higher levels of aggressive behaviors and characteristics and overall higher levels of anger also displayed hyperactivity in the amygdala and higher sensitivity to fear-based stimuli. Small changes and mild stressors in an environment causing a reactive response, correlating with hyperactive amygdala activity demonstrates the connection between the long lasting effects of chronic stress on later aggression and impulsivity. This effect can be traced back prenatally when infants experience second hand effects of their mother's stress. A longitudinal study by Romero-Gonzalez et al. (2018) examined 80 pregnant mothers' cortisol levels through each trimester of pregnancy, then followed the cortisol levels of their newborns for three month postnatal. Mothers who had excessive cortisol through pregnancy, especially during the third trimester, had children who similarly overproduced cortisol. Early overproduction of cortisol and other hormones and transmitters related to chronic stress and fear responses can dramatically change a baby's development, sensitizing the brain's reaction to fear and its sensitivity to stress. Numerous situations can be stress producing,

for example, the severe abuse that Whitman's mother faced while pregnant would create an extremely stressful environment.

Societal norms expect men to conceal strong emotions and not discuss feelings or situations that they struggle with, consequently making negative situations more difficult to handle. Pressure from other people to withhold expression of emotions or seeking help for emotional struggles can cause the stress of dealing with these problems to worsen. Several studies on the relationships between psychological stress and aggression have found that men and women deal with and display signs of struggle differently, part of this may be explained by societal norms surrounding emotions. One study by Stefanile, Matera, and Nerini (2017) examined psychological predictors of aggressive behavior in male and female inmates, finding that women more commonly respond to psychological problems with emotional dysregulation and decreases in self esteem, while men more often externalize these problems, favoring enger, aggression, and occasionally pursuing violence against others. A comparison study by Suchday and Larkin (2001) examined biological differences between men who externalize versus men who internalize anger, measuring biological differences including heart rate, blood pressure, and adrenaline concentrations. Participants who gravitate towards externalizing anger through aggressive behaviors were found to have higher blood pressures, slower heart rate recovery times, and increased adrenaline concentrations following roleplay situations designed to provoke anangery response. From these studies and several others we see the psychological and physical consequences of the pressure for men to suppress negative emotions. Whitman's personal writings demonstrate his awareness of his struggles with school work, lack of sleep, and an inability to control his anger, however he does very

little to reach out or ask for help, part of this may be attributed to the assumption that as a man he is expected not to feel these types of negative emotions.

Depression

A common side effect of dysregulated dopamine production, especially underproduction, is the development or worsening of existing depressive symptoms. Decreases in the production of dopamine have been shown to produce unwanted psychiatric symptoms, commonly anxiety-like and depressive symptoms in both human and animal models. Sedaghat et al. (2018) demonstrated the role of dopamine in the development of depressive symptoms in rats exposed to chronic mild stress. Rats exposed to chronic mild social stress for 5 weeks showed depressive and anxiety-like behaviors as well as increased cortisol production with decreased dopamine production. Similarly, Tye et al. (2013) found likewise results in mice through electrical manipulation of midbrain dopamine neurons. Inhibition of dopamine neurons produced depressive behaviors and increased the likelihood of repetition of these behaviors without manipulation. In humans, decreased dopamine production can stem from multiple sources such as long term stress (Karailiev et al. 2020), genetic predisposition (Ompeer et al. 2010) and drug withdrawal (Paulson & Robinson 1996) among others. In Whitman's case, we see a combination of multiple possible sources including genetic predisposition and alteration prenatally, extreme abuse in childhood, brief amphetamine use, and chronic stress described in his personal journals.

