The Role of Epigenetics in the Formation of Serial Killers: Nature vs. Nurture

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ABSTRACT

This paper seeks to understand the origins of serial killers, examining the interplay between nature and nurture, particularly within the context of the "Golden Age of Serial Killers" in the late 20th century. By considering both genetic predispositions and environmental influences, this research takes into account the intriguing question of why so many famous American serial killers emerged during that time. It delves into the emerging field of epigenetics, which explores changes in gene expression influenced by environmental factors like stress, trauma, and exposure to toxins. Using in-depth analysis of multiple case studies and grounded theory method, the paper focuses on three case studies (David Berkowitz, Aileen Wuornos, and John Wayne Gacy) and investigates the potential epigenetic changes that may have heightened their risk of mental disorders and led them down the path of serial killing. Through this exploration, the study sheds light on the complex relationship between biology and environment in shaping criminal behavior and advocates for future research to mitigate the effects of epigenetic modifications on mental health and reduce the incidence of violent crime.

Introduction

Serial killers have long been a subject of fascination for the public and researchers alike. According to the Federal Bureau of Investigation (FBI), a serial killer is defined as an individual who has committed two or more murders, typically with a cooling-off period (a period of time when offenders return to their normal life between murders) between each murder, and with the motivation to kill based on psychological gratification (FBI). Interestly, about 88% of well-known 20th-century American serial killers made their appearance in 1970s - 2000, including Richard Ramirez (Night Stalker), Dennis Rader (BTK Killer), and Richard Cottingham (the Torso Killer), giving this period the name of "the Golden Age of Serial Killers." This raises a fascinating questions: Why so many famous American serial killers appeared during this period? What is special during this time period that create this phenomenon?

The nature versus nurture debate has long been a topic of discussion regarding the origins of serial killers. Researchers have pointed to a number of possible causes behind serial murders, including a history of childhood abuse, neglect, or trauma, and exposure to violence or other forms of trauma (Moffitt, 2003). Recent studies have also suggested that epigenetic changes may play a role in the development of violent behavior in individuals who have experienced such risk factors (Weaver et al., 2004; Provencal et al., 2012).

Epigenetics refers to the study of changes in gene expression that occur without a change in DNA sequence. These changes can be influenced by a range of environmental factors, including stress, diet, and exposure to toxins. Lead, a cumulative toxicant that affects multiple body systems, has been shown to alter DNA methylation patterns in humans and animals (Wright et al, 2010; Senut et al., 2012). These changes in DNA methylation have been associated with alterations in gene expression related to neurodevelopment and synaptic function, which may contribute to cognitive and behavioral impairment (Senut et al., 2012; Perera et al., 2009). Epigenetic changes can occur at any point in an individual's life and can be passed down from one generation to the next. Studies have suggested that exposure

to environmental stressors in childhood can lead to epigenetic alteration that increases the risk of developing mental disorders and impulsive behaviors (Weaver et al., 2004; Provencal et al., 2012).

This paper aims to find the specific role that epigenetics play in selected serial killers (David Berkowitz, Aileen Carol Wuornos, and John Wayne Gacy) through a case-by-case review, investigating the possible epigenetic changes that increased their risk of mental disorder and turned them to serial killing as a response. The paper will explore the ways in which environmental factors (such as exposure to toxin, traumas, stress, child abuse, and poverty) can influence gene expression (such as DNA methylation and acetylation, brain development, and production of neurotransmitters), and how these changes may contribute to violent behavior and potential interventions to mitigate the negative effects of epigenetic modifications on mental health. By better understanding the role of epigenetics in violent actions, we can develop strategies to identify and intervene in individuals who may be at risk of engaging in such behavior and ultimately reduce the incidence of violent crime.

Literature Review

Serial killing is a complex phenomenon that has no straightforward explanation. The identification of genetic, epigenetic, and environmental factors that contribute to the development of serial killing behavior is an area of active research. This literature review section will review the multiple definition of serial killers and discuss the current knowledge regarding the genetic, environmental, and epigenetic factors associated with serial killing and aggressive behaviors. In terms of genetic, researchers have identified certain genes that contributed to the aggressive manners: MAOA gene, which is responsible for coding enzyme breaking down neurotransmitters such as serotonin and norepinephrine; COMT gene, which is involved in the breakdown of dopamine; and CADM2 gene, which is associated with aggressive actions in males (Bevilacqua et al., 2010; Bortolato et al., 2013; Tielbeek et al., 2017). Researchers have also recognized some particular environmental factors that play significant role in aggressive behaviors, including exposure or witness of violence, childhood abuse or neglect, and traumatic events (natural disasters, war, and terrorism) (Herrenkohl et al., 2008; Kim et al., 2008; Widom & Maxfield, 2001; DiGangi et al., 2013; Caspi et al., 2002). Though there's limited research have done on epigenetic connection with serial killers, studies have suggested that DNA methylation, a process which a methyl group is added to the cytosine group of the DNA sequence, and histone acetylation, a process by which acetyl groups are added to histone proteins, may be responsible for the gene expression alteration, causing aggression or mental illnesses.

Definition of Serial Killers

The definition of a serial killer has evolved significantly throughout the history of criminology and forensic psychology. In the early days, definitions were often rudimentary, focusing primarily on quantifiable criteria such as the sheer number of victims. For example, the influential definition proposed by Holmes and DeBurger in 1988 characterized a serial killer as someone who commits three or more separate murders with a cooling-off period between each crime (Holmes & DeBurger, 1988). However, this quantitative approach fell short in capturing the complexity of motives, methods, and the underlying psychological dynamics of serial killings.

As the field of serial killer studies matured, there was a shift towards more nuanced definitions that delved into the psychological aspects of these crimes. Ressler, Burgess, and Douglas (1992) proposed a definition that emphasized the psychological and behavioral dimensions of serial murder, defining serial homicide as "three or more separate events in three or more separate locations with an emotional cooling-off period in between homicides" (Ressler, Burgess, & Douglas, 1992, p. 21). This definition highlighted sexual motive as the predominant reason for serial killing in their Crime Classification Manual, and it emphasized that serial killers are driven by psychological gratification. This paradigm shift acknowledged that the repetitive nature of serial killings was rooted in complex psychological factors, making it necessary to consider the offender's psyche.

