



Understanding Aggressive Behaviour in Criminals and interventions to overcome aggressive behaviour.

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Abstract

Aggressive behaviour in criminals is not a uniform trait but a complex variety of behaviours influenced by cognitive, neurological, and environmental factors. This paper presents a literature review examining the nature, origins, and treatments of aggression in criminal offenders. Aggression can be classified by trigger (reactive or proactive), form (overt or covert), and function (adaptive, maladaptive, and displaced), along with models such as the Quadripartite Violence Typology. Neuroimaging research has found that criminal populations show structural brain differences, specifically in the front lobe, orbitofrontal cortex, and amygdala. However, these abnormalities differ significantly by offender subtype, with psychopathic criminals showing the most pronounced deviations. These structural vulnerabilities interact with chemical, hormonal, and genetic factors, alongside early biosocial hazards, childhood abuse, socioeconomic conditions, and cognitive distortions, increasing the likelihood of aggressive behaviour, following a cumulative "chain of risk" model. In the final section, the paper discusses rehabilitation approaches, and it has been found that cognitive behavioural therapy emerges as the most effective and empirically supported intervention for reducing recidivism. Other mindfulness-based practices and neuroscience-based interventions such as neurofeedback and deep brain stimulation have been promising but raise ethical and legal concerns. Overall, the findings propose a biopsychosocial understanding of aggression in criminals, where biological vulnerabilities are catalysed by environmental and psychological factors. In addition, the findings highlight the need for individualized, evidence-based rehabilitation strategies over one-size-fits-all approaches.

Keywords: Criminal behaviour, aggression, reactive and proactive aggression, Antisocial Personality Disorder (ASPD), psychopathy, prefrontal cortex, orbitofrontal cortex, amygdala, neurocriminology, biopsychosocial model, cognitive behavioural therapy (CBT), recidivism.

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I. Introduction

Thoughts are like threads on the fabric of mind. Our behaviour is governed by thoughts. The only difference between a criminal and normal person is the specific way in which they process their thoughts. This processing is governed by brain and external factors. In this study, by way of literature survey I have tried to explore some reason behind aggressive behaviour in criminals.

What is Aggression?

Aggressive behaviour is a hostile physical or verbal behaviour which is intended to cause harm to others. Scientific literature demonstrates that aggression is not a single, uniform trait, but exists as a complex variety of behaviors.

Types of aggressions

Aggression can be categorised into various types based on

- How it is triggered
- How it is expressed (form and visibility)
- Level of emotional involvement
- Intent
- Outcome

Types of aggression based on how it is triggered

Reactive aggression - also known as hostile, affective, defensive, or angry aggression - is described as 'hot-blooded', impulsive aggression often involving negative emotional states such as embarrassment, anger,

humiliation, and shame (8, 10, 12, 15, 19, 21, 23). It appears as spontaneous and unplanned aggressive behaviors with no identifiable goal, that are responses to frustration, provocation, or perceived threats, and are often inordinate to the provocation (5, 8, 10, 11, 12, 20). It is linked to the central nervous system and autonomic nervous system arousal (9, 10, 12, 21). The autonomic nervous system controls involuntary physiological processes such as heart rate, blood pressure, respiration, digestion, and sexual arousal. Moreover, it triggers the acute threat response system in the brain - which includes brain areas like the amygdala, hypothalamus, locus coeruleus, hippocampus, prefrontal cortex - especially when caused by anger (8, 10). Examples of reactive aggression include losing temper, physical retaliation, interpersonal outbursts, or overreacting in an argument (8, 12).

Proactive aggression - often referred to as premeditated, instrumental, cold, predatory, or offensive aggression - is deliberate, controlled, conscious, and carefully planned aggressive behavior that is not spontaneous in nature, and not linked to an affective state or heightened emotional arousal (5, 8, 10, 11, 12, 19, 20, 21, 23). It is motivated by a desire to attain a larger goal, typically a reward or advantage to the aggressor, and the harm caused to the victim simply serves as a means of attaining that goal (8, 10, 11, 12, 19, 21). Unlike reactive aggression, this type occurs unprovoked, without acute anger (10, 20, 21). Based on social learning theory, (Bandura, 1978), it is defined as "cold-blooded", controlled and deliberate aggression resulting in personal rewards such as higher social status and positive affiliation (10, 15).