Depression caused by prolonged periods of stress may result in adverse behavioral changes. As previously discussed, depression in men and women tend to

manifest differently, in that, men more commonly present externalized symptoms including increased anger, hostility, difficulty feeling emotions, and increased impulsivity. (Mawr 2018) In a self-report study by Troisi and D'Argenio (2003) examining clinically depressed men, positive correlations were found between increased anger and insecure attachment. Another self-report study by Oliffe et al. (2012) focusing on the relationship between masculinity, social expectation, and depression in men describes three common types of men based on their presentation of depressive symptoms. Of the three types, solitary, angry, and risk-reliant, Charles Whitman most closely matches the description of the angry type; externalizing his emotions and frustrations through lashing out against others as a means to relieve some distress. Across all types, participants did not actively seek help or express their struggles to others out of fear of being judged or seen as weak by others. In a similar study examining the relationship between anger, drug use, and suicidality in men, Rice et al. (2018) found that young men who reported high levels of depressive symptoms were at an increased risk for suicidal ideation, were more likely to externalize their emotions through anger, and were more likely to engage in illicit drug use. A commonality among men who display depressive symptoms is to express frustration and struggle through aggression and adverse behaviors. Although never formally diagnosed, Charles Whitman documented several months of emotional struggle resulting from the stress of his homelife, school, work, and the homicidal ideation that developed.

Violence, including homicide can stem from a multitude of sources, one of those being depression and chronic stress. Men who struggle with depression and external stressors have been shown to be more likely to commit violent acts compared to those

who do not. A study by Chen and Jaffe (2019) examining men who committed intimate partner homicide found that men who struggle with depression were 1.5 times more likely than non depressed men to commit this crime. In Whitman's case, before going to the university and committing the notorious mass shooting, he first stabbed both his mother and wife Kathy; prior to these homicides Whitman had documented months of struggle with depressive symptoms stemming from various sources of extreme stress in his life. A 2019 study by the National Council on Behavioral Health (NCBS) examined the data and correlations between mental illness and mass violence in the United States, positing that nearly a third of all mass shootings in the U.S. are committed by people suffering from some form of a serious mental illness. Similarly, an Australian study by Brownhill et al. (2005) comparing the experience of depression in men versus women found no significant difference in the experience of symptoms, rather drastic differences in the expression of the depression. Men in this study commonly expressed their depression through aggression, hostility, impulsivity, and occasionally violence against others. A clear correlation from these studies and several others, is established between depression in men and an increased likelihood to act out aggressively or violently as a result. Influence from depressive symptoms on top of negative effects from chronic stress would only increase the likelihood of aggression and severity of a possible act of violence.

Chapter 5: Self Esteem

Childhood abuse and Trauma

Trauma resulting from childhood abuse can result in lifelong negative impacts on one's behavior, development, and self esteem. The case of Charles Whitman demonstrates how later violence in life can be traced back to the abuse experienced during his childhood. In male mice, Preez et al. (2020) found that following six weeks of chronic stress exposure, then six weeks of social isolation, adolescent male mice demonstrated depressive-like symptoms, as well as biological changes including decreased hippocampus volumes. The continuation of symptoms from adolescence into adulthood in the mice demonstrate the last impacts of adversity experienced during childhood. Celik and Odaci (2019) demonstrate this trend in a self-report, correlational study, examining the connections between childhood abuse, depression, anxiety, self-esteem, and stress levels. They found childhood abuse to negatively correlate with depression and self esteem, with anxiety and stress being secondarily correlated through depression as a modulator. Similarly, in a comparative study, Finzi-Dottan et al. (2006) found among 190 Isreali undergraduate students who reported emotional childhood abuse, also demonstrated low self esteem, immature emotional control, and increased likelihood towards developing abnormal psychopathologies. Experiencing adversity such as abuse during childhood, leads to the resulting negative outcomes that are the product of disrupted development.

Small developmental changes at the epigenetic level may occur among those who experience childhood abuse. Research by Peng et al. (2018) examining monozygotic

twins that experienced trauma during childhood found changes in methylation and expression of stress and depression associated genes. The expression of five genes, BDNF, NR3C1, SLC6A4, MAOA, and MAOB, were identified to have been changed following trauma exposure, and later correlated to stress and depressive symptoms. Park et al. (2016) solidifies discussion about multiple epigenetic changes resulting from childhood abuse and correlated to depression in a systematic review, identifying 13 genes related to these changes. The majority of the identified genes are associated with depression and stress responses, NR3C1, SLC6A4, BDNF, FKBP5, SKA2, OXTR, and serotonin signaling, NR3C1, SLC6A4, BDNF. Epigenetic modifications resulting from abuse trauma can impact later behaviors and emotional development. Changes in stress responses and sensitivity, emotional control, and disrupted neural signaling increases the likelihood of adverse behaviors and psychopathologies. (Bartlett et al. 1970)