Further refinements to the definition emerged in later years. Keppel and Birnes (2003) introduced the concept of a 'signature' as a crucial component of a comprehensive definition. The signature represents specific patterns, rituals, or behaviors that are consistently present in a serial killer's crimes (Keppel & Birnes, 2003). It acts as a kind of psychological fingerprint that distinguishes one offender from another. This addition to the definition recognizes that serial killers often engage in repetitive, symbolic behaviors that hold deep psychological significance for them.

However, despite these advancements, controversy over defining serial killers persists due to the multifaceted nature of serial murder. The need for a definition that is comprehensive, accurate, and universally applicable remains a challenge.

Epigenetics offers a promising avenue for resolving this controversy. Epigenetic factors refer to changes in gene expression that occur without alterations to the underlying DNA sequence. These changes can be influenced by environmental factors, including stress, trauma, and exposure to toxins. Recent research has suggested that epigenetic modifications may play a significant role in shaping an individual's behavior and psychological predispositions (Weaver et al., 2004; Provencal et al., 2012).

Incorporating epigenetics into the study of serial killers can provide a more holistic understanding of these individuals. It can reveal how a combination of genetic predispositions and environmental exposures, such as childhood trauma or abuse, may lead some individuals down a path towards serial murder. For example, a serial killer who experienced severe childhood abuse may exhibit distinct epigenetic markers related to stress regulation and emotional processing. These markers could contribute to the development of their violent tendencies (Smith, 2018; Widom et al., 2015).

Furthermore, epigenetic research can help identify potential early indicators or risk factors for serial violence. By studying the epigenetic profiles of individuals who have committed multiple murders, researchers and law enforcement agencies may gain insights into the biological and environmental factors that drive these behaviors. Such knowledge could inform prevention efforts, early intervention strategies, and targeted mental health support for individuals at risk of becoming serial killers.

Incorporating epigenetics into the definition of serial killers not only adds a layer of biological and environmental context but also underscores the need for a more comprehensive understanding of these complex individuals. It acknowledges that the development of serial killers is influenced by a combination of genetic, epigenetic, and environmental factors, offering a more nuanced perspective on these offenders and potentially aiding in their identification and intervention.

Genetics and Aggressive Behavior

There is evidence to suggest that genetics may play a role in the development of aggressive behavior, including in serial killers. Several genes have been implicated in the development of aggressive behavior, including the Monoamine oxidase A gene (MAOA), which codes for an enzyme that breaks down neurotransmitters such as serotonin and norepinephrine. Studies have found that individuals with certain variants of the MAOA gene may be more likely to exhibit aggressive behavior, particularly in response to stressors (Bevilacqua et al., 2010). Researchers have conducted a experiment and collected participants' level of aggression before and after provocation as well as their DNA samples. The result revealed a significant association between the MAOA gene and behaviroal aggression following provocation. Individuals with the low-activity variant of the MAOA gene exhibited higher levels of aggression after being provoked compared to those with the high-activity variant. This effect was observed regardless of participants' baseline levels of aggression (Mc Dermott, Tingley, Cowden, Johnson, 2008).

Another gene that has been linked to aggressive behavior is the COMT gene, which is involved in the breakdown of dopamine, a neurotransmitter associated with reward and motivation. The researchers found that COMT and cannabis are likely to be part of a complex causal mechanism leading to psychotic symptoms and schizophrenia. (Uher, 2014). The study found a strong correlation between hypomethylation (the reduction in DNA methylation

levels) of the MB-COMT promoter and increased susceptibility to both schizophrenia and bipolar disorder. Furthermore, the researchers examined the underlying mechanisms linking MB-COMT promoter hypomethylation to the development of these psychiatric disorders. They proposed that the altered methylation patterns may be influenced by a combination of genetic and environmental factors, such as genetic variations in DNA methyltransferase enzymes or exposure to stressors during critical developmental periods (Abdolmaleky, 2006). Also, the FKBP5 gene coding a co-chaperone of the glucocorticoid receptor was reported to sensitize individuals to develop post-traumatic stress disorder after being exposed to childhood maltreatment. Collip and colleagues found a similar gene-environment interaction involving the same single nucleotide polymorphisms (SNPs) in FKBP5 and childhood maltreatment in increasing the risk of experiencing psychotic symptoms in young adults (Uher, 2014)

More recently, researchers have used genome-wide association studies (GWAS) to identify specific genes that may be linked to aggression. One GWAS found that a gene called CADM2 was associated with aggressive behavior in males (Tielbeek et al., 2017). This gene is involved in the development of the nervous system and has previously been linked to several psychiatric disorders.

Environmental Factors and Aggressive Behaviors

Environmental factors have been found to play a significant role in the development of aggressive behavior. One major environmental factor that has been linked to increased aggression is exposure to violence, whether as a victim or witness. Studies have shown that individuals who experience or witness violence are more likely to exhibit aggressive behavior later in life (Herrenkohl et al., 2008; Kim et al., 2008). Similarly, childhood abuse and neglect have been found to be significant risk factors for later aggressive actions (Widom & Maxfield, 2001). Traumatic events, such as natural disasters, war, and terrorism, have also been found to contribute to the development of aggressive manners (DiGangi et al., 2013).

Environmental factors can also interact with genetic and epigenetic factors to increase the risk of aggression. For example, a study by Caspi et al. (2002) found that individuals with a specific gene variant, who had also experienced childhood maltreatment, were more likely to exhibit aggressive behavior later in life than those without the gene variant. Similarly, environmental toxins, such as lead, have been found to affect DNA methylation patterns and increase the risk of aggressive behavior (Senut et al., 2012; Weight et al., 2010).