Types of aggression based on form and visibility

This type of aggression is based on how the aggression and harm is delivered (10, 14, 19).

1. Overt Aggression (Direct delivery of harm)

In this type of aggression there is an effect that is directly seen. This can be categorised into the following three types:

(i) **Physical overt aggression** is a type of overt aggression, which harms another person physically, through actions such as punching, kicking, stabbing, or shooting (7, 19, 22). Direct aggression is a type of overt aggression that is often synonymous with physical aggression, where an individual is put at "an immediate competitive disadvantage, by physically injuring them" (19, 22).

(ii) **Verbal overt aggression** is a form where words are used to harm others through acts such as swearing, name-calling, or shouting (19).

(iii) **Nonverbal Overt aggression/postural aggression** is a form of non-verbal intimidation where an individual uses their body to establish dominance, threaten, or evoke fear in another person (19). This is often done through behaviours such as invasion of personal space, standing too close, or using an expansive, rigid stance (19).

2. Covert or indirect aggression (Harm is indirectly delivered)

This type of aggression is contrastingly clandestine, quiet, hidden, and low in visibility, occurring when the victim is physically absent (12, 19, 22). Covert aggressive behaviours include social exclusion, gossiping, passive-aggressive actions, and gaslighting.

Relational aggression is a subtype of covert aggression that involves harming others by damaging their peer relationships or making them feel unwelcome and excluded (7, 19, 22). It often involves social manipulation, where social structures are used to harm the victim by damaging their reputation or social standing to remove them from a social group, without personal involvement (22). It is typically a "lower cost form of aggression than direct forms are, achieved either by hiding the aggressor's identity or by enabling them to deny aggressive intent" (Karin Österman, 2010) (22)

Type of aggression based on its function or outcome

Adaptive Aggression

Adaptive aggression involves aggressive behaviours that are contextually appropriate, goal-based, socially protective or useful for survival (10). It arises from an optimally functioning central nervous system due to evolutionary adaptation (10).

Maladaptive Aggression

Maladaptive aggression involves behaviors that are impulsive, sudden, erratic, highly intense, and often protracted, triggered by minimal or negligible provocation (10). It may be linked to a poorly functioning and damaged central nervous system and has a higher likelihood of occurring in those with psychiatric or neurological illnesses (10).

Displaced Aggression

In this type of aggression an individual cannot target the original source of their anger or frustration, so they direct their aggression towards an innocent party instead, whereas triggered displaced aggression occurs when a substitute target commits a minor provocation, evoking a disproportionately hostile reaction from the aggressor (19).

Overlap of different types of aggression

It is evident that there is an expansive variety of aggressive behaviours, but these types are not completely independent of each other, as several overlaps can be identified (12, 19). They can be grouped together to form two key separate types: the impulsive-reactive-hostile-affective subtype and a controlled-proactive-instrumental-predatory subtype (12, 19, 20, 23).

Quadripartite Violence Typology (QVT)

The Quadripartite Violence Typology (QVT) is a model of conceptualization of aggression that builds on the traditional and most common dichotomous conceptualization of reactive and proactive aggression (15). In 2011, Dr. Rick Howard argued that the original model confuses self-control and affective valence, and hence, created the QVT with four types of aggression: rage, revenge, reward, and recreation aggression (15). This model treats self-control and motivational valence as separate, independent factors (15). Motivation can either be aversive - negative, driven by anger, frustration, or a desire for revenge - or appetitive - driven by a desire for rewards, excitement, or fun (15). Self-control can be impulsive or controlled (15).

Rage aggression, traditionally reactive aggression, is impulsive and aversive, and is driven by acute anger or frustration (15).

Revenge aggression is controlled and aversive, it is a planned and calculated aggressive act driven by intense negative emotions such as grudge-holding (15).