Childhood abuse and trauma have been linked to various psychopathologies that contribute to negative behaviors later in life. Independent of gender or type of abuse, correlations between childhood abuse and later negative psychopathology have been heavily researched. In a comparative, long term study, Rehan et al. (2016) found that instances of abuse during childhood can have lasting impacts on the likelihood of psychopathologies developing, from a single abuse event to severe, continuous abuse. The severity, length, and type of abuse were found to influence the likelihood and severity of later developed mental illnesses, with severe, long term, multi-type abuse having the most significant influence of pathology development. In Whitman's case we see a combination of severe emotional and physical abuse, carried out daily for 18 years, equating to the combination of factors to most greatly influence irregular pathology

development. Young and Widom (2014) further examined emotional development in a long term study involving abused and neglected children, following up during middle age (32-51 years old) to examine emotional processing. Of the returning participants (n=294) who had experienced neglect or abuse during childhood, approximately nearly 30% reported pathologies including major depression, generalized anxiety, dysthymia, and PTSD. Previously abused and neglected participants demonstrated deficits in emotional processing that are suggested to be caused by the abuse/neglect, and moderated by any pathologies. Childhood maltreatment has been linked to several disorders, most commonly PTSD and depression, as well as severe disorders including antisocial personality disorder. (DeLisi, Drury, & Elbert 2019) All disorders and pathologies correlated with childhood maltreatment and trauma only serve to disadvantage one's ability to process and regulate their emotions, and may contribute to adverse behaviors later in life. Charles Whitman exhibits anxiety-like and depressive-like symptoms throughout his life resulting from extensive and severe childhood abuse.

Cognition

Developmental changes resulting from abuse can disrupt cognitive development, further damaging one's self esteem. Changes in cognitive function can influence the likelihood of one having mental health issues later in life, especially depression and anxiety-related disorders. One long term study by Huh et al. (2017) examined the connections between childhood trauma, psychopathologies, and cognitive emotional regulation, finding that psychiatric disorders related to childhood abuse were mediated by cognitive emotional regulation. Participants who reported childhood trauma from abuse

were found to have lower cognitive emotional control based on the Cognitive Emotional Control Questionnaire (CEMQ) compared to their nonabused counterparts. Previously abused participants with lower CEMQ scores also displayed a higher rate of psychiatric disorders, focusing specifically on depressive and anxiety-related disorders, suggesting a mediating relationship between childhood abuse, mental illnesses, and cognition. The physical toll of childhood abuse, physical abuse being specifically related to Whitman's case, can further influence self-esteem, self perception, and the likelihood in which a person develops a psychiatric disorder. Ponsford, Kelly, and Couchman (2014) demonstrate this concept in a comparative study examining traumatic brain injury (TBI) participants and non TBI participants. It was found that following TBI can dramatically change one's self perception, damaging self esteem and increasing the likelihood that someone with TBI may develop a psychiatric disorder. We see the same possibility in Whitman's case via the severe physical abuse endured during his childhood as well as a head injury he sustained while serving in the military. Following years of abuse and a concussion, a change in Whitman's internal self perception is noted in the personal journals he kept, resulting in a dramatic drop in self esteem.

Damages to self esteem have been found to have lasting negative impacts on one's cognitive function. Cognitive functions such as memory, learning, and decision making have been found to be influenced by the level of one's self esteem; lower self esteems have been suggested to hinder these cognitive functions. In a memory-focused comparative, self-report study by Romero et al. (2014) participants with diagnosed with major depression (MDD) who reported low self esteem (n=39) were found to have impaired recall while performing memory tasks compared to non-depressed participants