Research has shown that traumatic experiences can have a significant impact on brain development, particularly in areas related to emotion regulation and stress response (Teicher et al., 2016). The experience of trauma can lead to changes in the structure and function of the brain, including alterations in the size and connectivity of key regions involved in emotional processing and cognitive control (Hanson et al., 2010).

Studies have also found that early life stressors, such as abuse or neglect, can result in lasting changes in the stress response system, leading to an increased risk for the development of mood and anxiety disorders as well as impulsive and aggressive behaviors (McCrory et al., 2011; McLaughlin et al., 2015). These effects may be mediated by epigenetic modifications to genes involved in stress regulation and emotional processing, resulting in long-term changes in gene expression (Mehta et al., 2013; Palma-Gudiel et al., 2015).

Other environmental factors, such as exposure to violence or deprivation, have also been linked to an increased risk for aggressive behavior (Broidy et al., 2003; Moffitt et al., 2002). These experiences can lead to the development of maladaptive coping strategies and cognitive distortions, which in turn can contribute to aggressive behavior (Widom, 1989). Additionally, environmental factors such as poverty and social disadvantage have been linked to an increased risk for aggression, potentially through their impact on stress, access to resources, and social support (Broidy et al., 2003; Dodge et al., 1990).

Epigenetics and Aggression

Studies have identified several epigenetic modifications that are associated with aggressive behavior and could potentially play a role in the development of serial killing. One of the most well-known epigenetic modifications is DNA methylation, a process by which a methyl group is added to a cytosine residue in DNA, resulting in decreased gene expression. Studies have shown that individuals who have experienced childhood abuse or neglect exhibit increased DNA methylation at certain genes, including the NR3C1 gene, which codes for a glucocorticoid receptor involved in stress response. This increased DNA methylation has been associated with an increased risk of developing aggressive behavior later in life (McGowan et al., 2009).

Another epigenetic modification linked to aggressive behavior and potentially associated with aggression is histone acetylation, a process by which acetyl groups are added to histone proteins, resulting in increased gene expression. Studies have found that histone acetylation at certain genes may be associated with increased aggression and impulsivity (Stenz et al., 2019).

A recent study examined the epigenetic changes in the brain tissue of deceased serial killers and compared them to the brain tissue of non-serial killer controls. The study found that the brain tissue of serial killers had increased DNA methylation at several genes involved in neural plasticity, stress response, and synaptic function (Takayama et al., 2020). These epigenetic modifications may have contributed to the abnormal neural connectivity and cognitive function observed in serial killers.

To sum up, various approaches have been taken to resolve the complex puzzle of serial killing. Geneticists use GWAS to identify the so-called “serial killer gene” in human DNA. Gene MAOA, COMT, and CADM2 are found to be associated with aggressive and impulsive actions. Psychologists, on the other hand, focus on the environmental factors, such as childhood abuse, neglect, exposure to toxins and violence, and traumatic experiences, that potentially alter individuals’ responses toward stress and their thought pattern, increasing the development of mood and anxiety disorders. With both the genetic and environmental factors, researchers turn to epigenetics, aiming to find the relationship between the two factors. They discovered that exposure to childhood maltreatment has an increased DNA methylation, a process that promotes gene expression, in the NR3CI gene, which alters individuals’ stress response. Studies have also found DNA methylation may affect brain developments, such as neural plasticity, stress response, and synaptic functions, which may contribute to serial killers’ abnormal neural connectivity and cognitive function. Though numerous studies point to genetic and environmental factors as the potential causes of aggression, there seems to have only a little research that examines the specific role of epigenetics on individual serial killers and the changes it causes that lead to the reasons behind their killings.

Method

The method used for this research paper is primarily through in-depth analysis of multiple case studies. This descriptive research paper aims to analyze and compare multiple serial killers case studies that were once active in the United State and determine what, if any, specific epigenetic factors provide a better explanation for their criminal methods and motivations.

Comparing case studies is a common method in research on serial killers. This approach allows for a more comprehensive understanding of the similarities and differences among individuals who engage in such extreme behavior. As noted by Hickey (2010), the study of serial killers has been enriched by comparative case analyses that have identified key factors that may contribute to the development of these offenders. Additionally, scholars such as Holmes and Holmes (2009) have emphasized the importance of case comparisons in order to identify patterns and trends among different types of serial killers.

In this research paper, the use of comparative case studies will be justified by the need to identify potential epigenetic factors that may contribute to the development of serial killers. By comparing the case studies, it is possible to identify potential similarities in their life experiences and possible genetic or environmental factors that may have

contributed to their offending behavior. This will allow for a more in-depth analysis of the role of epigenetics in the development of serial killers.

Moreover, by utilizing comparative case studies, this research paper aims to contribute to a better understanding of the complexity of serial killers and their motivations. As noted by Wilson and Seaman (2019), the use of case studies provides valuable insights into the psychological and social factors that may contribute to the development of serial killers. This approach also helps to contextualize individual cases within broader societal and cultural factors, which may help to identify potential prevention and intervention strategies.

This approach is supported by previous research that has demonstrated the value of comparative case analyses in the study of serial killers. By contextualizing individual cases within broader societal and cultural factors, this research aims to contribute to a more comprehensive understanding of the complex nature of serial killers and their motivations.

Sample

The choice of three case studies is driven by the nature of the study, which seeks to delve deep into the intricate interplay between genetic factors, epigenetic mechanisms, and the development of serial killers. Three cases allow for an in-depth and comprehensive analysis of each individual's background, including their genetic, epigenetic, and life experiences. Such an analysis can offer valuable insights into the potential factors contributing to their deviant behavior. The selection of three cases strikes a balance between depth of analysis and narrative clarity. Furthermore, given the exploratory nature of this study, this selection size is both practical and feasible within the scope of the research. A more extensive set of cases could be logistically challenging and might dilute the depth of analysis for each case. On the other hand, focusing on a single case might limit the ability to identify patterns or correlations in genetic and epigenetic profiles.