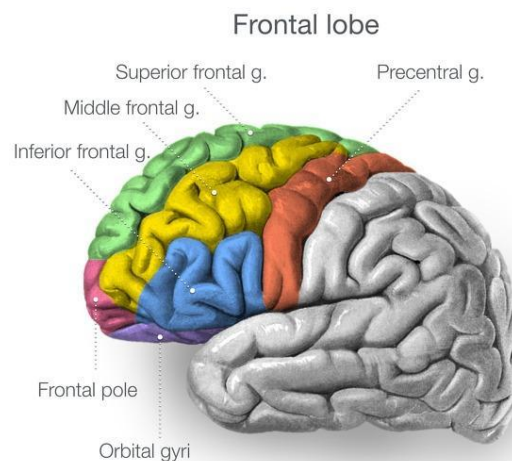
Reward aggression, traditionally proactive aggression, is deliberate and goal-directed, with the aim of gaining status, money, or power (15).

Recreational aggression is impulsive and appetitive, involving spontaneous behaviour that is driven by a desire for excitement or thrill at another individual's expense (15).

How a criminal brain differs from a normal brain in terms of structure

Criminal offenders are not a monolithic group but are structurally and behaviourally diverse. Psychopaths make up 10% to 15% of all offenders (24), individuals with Antisocial Personality Disorder (ASPD) make up 40% to 70% (25), and the remaining offenders are non-psychopathic, non-ASPD, situational or neurotypical offenders (25).

In order to understand the causes of aggressive behaviour across these groups, neuroscientists frequently examine brain structures of offenders against non-offenders, revealing that "the frontal lobes of violent criminals often show signs of serious damage" (26, 29). This is frequently caused due to organic diseases, injuries, or closed head trauma (26, 29, 35). The frontal lobe (see figure 1) is the brain's largest lobe, and its key responsibilities include behavioural and emotional control and decision-making, among others.



Adapted from illustration from "Sobotta's Textbook and Atlas of Human Anatomy" 1908, now in the public domain. 

Figure 1. Lateral view of the human brain highlighting the frontal lobe, the region responsible for behavioural and emotional control and decision-making. Adapted from Gaillard, F., Radiopaedia.org.

This structural damage caused by head injuries can hinder decision-making ability and regulation of affect, influencing violent and aggressive behavior (35). The specific region within the frontal lobe responsible for such tasks is the orbitofrontal cortex (see figure 2), part of the prefrontal cortex (26, 29, 35). It is essential for emotional regulation, social behavior, impulse control, and decision making (26, 29, 35). Research involving war veterans and other subjects found a "significant connection between orbitofrontal lesions and subsequent

antisocial behaviour" (26). A striking clinical demonstration of this was a case where a Virginia schoolteacher was showcasing sociopathic behavior, and it was found that a large brain tumour had displaced his orbitofrontal cortex (26, 29). Once this tumour was removed, his sociopathic behaviour ceased, researchers concluding the tumour "was preventing the frontal lobes from functioning properly and was thereby causing the sociopathic behavior" (29). A lack of activity in the frontal lobes of violent offenders has also often been noted compared to healthy non-offenders, as well as brain disease (26, 29). Ultimately, objective neuroimaging also supports this trend: Aigner et al. (2000) used MRI scans to examine structural brain differences between highly violent and low violent offenders (35). The sample excluded those with severe mental disorders, neurological diseases, or psychopathy (35). The authors found that "65.5% of the high violent group had identifiable MRI abnormalities compared to only 16.6% of the low violent group" (35).