who reported average levels of self esteem (n=40). During tasks pertaining to memorizing adjectives, participants with MDD scored significantly lower on recall suggesting a mediation based relationship between low self esteem and memory. Ferradas et al. (2019) demonstrated the impacts of self esteem on learning in a comparative study focusing on academic achievement, learning, and self esteem among university students (n=1,028). Among four different characterized groups developed through this study, students who reported low self esteem were also significantly more likely to report low learning levels and low academic achievement compared to their average and high self esteem-reported counterparts. Ferradas et al. (2019) suggests pessimism and self doubt, stemming from low self esteem, to hinder motivation and achievement, creating a cycling self-fulfilling prophecy. Following his discharge from the military, we observe Whitman's academic performance decline along with his motivation to continue in extracurriculars as well as a significant dip in self esteem. This negative self perception that Whitman develops spirals as he struggles with homicidal intrusive thoughts, building upon itself leading up to the day he attacked the University of Texas, Austin. The thought process and decision making behind it may have also been impacted by cognitive deficits. Self esteem in relation to decision making has been found to impact reward-based decision making, with low self esteem increasing the likelihood of a high risk, high possible reward decision. Ogasawara et al. (2020) exemplifies this in a reward based study using decision making tasks and correlating decision types to reported levels of self esteem. Participants who reported below the average or expected levels of self esteem were more likely to make decisions based on high reward, independent of possible risk factors suggesting increased impulsivity and a propensity towards bad decisions if the

perceived reward is high enough. In Whitman's case, the decision to attack UAT felt like the only viable decision, he also anticipated his own death, which was also perceived to be the only good decision he could make to solve his perceived life problems.

Locus of Control

Struggling to gain control over his own life, Whitman saw violence as the only feasible solution to free himself of this loss. The degree in which a person feels they have control over their own life can have a great influence on their behavior and self esteem. This perceptual concept, commonly referred to as locus of control (LOC), was first posited by Julian Rotter in 1966 and focused on a person's expected outcome to a situation based on personal experience and external factors (Rotter 1966) A scale measuring how much weight personal influence has over any given situation is used to determine locus of control in individuals. The level of LOC has been heavily correlated to self perception and self esteem; higher LOC has typically been shown to positively correlate with high self esteem. Tangney et al. (2008) demonstrates this correlation using self report methods and the LOC scale, finding that high LOC and high self esteem positively correlate, producing outcomes including higher GPAs, stronger self control, and decreased levels of psychiatric disorder among students. It can be inferred based on the characteristics strengthened by a high LOC that oppositional characteristics including low self esteem, increased chances of psychiatric disorders, and others, would be correlated with a low LOC.

Self esteem and emotional control and coping are vital factors that play into one's daily functioning and decision making, all of which influence and are influenced by locus

of control. In a sample of university students (n=418) Kurtović et al. (2018) found that among participants who completed self report scales measuring depression and anxiety, as well as the Rotter I-E scale, higher scores on the Rotter I-E scale correlated with lower scores of self reported depression and anxiety symptoms. In the long term, LOC has been found to continue to accurately predict and moderate symptoms of psychopathologies. In a long term, nine year study, Hovenkamp-Hermelink et al. (2019) examined the relationship between LOC, stability, and change, finding little change in participant's self report and Rotter I-E scale scores. Participants in this study who consistently experienced anxiety and depression displayed stable, unchanging LOC scores, with some changes occurring following major life events and periods of adjustment. Whitman's case exemplifies the results of a low LOC, in that, Whitman's journals describe a perceived loss of control over his life and own thoughts. Stress from school, homelife, and work as well as the burden of trauma and the biological changes experienced from the tumor later found on his amygdala, all of these factors play a part in significantly lower Whitman's LOC, thus lowering his self esteem and perceived self worth.

Those with a low locus of control run the risk of becoming vulnerable to adverse behavior as a result of pathologies or self esteem issues that may develop secondary to low LOC levels. LOC can serve as a moderator between emotions and behaviors, promoting positive emotions and behaviors when one has a high LOC. In a long term study by Yang et al. (2019) LOC among children was consistently measured through young adulthood and compared across the sample, taking into account factors such as childhood maltreatment, excluding sexual abuse, and depressive symptoms. It was found that mistreated children with low LOCs were significantly more likely than their non