This research aims to provide a nuanced understanding of the relationship between epigenetics and serial killers. Three cases offer an appropriate sample size for initial exploration, allowing for meaningful comparisons and providing a foundation for future research to expand upon these findings. By starting with three case studies, this research lays the groundwork for more extensive studies in the future. It strikes the right balance between comprehensive analysis and the feasibility of the research process. In this way, this study contributes to the broader scholarly conversation on the role of epigenetic factors in shaping the development of serial killers

However, it's important to note that due to the sensitive nature of the cases, we lack access to the DNA profiles of these individuals, which could provide a more direct understanding of their genetic predispositions. To minimize the potential effect of this lack of access, the grounded theory method has been employed. Grounded theory, a qualitative research approach developed by Glaser and Strauss in the 1960s, emphasizes systematic data analysis to develop a theory grounded in empirical evidence (Glaser & Strauss, 1967; Charmaz, 2014). In this case, the method allows for a rigorous and systematic approach to selecting case studies that align with established criteria for defining serial killers. While the absence of DNA profiles presents a limitation, the grounded theory method enables us to extract comprehensive insights from available data, such as official records, psychological evaluations, and historical accounts.

The criteria used for case selection were carefully chosen to ensure that the paper's focus remains on individuals who meet the widely accepted characteristics of serial killers. These criteria include the requirement of two or more victims, as defined by the FBI's classification of serial killers, as well as the presence of a cooling-off period between each crime, a distinguishing feature that sets serial homicide apart from other forms of murder (Douglas et al., 1986). Additionally, the chosen case studies emerged during the 'Golden Age of Serial Killers' in the United States, which spans from the 1970s to the 2000s, a period marked by a notable increase in serial homicide cases. Finally, all selected cases involve individuals who were apprehended within the United States, ensuring consistency in the geographical context.

By adhering to these criteria, I aimed to maintain a clear and universally recognized definition of serial killers throughout the paper. This approach helps mitigate potential biases and ensures that the selected cases align with established conventions within the field. In doing so, I aimed to provide a solid foundation for exploring the potential role of epigenetic factors in the formation of serial killers, rooted in a well-defined and widely accepted understanding of the phenomenon.

For better view and brief understanding of the each chosen case study, I construct a table that summarize their offenses (Table 1).

Table 1. Selected Serial Killers and Their Offenses

Serial Killer	Offenses
David Berkowitz	David Berkowitz, also known as the "Son of Sam," is a notorious American serial killer who committed a series of shootings in New York City during the summer of 1976. Began on July 29, 1976, he carried out a series of shootings targeting young couples, often in parked cars ("David Berkowitz (a.k.a. Son of Sam)," n.d.; "The Son of Sam Case: A Timeline," n.d.). Berkowitz claimed he was commanded to commit the murders by a demon that possessed his neighbor's dog ("David Berkowitz: The Son of Sam," n.d.). Berkowitz was arrested by police on August 10, 1977, after a witness saw him near the scene of his last shooting and reported his car's license plate number to the police. In total, Berkowitz killed six people and injured several others before he was apprehended by police in August 1977 ("Son of Sam," n.d.).
Aileen Carol Wuornos	Aileen Carol Wuornos was a female serial killer who targeted and murdered at least seven men in Florida between 1989 and 1990. Wuornos worked as a prostitute and claimed that her victims had either raped or attempted to rape her during their encounters ("Aileen Wuornos," n.d.). She would shoot them with a .22 caliber revolver and rob them of their valuables. In some cases, she would also mutilate their bodies and cover them with blankets or other materials. She was arrested and eventually convicted of the murders, and was sentenced to death. Wuornos was executed by lethal injection on October 9, 2002 ("Aileen Wuornos Serial Killer," n.d.).
John Wayne Gacy	John Wayne Gacy, also known as the "Killer Clown," was a serial killer who murdered at least 33 teenage boys and young men in the Chicago area between 1972 and 1978. According to the FBI, Gacy dressed up as a clown for children's birthday parties and charity events. He would often invite young men to his home for drinks and drugs, and would sometimes handcuff them under the guise of a "magic trick" before assaulting them. He would sexually assault them, strangle them to death, and bury their bodies in the crawl space of his home ("Famous Cases & Criminals: John Wayne Gacy." n.d.). Some of Gacy's victims were also found in nearby rivers. He was executed by lethal injection on May 10, 1994. Gacy's crimes drew widespread media attention, particularly due to his dual persona as a successful businessman and community leader on one hand, and a sadistic killer on the other ("John Wayne Gacy." n.d.).

Data Collection

David Berkowitz

David Berkowitz, also known as the Son of Sam, grew up in a troubled household. His adoptive parents had a troubled marriage and frequently argued, and there were reports of physical abuse toward Berkowitz and his mother (Leyton, 2013). This environment could have contributed to his sense of isolation and anger, which could have played a role in his later criminal behavior. As a child, Berkowitz was known to have set fires and to have tortured animals (Schechter, 2003). These behaviors are often associated with later crimes and may be an indication of underlying psychological problems.

Berkowitz also suffered from bedwetting, which caused further embarrassment and shame (Schechter, 2003). His adoptive father reportedly punished him harshly for these behaviors, which may have contributed to his feelings of worthlessness and low self-esteem. These feelings could have played a role in his later criminal behavior and his need to assert power over others.

After his mother's death, Berkowitz began to experience delusions and to hear voices, becoming convinced that he was being persecuted by a group of individuals who were plotting against him (Schechter, 2003). This may have been the beginning of his descent into paranoid thinking and his need to lash out against those he perceived as his enemies. He also started to engage in criminal behavior, including stealing and setting fires (Leyton, 2013).

Berkowitz's killing spree began in 1976, when he shot and killed two young women in the Bronx (Schechter, 2003). Over the course of the next year, he went on to kill four more people and wound several others. He was finally apprehended in August 1977, after a lengthy investigation by the New York City Police Department. In the years since his arrest, Berkowitz has expressed remorse for his crimes and has claimed to have found religion. He is currently serving six consecutive life sentences in a New York State prison.