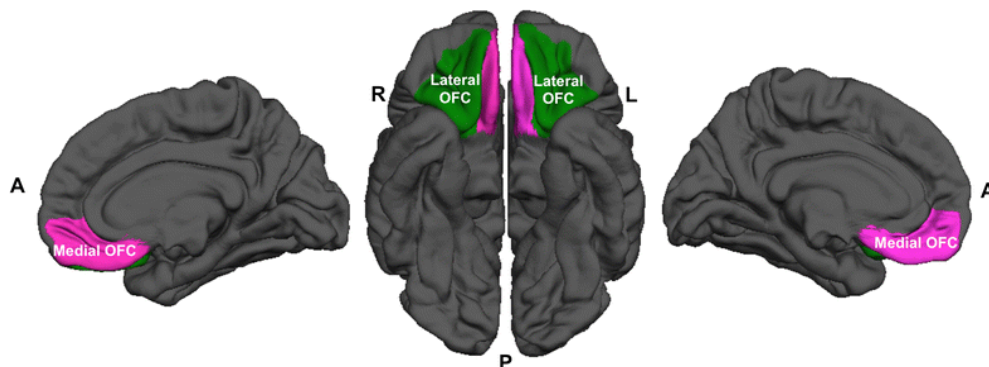


Figure 2. Three-dimensional rendering of the brain showing the location of the lateral and medial orbitofrontal cortex (OFC), a region implicated in emotional regulation, impulse control, and social behaviour. Adapted from Won et. al, 2016

Beyond gross physical trauma, the criminal brain is also found to have measurable micro-structural tissue differences compared with non-offenders, providing evidence that persistent violent offenders (particularly those with ASPD) have abnormal brain anatomy (28, 32). Grey matter reductions are one of the most consistent findings, with MRI studies showing decreases in "overall prefrontal grey matter volume" (26, 29). Particularly, these grey matter reductions were seen in the prefrontal cortex (26, 29, 31, 35), orbitofrontal cortex (28, 32, 35), frontopolar cortex (28, 32), right superior frontal region (31), left inferior parietal region (31), right middle and superior temporal gyri (31), and postcentral gyri (28, 32) (see figure 3). Grey matter loss is not linked to psychopathic traits like proactive aggression and emotional detachment, but behavioural symptoms such as reactive aggression and antisocial behavior (31). Additionally, a strong negative correlation can be seen between aggressive, antisocial behavior and prefrontal grey matter volume (26, 29, 31). However, it is important to note that while reduced frontal grey matter has higher incidence in antisocial or personality-disordered individuals, it is not present in every sample (34). One study (Dolan et al.) investigated differences in frontal and temporal brain regions on MRI between impulsive-aggressive male personality-disordered (PD) patients and healthy controls (34). They found 20% smaller temporal lobes in the PD patients, but the expected loss in frontal lobe volume was not present (34). Moreover, the study found no differences in brain asymmetry (34).

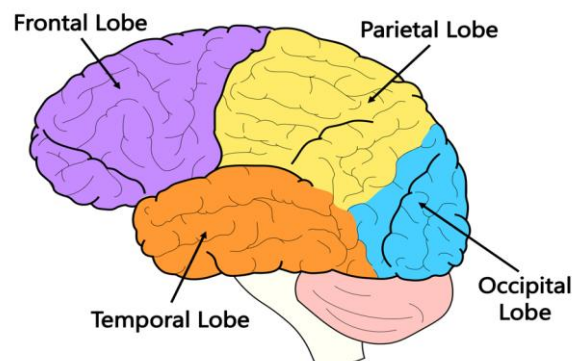


Figure 3. Lateral view of the brain showing the frontal, parietal, and temporal lobes. Grey matter reductions in violent offenders have been localized to sub-regions within these lobes, including the prefrontal, orbitofrontal, and frontopolar cortices (frontal lobe), the inferior parietal region (parietal lobe), and the middle and superior temporal gyri (temporal lobe). Adapted from BrainFrame-Kids

The amygdala (see figure 4) in the criminal brain has also often been observed to be structurally abnormal, which has been consistently associated with violent behavior and trait aggression (35).

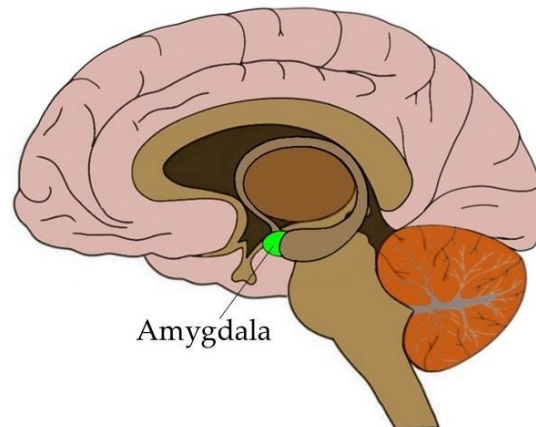


Figure 4. Location of the amygdala, a subcortical structure associated with fear processing and emotional regulation. Adapted from Neuroscientifically Challenged