abused counterparts to develop depressive symptoms into adolescence and adulthood. Low LOC in childhood stemming from mistreatment and abuse promoted externalized behaviors and later depressive symptoms including decreased social interaction and poor self image. External influences on LOC, such as peer groups and social settings, can greatly change perceived control; negatively perceived settings have been correlated with low LOC and an increased likelihood for one to act aggressively towards others. A comparative study by Schmidt et al. (2016) examined the relationship between male social groups, LOC, and the likelihood of a male to commit acts of interpersonal violence towards a partner. Men who scored low on the LOC scale and reported participating in negative social settings, described as settings that promote aggressive and provocative behaviors, were more likely than others to act violently towards an intimate partner. This study suggests an external influence on LOC and aggressive behavior from negative social settings such as delinquent peer groups or abusive settings. A key aspect of social learning theory, we see the influence of the examples set by others on the perceived sense of control over one's life, and how deficits in this area may result in adverse consequences, including the risk of harming others. Whitman's case demonstrates multiple settings in which a negative atmosphere, especially that of his home life, foster low LOC and perpetuate violence as a means of coping with that emotional dysregulation.

Conclusion

Charles Whitman's story serves as an ideal case to examine various causal factors when trying to understand why people commit violent crimes, such as mass murder as he did. His history of childhood abuse, predisposition towards violence, modeled aggressive behavior, and biological malfunction creates a positive feedback loop, eventually leading to the unfortunate shooting at the University of Austin Texas. Understanding the underlying causes of these crimes allows for better future prevention. There are inumerable accounts of child abuse, people with psychiatric disorders, and various cases of biological disfunction, and individual cases of disfunction often do not lead to mass murder. In Whitman's case, however, we observe the disruption of all of these major systems and functions, all of them feeding into each other, resulting in Whitman's loss of control and the unfortunate events that transpired at UAT.

The impacts of abuse on Whitman began before his birth as he felt the prenatal impacts of his mother's abuse. Changes in his fetal development including the sensitization of his stress response system and dysregulation of the central nervous system were only the start of his downfall. Changes in genetic expression, influenced prenatally, continued through childhood as he developed predisposing Whitman to aggressive tendencies, all of which are reinforced as his father models violent behavior. Whitman is taught from an early age to gain control and cope with emotions through violence. The witnessing and victimization of domestic abuse greatly increases Whitman's risk of developing psychiatric disorders later in life, a common outcome of

abuse survivors. From a very early age, even before birth, we observe various sources of dysfunction that only promote adverse outcomes for Whitman's future.

Maldevelopment that began at a young age progresses through his life as the sensitization and malfunction of Whitman's limbic system begin to have its own impacts. Sensitivity to stress, increased reactivity, and the beginnings of Whitman's own aggression towards others began to develop shortly after he joined the Marine Corps. Following a concussion sustained during a car accident, we see the full development of his aggression as well as the beginnings of his homicidal ideations. Remaining impacts from his childhood coupled with the disruption of his limbic system and a head injury only foster adverse behavior as the causes of dysfunction continue to build. Dopaminergic and hormonal irregularities that followed Whitman through his life are further exaggerated after the development of a tumor on his amygdala. At this point in Whitman's life, personal journals documenting homicidal ideations, chronic, severe stress, and low self esteem explain a self awareness that he holds about his thoughts and a concern for future behaviors.

With this self awareness, Whitman's choice to seek help landed him an amphetamine prescription, not necessarily a high enough dose to cause severe disruption, however the effects of this drug may have been the tipping point. Further disruption of the dopaminergic system and sensitization of the limbic system provoke an already highly at risk individual towards violent crime, especially Whitman who wrote about his personal struggles with homicidal ideation. As Whitman continues to spiral and his self esteem plummets, we see an even deeper loss of control over his own thoughts, eventually building up to a loss of his behavior.

Charles Whitman's case provides an opportunity to study the cause of violence from various viewpoints. The multiple layers of causation that built up to Whitman's crime can be individually studied and understood, however to understand the full capacity of the crime and to find an answer to the question, why?, all the individual parts need to be combined. His crime, a school shooting, is one that in present day, is unfortunately all too familiar. As these crimes continue to happen, the questions will continue and the assumption that only one area of a person's life is to blame may not provide adequate answers. Humans are complex, complicated beings, and the explanations for questionable behaviors are expected to be just as complex and complicated. Future cases can be informed by Whitman's case, and a multiple causation approach to future questions may be the appropriate answer.

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