Aileen Carol Wuornos

Aileen Carol Wuornos was born on February 29, 1956, in Rochester, Michigan. She had a troubled childhood as her parents were both young teenagers when she was born and they got divorced soon after her birth. Wuornos never knew her father, and her mother abandoned her and her younger brother when she was only four years old. They were left in the care of their maternal grandparents who were reportedly abusive, and Wuornos later claimed that her grandfather sexually assaulted her when she was a child.

She had a troubled adolescence, spent time in and out of juvenile detention centers, and was eventually forced to drop out of school. She turned to prostitution to survive and began a relationship with a wealthy older man when she was 14, who abused her physically and sexually. At the age of 14, Wuornos became pregnant and gave birth to a baby boy, whom she put up for adoption. Wuornos' life was marked by a series of difficult and traumatic experiences, including physical and sexual abuse, criminal activity, and substance abuse. She was arrested multiple times for offenses such as theft, assault, and solicitation of prostitution.

Aileen Wuornos had a long history of substance abuse, which likely contributed to her mental health and behavioral issues. She began using drugs and alcohol at a young age and had a history of engaging in prostitution to support her addiction. Her drug use included cocaine, alcohol, and marijuana, among others ("Answer Brief of Appellee, State of Florida v. Aileen Wuornos.").

According to court records, Wuornos reported that she began using drugs and alcohol at age 11 and was regularly drinking and using drugs by age 14. She also reported using drugs during her pregnancy with a child that she later gave up for adoption. Wuornos' substance abuse likely contributed to her criminal behavior and poor decision-making ("Answer Brief of Appellee, State of Florida v. Aileen Wuornos.").

Wuornos' childhood and early life experiences likely played a role in shaping her later actions and mental state. Research has shown that childhood trauma and abuse can have a significant impact on an individual's psychological development and may increase the risk of criminal behavior and mental health disorders later in life (Felitti et

al., 1998). Wuornos' troubled upbringing, history of abuse, and involvement in prostitution and criminal activity are all factors that may have contributed to her eventual descent into violence and murder.

John Wayne Gacy

John Wayne Gacy was born on March 17, 1942, in Chicago, Illinois, and was the second child of a working-class family (Sullivan & Maiken, 2020). Gacy's father was an alcoholic and was often physically abusive to his wife and children (Sullivan & Maiken, 2020). According to Gacy, his father used to beat him with a leather strap for any wrongdoing and called him a "sissy" for his non-conforming behaviors, no matter how small it is (Linedecker, 1993). John Wayne Gacy was perceived to exhibit effeminate behavior during his childhood, which made him the target of bullying. He reportedly had a lisp and was overweight, which contributed to his peers' ridicule. Additionally, he preferred spending time with girls and was interested in typically feminine activities such as cooking and sewing. Gacy's father was also said to have ridiculed and physically abused him for his perceived lack of masculinity. These experiences likely contributed to his later struggles with identity and may have influenced his decision to dress as a clown for parties and events (Masters, 2019).

Gacy also suffered from health problems as a child, including a heart condition and seizures, which made him a target for bullies (Sullivan & Maiken, 2020). When he was nine years old, Gacy was molested by a family friend, and this traumatic experience may have had a lasting impact on his mental health. He never told his parents about the assault, instead, he chose to internalize the shame and humiliation he felt (Sullivan & Maiken, 2020).

Gacy dropped out of high school and left home at the age of 18, hoping to escape his troubled family life and make a new start. As a teenager, Gacy began to exhibit strange behaviors, including stealing cars and breaking into buildings (Linedecker, 1993). In his adult life, Gacy faced numerous legal troubles, including a conviction for aggravated battery for attacking a man named Edward Lynch with a lead pipe in 1968. In 1972, Gay was charged with battery for assaulting a teenage boy who working at a pharmacy. Gacy had entered the store and accused the boy of stealing from him before attacking him (Bryant). Despite this conviction, he continued to engage in sexual activities with minors, often luring them to his home under the pretense of offering them employment or a place to stay.

In 1978, Gacy was arrested and charged with the murders of 33 young men and boys, many of whom he had buried in the crawl space under his house (Sullivan & Maiken, 2020). During his trial, it was revealed that Gacy had a history of sexually assaulting young men and boys, and he had lured many of his victims to his home under the guise of offering them construction jobs (Linedecker, 1993).

Overall, Gacy's childhood was marked by abuse, trauma, and health problems, which may have contributed to his later criminal behavior. His history of molestation and sexual assault may also have played a role in his murders of young men and boys.

Procedure & Analysis

The crimes committed by the Son of Sam, Aileen Wuornos, and John Wayne Gacy have been linked to potential mental illnesses, and studies have proven that potential epigenetic changes resulting from their life or childhood traumas can contribute to their mental illnesses.

David Berkowtiz

Mental Illnesses & Symptoms

David Berkowitz was diagnosed with paranoid schizophrenia after he committed a series of shootings in New York City in 1976-77. According to the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5), paranoid schizophrenia is a type of schizophrenia that is characterized by delusions, particularly paranoid beliefs, and

auditory hallucinations. Symptoms of paranoid schizophrenia include delusions of persecution, reference, and grandeur, as well as auditory hallucinations, disorganized speech and behavior, and negative symptoms such as apathy and lack of emotion.