Researchers suggest this may impair fear processing and emotional regulation (35). Not only do criminal brains show abnormalities of smaller size, but larger as well (28, 32). In a study comparing 26 "persistently violent offenders with antisocial personality disorder" to 25 healthy men (Tiihonen et al.) (28, 32), the offenders displayed larger white matter volumes in the occipital lobe, parietal lobe, and left cerebellum (28, 32). Additionally, they also had larger grey matter volume in the right cerebellum (28, 32) (see figure 5). Researchers suggest these enlarged posterior brain regions may point to "atypical neurodevelopmental processes that underlie early-onset persistent antisocial and aggressive behavior" (28, 32).

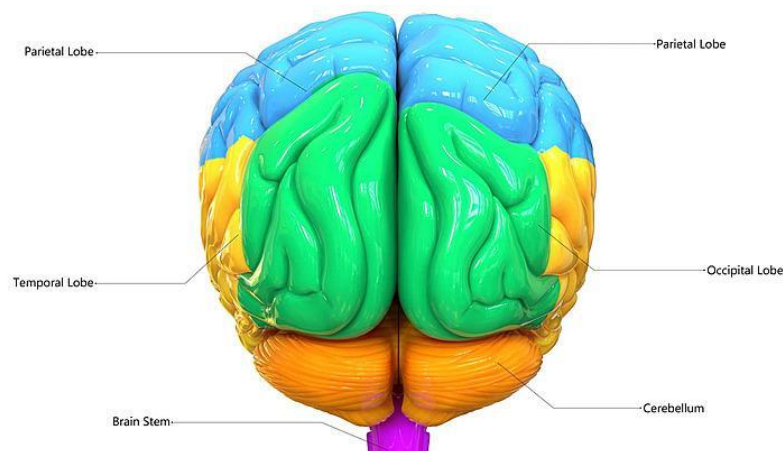


Figure 5. Posterior view of the brain highlighting the occipital lobe, parietal lobe, and cerebellum. Persistently violent offenders with antisocial personality disorder showed larger white matter volumes in the occipital and parietal lobes and left cerebellum, and larger grey matter volume in the right cerebellum, compared to healthy controls (Tiihonen et al.).

While these structural abnormalities are evident in criminals, there is no single "criminal brain" as discussed earlier (24, 25, 27, 30, 33). Imaging studies show that different neurological profiles exist depending on offender type - affective, predatory, psychopathic, and personality-disordered (27, 30, 33). ASPD+P (Antisocial personality disorder + psychopathy) is consistently linked with brain abnormalities, with this group of offenders showing "significantly reduced GM [gray matter] volumes" compared to both healthy non-offenders and violent offenders without psychopathy (ASPD-P)" (27, 30). Specifically, these grey matter reductions are found in the anterior rostral prefrontal cortex (Brodmann area 10) (27, 30), temporal poles (Brodmann area 20/38) (27, 30), anterior rostral medial prefrontal cortex (27), and the anterior insula (27). These regions of the brain are important for empathy, moral reasoning, guilt, and prosocial emotions (30). Even when ASPD-P offenders show reduced brain volumes, psychopathic offenders often show the smallest brain volumes (32). This is seen in regions

such as the orbitofrontal cortex, frontopolar cortex, and postcentral gyri - which are important for impulse control, decision-making, and emotional regulation (28, 32).

In contrast, non-psychopathic violent offenders (ASPD-P) show little to no structural abnormality when compared to healthy non-offenders, with highly similar grey matter volumes (27, 30). This suggests that violent, aggressive behaviour alone doesn't necessarily require structural brain differences (30).