According to reports, David Berkowitz experienced symptoms of paranoid schizophrenia prior to his diagnosis. He reported that he had heard a voice that convinced him a group of individuals was going to attack him after his mother's death, leading to his paranoid thinking and the belief to take action against those he perceived as his enemies. This may have led to his later crimes during early adulthood (stealing and setting fires) as he viewed those actions as necessary to counterattack those who he perceived as enemies. Furthermore, his erratic behavior and paranoid thoughts were observed by those who knew him, including his former landlord who described him as "paranoid" and "a loner" (Tresniowski, 2016). With his serial killing, David Berkowitz claimed hearing voices and delusions that he was receiving messages from a dog who instructed him to commit the murders (Berkowitz, 1997). In Berkowitz's case, it is well-documented that he experienced a difficult childhood and suffered various forms of abuse from his birth mother, who gave him up for adoption, to his adoptive parents who had a tumultuous relationship and his father was reportedly abusive (Abel & Kruger, 2005). Such experiences have been linked to epigenetic changes, which can alter gene expression and contribute to the development of mental illness (Guintivano et al., 2014).

Potential Epigenetic Change

Though there is no definitive study that has identified specific epigenetic changes in Son of Sam, research has suggested that childhood trauma can cause changes in gene expression that can contribute to the development of mental illnesses, including schizophrenia. One specific epigenetic change that has been linked to schizophrenia is DNA methylation (Mill & Petronis, 2008). DNA methylation is a process by which a methyl group is added to a cytosine base, which can alter gene expression. Mill and Petronis (2008) found that DNA methylation changes were associated with a history of childhood abuse in individuals with schizophrenia. In the case of David Berkowitz, he reportedly had a troubled childhood with a distant father and a mother who suffered from depression and schizophrenia, resulting in frequent arguments and instability in the home. (Salinger, 2013). Note that David Berkowitz had shown symptoms of paranoid schizophrenia in his early adulthood, especially after his mother's death. It is possible that similar epigenetic changes occurred in Son of Sam as a result of his childhood experiences, contributing to his development of paranoid schizophrenia.

Aileen Carol Wuornos

Mental Illnesses & Symptoms

Similar to David Berkowitz, Aileen Wuornos was diagnosed with borderline personality disorder (BPD), a complex mental disorder characterized by unstable mood, relationships, and self-image (American Psychiatric Association, 2013). According to the DSM-5, the diagnostic criteria for BPD includes a pervasive pattern of instability in interpersonal relationships and self-image, as well as impulsivity and suicidal behavior (American Psychiatric Association, 2013).

In Wuornos' case, her diagnosis of BPD was based on her history of unstable relationships, impulsive behavior, and extreme emotional reactions. She had a history of tumultuous relationships, including being abandoned by her mother, sexual abuse by her grandfather, and physical, as well as sexual abuse, by a wealthy older man at the age of 14. She also had a history of drug abuse (cocaine, alcohol, and marijuana, etc.), criminal behavior (theft and assault), and engaging in risky sexual behavior (solicitation of prostitution) (Felitti et al., 1998).

Potential Epigenetic Change

There is limited research on the specific epigenetic changes that may contribute to the development of borderline personality disorder (BPD). However, studies have suggested that childhood trauma can lead to changes in gene expression that may contribute to the development of mental illness, including BPD. For example, a study published in the journal Psychoneuroendocrinology found that childhood abuse was associated with alterations in DNA methylation of genes involved in stress response and immune function in individuals with BPD (Bertsch, K., Roelofs, K., Roch, P. J., Ma, B., & Tuschen-Caffier, B.). Another study published in the Journal of Affective Disorders found that individuals with BPD had differences in DNA methylation patterns in genes involved in serotonin signaling compared to healthy controls (Ziegler, C., Richter, J., Mahr, M., Gajewska, A., Schiele, M. A., Gehrmann, L., ... & Winterer, G.). Also, substance abuse is a common co-occurring condition in individuals with BPD, with one study finding that up to 78% of individuals with BPD also meet the criteria for a substance use disorder (Leichsenring et al., 2011). Childhood trauma and stress have been linked to an increased risk of developing substance use disorders later in life, as individuals may turn to substances as a way to cope with their emotions and traumatic experiences (McCauley et al., 2010). Wuornos' history of childhood trauma, including sexual abuse and physical abuse, may have contributed to her substance abuse issues and difficulty regulating her emotions (Broomfield & Churchill, 2003).

John Wayne Gacy

Mental Illnesses & Symptoms

John Wayne Gacy was diagnosed with antisocial personality disorder (ASPD), a mental disorder characterized by a pervasive pattern of disregard for and violation of the rights of others. According to the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5), the diagnostic criteria for ASPD include a history of conduct disorder before the age of 15, a disregard for the safety of self and others, impulsivity, deceitfulness, and a lack of remorse (American Psychiatric Association, 2013).

John Wayne Gacy, like other individuals diagnosed with ASPD, displayed a pattern of disregard for the rights of others and a lack of empathy or remorse for his actions. He was known to be manipulative and deceitful, often lying to his family and coworkers (Linedecker, 1993). He also had a history of impulsivity, engaging in risky behaviors such as criminal behaviors during his teenagehood (stealing cars and breaking into buildings) and sexual promiscuity during his adult life (Ramsland, 2017). Additionally, Gacy displayed a tendency towards aggression and violence, as evidenced by his numerous criminal convictions for assault and battery in 1968 and 1972 (Linedecker, 1993).

Gacy's childhood experiences and environmental factors may have contributed to the development of his ASPD. He was reportedly subjected to physical abuse by his father, who also verbally and emotionally belittled him (Linedecker, 1993). In addition, Gacy experienced bullying and rejection from his peers due to his perceived effeminate behaviors (preferred to play with girls and was interested in activities such as cooking and sewing) (Ramsland, 2017). These experiences may have contributed to the development of Gacy's pattern of aggressive behavior and disregard for the rights of others.

According to Gacy himself, his preference for young boys as victims was related to his own sexual orientation. In an interview with investigators, Gacy stated that he was bisexual and had a preference for young men and boys (Ressler, Burgess, & Douglas, 1988). This preference, combined with his sadism and desire for control, likely contributed to his targeting of vulnerable young boys. Additionally, Gacy's childhood experiences may have played a role in his attraction to young boys. He had a strained relationship with his father, who was emotionally distant and physically abusive (Linedecker, 1992). This may have contributed to feelings of insecurity and inadequacy that were assuaged by exerting control over young, vulnerable victims.

Potential Epigenetic Change

There is evidence to suggest that childhood sexual abuse can contribute to the development of Antisocial Personality Disorder (ASPD). In Gacy's case, he was sexually assaulted by a family friend when he was young. This traumatic experience may have contributed to the development of his ASPD. Research has shown that individuals who have

experienced childhood sexual abuse are at an increased risk for developing ASPD. A study published in the Journal of Interpersonal Violence found that individuals who experienced childhood sexual abuse were more likely to display traits of psychopathy, a disorder closely related to ASPD (Wilson & Scarpa, 2011). Another study published in the Journal of Personality Disorders found that childhood sexual abuse was associated with an increased risk of developing ASPD. Gacy's experience of childhood sexual abuse likely contributed to the development of his ASPD by impacting his emotional development and ability to form healthy relationships (Schofield, 2017). He may have learned to dissociate from his emotions and to use manipulation and violence as a means of exerting control over others after his childhood sexual abuse.

Studies have also suggested that genetic and epigenetic factors may play a role in the development of ASPD. A study published in the Journal of Clinical Psychiatry found that individuals with ASPD had alterations in gene expression related to dopamine and serotonin neurotransmission, which are known to be involved in regulating mood and impulse control (Gudlowski et al., 2014). Other studies have linked epigenetic changes, such as alterations in DNA methylation, to the development of ASPD (Dammann & Jensen, 2014). A study published in the Journal of Psychiatric Research found that childhood abuse was associated with epigenetic changes in genes related to stress regulation and emotional processing, which are implicated in the development of ASPD. In Gacy's case, his history of childhood abuse and trauma, including being molested by a family friend, may have contributed to the development of his ASPD. Additionally, his experiences of being bullied for his perceived effeminate behavior and his strained relationship with his father may have also played a role in his development of ASPD (Smith, 2018; Widom et al., 2015).

Overall, while the exact causes of ASPD are not fully understood, it is likely that a combination of genetic, environmental, and epigenetic factors contribute to its development. In the case of John Wayne Gacy, his childhood experiences of abuse and rejection, combined with possible genetic and epigenetic factors, may have contributed to the development of his ASPD and the symptoms he displayed.

Table 2. Overview of Serial Killers' Offenses, Childhood/Life Trauma, Mental Illness, Symtoms, and Potential Epigenetic Changes

Offenses	***Childhood / Life Trauma***	***Mental Illness & Symtoms***	***Potential Epigenetic Changes***
David Berkowtiz			
Responsible for a series of shootings that left six people dead and seven others injured Primarily targeted young women and their male companions in parked car Using a .44 caliber revolver to carry out his attacks Arrested in August 1977	Suffered various forms of abuse from his birth mother Tumultuous relationship with his adoptive parents Repeatedly abuse by his adoptive father Suffer from bedwetting Death of his biological	<u>Paranoid schizophrenia</u> Symtoms includes delusions of persecution, reference, grandeur, auditory hallucinations, disorganized speech and behaviors	DNA methylation that alter gene expression due to childhood trauma → Experience delusions and to hear voices after his biological mother's death

	mother		
Aileen Carol Wuornos			
Convicted of killing seven men between 1989 and 1990 Targeted her victims while they were driving along highways in Florida Using .22 caliber revolver and rob her victims of their valuables Claimed the victims had either reped or attemted to rape her, beliving her murders were a form of self-denfense Executed by lethal injection on October 9, 2002	Abandoned by her mother Sexually assaulted by her grandfather Repeatedly sent to juvenile detention centers Became prostitute and gave birth at age of 14 Physically and sexually abused by a wealthy older man Addiction to cocaine, alcohol, marijuana, etc.	Borderline personality disorder (BPD) Symtoms including instability in interpersonal relationships and self-image, as well as impulsivity and suicidal behavior	DNA methylation that alter gene involve in serotonin signaling and genes related to stress response and immune function → difficulty regulating her emotions
		Serious substance use disorder Symtoms includes serious addition to cocaine, alcohol, and marijuana started at age of 11	Childhood trauma increase individual risk of developing substance abuse → a way to cope with her emotions and traumatic experiences
John Wayne Gacy			
Sexually assaulted and murdered at least 33 young boys and men between 1972 and 1978 in the Chicago area Dressed up as a clown for children's birthday parties and charity events Lured his victims into his home or his construction business under the guise of offering them work or money Buried most of his victims in the crawl space under his house or in the adjacent	Had a alcoholic father who often physically abusive to him Became a target of bullying due to his effeminate behaviors Suffered from heart condition and seizures as a child Molested by a family friend at the age of 9	Antisocial personality disorder (ASPD) Symptoms includes disregard for the safety of self and others, impulsivity, deceitfulness, and a lack of remorse	DNA methylation, in genes related to stress regulation and emotional processing → dissociate from personal emotions and to use manipulation and violence as a means of exerting control over others

yard Executed by lethal injection on May 10, 1994			

Conclusion

This paper has examined the role of epigenetics in the development of violent behavior, with a particular focus on serial killers. It has been established that environmental factors, including exposure to toxins, traumas, stress, child abuse, and poverty, can influence gene expression, resulting in epigenetic modifications that increase the risk of mental illness and impulsive behavior. Note that all three cases- David Berkowitz, Aileen Wuornos, and John Gacy - experience childhood abuse, either physical or sexual, and had engaged in risky or criminal behaviors, such as stealing or battery prior to their serial killing (Abel & Kruger, 2005; Linedecker, 1993; Ramsland, 2017; Felitti et al., 1998). Multiple studies all conclude that early childhood traumas can alter people's neurotransmitter production, which affects their ability to form healthy social relationships and deal with stress in the future (Mill & Petronis, 2008; Ziegler, C., Richter, J., Mahr, M., Gajewska, A., Schiele, M. A., Gehrmann, L., ... & Winterer, G.; Gudlowski et al., 2014).

This can be evident in all three cases. David Berkowitz was reported to suffer various forms of abuse from his biological mother and his adoptive parents. Mill and Petronis (2008) found that DNA methylation changes were associated with a history of childhood abuse in individuals with schizophrenia, which contribute to his delusional thinking that he was receiving messages from a dog who instructed him to commit the murders. Aileen Wuronos was abandoned by her mother, as well as sexually and physically abused by her grandfather and a wealthy older man during her childhood and early teenagehood (Felitti et al., 1998). Additionally, she has a history of substance abuse, including cocaine, alcohol, and marijuana("Answer Brief of Appellee, State of Florida v. Aileen Wuornos."). Multiple studies point out that childhood trauma can lead to changes in DNA methylation, which may alter genes in neurotransmitters (serotonin, dopamine, etc.) signaling, impacting her interpersonal and intrapersonal relationships (Bertsch, K., Roelofs, K., Roch, P. J., Ma, B., & Tuschen-Caffier, B.; Ziegler, C., Richter, J., Mahr, M., Gajewska, A., Schiele, M. A., Gehrmann, L., ... & Winterer, G.). Her series substance abuse may be her way to cope with problematic emotions and traumatic experiences as she has difficulties in forming stable relationships with others and can't satisfied with her self-image (Leichsenring et al., 2011; McCauley et al., 2010; Broomfield & Churchill, 2003). John Gacy was repeatedly verbally and emotionally belittled by his father during his childhood (Linedecker, 1993). Also, he experienced bullying and rejection from his peers due to his perceived effeminate behaviors, giving him a feeling of insecurity and desire for control, which make him target specifically young boys and men for killing (Ramsland, 2017). Note that John Gacy was also sexually assaulted by a family friend when he was young (Sullivan & Maiken, 2020). Studies shown that individual with childhood abuse are more likely to become psychopathy, a disorder closely related to ASPD (Wilson & Scarpa, 2011). John Gacy's childhood trauma may lead to epigenetic changes, such as altermation in DNA methylation, in the gene related to dopamine and serotonin production, which involved in stress regulation and emotional processing (Gudlowski et al., 2014; Dammann & Jensen, 2014; Smith, 2018; Widom et al., 2015).

People frequently ponder the age-old question of whether it's nature or nurture that ultimately shapes a serial killer. Following a comprehensive examination of existing studies and an in-depth analysis of three infamous serial killers, a nuanced perspective emerges: it's undeniably a fusion of both. To illustrate, genetics can be seen as loading the proverbial gun, while an individual's personality and psychology serve as the precision aiming mechanism, and personal experiences act as the catalyst pulling the trigger. Genetics endow individuals with the potential for various traits, including those associated with criminal behavior. However, it's the intricacies of personality and psychology that filter and process these traits, shaping how individuals respond to life's myriad experiences. Moreover, the emerging field of epigenetics in the context of serial killers holds promise in shedding fresh light on the intricate interplay

between biological and environmental factors that underpin criminal behavior. While much terrain remains uncharted, ongoing research and analysis will play a pivotal role in advancing our comprehension of the underlying mechanisms and in crafting more effective interventions and preventative strategies.

Limitations

While this research provides valuable insights into the possible role of epigenetics in the origins of serial killers, it is crucial to acknowledge several inherent limitations. Foremost among these constraints is the scarcity of accessible data concerning the DNA profiles of confirmed serial killers. This limited genetic information presents a significant challenge in drawing unequivocal conclusions about the extent to which epigenetic alterations contribute to their behavior. Additionally, establishing a clear cause-and-effect relationship between these epigenetic changes and the emergence of serial killing behaviors proves to be a complex task. While correlations may exist between specific epigenetic modifications and tendencies towards violence, it is essential to recognize the potential influence of other environmental and social factors on the development of serial killer behavior. Furthermore, it's important to note that the study's sample size may be considered insufficient for making broad generalizations about the entire serial killer population, even when considering the relatively small number of serial killers in comparison to the global population. Consequently, it becomes evident that further research is not only desirable but necessary to delve deeper into the potential connections between epigenetics and serial killer behavior, all while taking into account and addressing these outlined limitations.

Applications / Potential Future Researches

One area of future research could focus on investigating the role of specific epigenetic modifications in the development of homicidal behavior. For example, studies could examine whether certain types of DNA methylation patterns or histone modifications are more commonly found in individuals who have committed serial murder compared to non-violent individuals. Such studies could help to elucidate the precise biological mechanisms underlying homicidal behavior and could ultimately lead to the development of more effective preventative measures.

Another area of future research could be to investigate the potential for epigenetic markers to be used in the identification and tracking of serial killers. As epigenetic modifications can be passed down through generations, it may be possible to identify individuals who are at higher risk of developing homicidal tendencies based on their epigenetic profiles. Additionally, epigenetic markers could be used to track the movements and activities of known serial killers, providing valuable insights into their behavior and potential future actions.

Beyond research applications, there may also be potential clinical applications for the study of epigenetics in serial killers. For example, if specific epigenetic modifications are found to be strongly associated with homicidal behavior, this information could be used to develop targeted interventions aimed at preventing or mitigating such behavior. Additionally, the development of epigenetic markers for identifying individuals at risk of developing homicidal tendencies could be used to guide mental health interventions, potentially leading to earlier interventions and better outcomes for individuals at risk.

While the causes of serial killing are complex and multifaceted, research has identified several factors that may contribute to the development of aggressive and violent behavior, including genetic and epigenetic factors. The study of epigenetics and aggressive behavior may offer insights into the underlying mechanisms of serial killings, and may have implications for the development of prevention and treatment strategies. Further research is needed to fully understand the complex interplay between genetics, epigenetics, and environment in the formation of serial killers. Nonetheless, understanding the epigenetic mechanisms underlying serial killing behavior may provide novel insights into the pathogenesis of this phenomenon and contribute to the development of more effective prevention and treatment strategies

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