Further differences can be seen within offender types - violent predatory (VP) offenders have significantly larger grey matter volumes in the right middle frontal gyrus compared to violent affective (VA) offenders (33). In contrast, violent affective offenders have a smaller gray matter volume in this same region, supporting the hypothesis that criminals with impulsive, unplanned aggression have a reduced ability to regulate and control their violent impulses (33). Furthermore, predatory offenders, when compared to healthy individuals, show significantly higher diffusion values (axial diffusivity, radial diffusivity, and mean diffusivity) in the right rectus gyrus (33). This increased diffusion may be linked to an increase in extra-cellular space, often caused by vasogenic edema or partial axonal loss (33). However, this group has smaller grey matter volumes in the bilateral thalamus compared to non-violent offenders (33). Non-violent offenders also show increased grey matter volumes when compared to healthy control subjects (33). Contrastingly, when compared to healthy controls, neither affective nor predatory offenders show any significant alterations in overall gray matter volume (33). Ultimately, neurological differences are specific to criminal subtype rather than universal across all offenders (27, 30, 33). Psychopaths show the most significant and severe brain abnormalities (27, 30, 32), while other subtypes' brain structures more closely resemble those of healthy individuals (27, 30, 33).

What are the causes that develop aggressive behavior in criminals?

Modern criminology has shifted away from the "nature vs. nurture" debate, and instead, aggressive criminal behavior is being examined through biopsychosocial or biosocial interaction lenses. Aggressive behavior in criminals is a result of intrinsic biological and neurological vulnerabilities and abnormalities that are catalysed, triggered, and amplified by hostile social environments (37, 39, 46).

1. Differences in brain structure and function

A primary cause that develops aggression in criminals is their physical brain structure and chemical makeup, which create a biological vulnerability to aggressive behavior. Firstly, criminal populations consistently show structural brain damage in regions essential for decision-making, impulse control, emotional regulation, social cognition, fear conditioning, and empathy. These regions include the prefrontal cortex, the orbitofrontal cortex, and the amygdala (37, 38, 39, 49). Criminals show reduced gray matter and slower glucose metabolism in the prefrontal cortex, destroying their impulse control (37). They also show abnormalities in the orbitofrontal cortex, which creates a lack of empathy. If an individual suffers a localized injury to the orbitofrontal cortex, it leads to sudden, explosive, unprovoked, and impulsive aggression, where the brain is unable to control an aggressive urge (38, 49). Moreover, criminals have also consistently demonstrated structurally deformed amygdala, which makes it very difficult for them to feel guilt or empathy, leading to a "diminished fear of consequences" (39, 49). Furthermore, dysfunction in the left brain hemisphere has been observed, which is consistently linked to psychopathy, calculated cruelty, and severe personality disorders. Deficits have also been recorded in the right brain hemisphere in criminals, which is tied to general delinquency, rule-breaking, and school failure (36).

2. Chemical and Hormonal effect on aggressive behaviour

Role of neuro chemicals in aggression

Chemicals that are involved in various processes (neurotransmitters) are also primary drivers in creating vulnerability to aggressive criminal behavior. In the nervous system, criminals have been consistently observed to have serotonin hypoactivity, dopamine hyperactivity, and autonomic nervous system hypoarousal (37, 39, 49). Serotonin hypoactivity refers to reduced serotonin signalling in the brain. Serotonin regulates mood and stabilises emotion, so low levels cause individuals to be volatile, hyper-reactive, and emotionally fragile (37, 49). Dopamine hyperactivity refers to the overactivity of dopamine pathways in the brain. Dopamine functions as the brain's primary messenger for reward, pleasure, and motivation, so increased levels cause intense, addictive, risk-seeking behavior (39, 49). When this is combined with low serotonin, an individual feels excessive pleasure and reward from aggressive dominance (thrill-seeking behavior), and is unable to regulate or stabilize those emotions. Moreover, the autonomic nervous system is a part of the peripheral nervous system that controls involuntary physical processes such as heart rate, blood pressure, digestion, respiration, and sexual arousal. Criminals have been consistently linked to low levels of arousal in the ANS (Autonomous nervous system) - low baseline heart rate, low skin conductance, etc. (39, 49). This causes two major issues. The first is sensation seeking, where criminals must engage in high-risk, dangerous, and violent behaviors to simply feel normal levels of arousal. Another is learning deficits. Due to this hypoactivity, criminals are physically unable to register a physiological

consequence for bad behavior - such as a stressful "fight or flight" response - hence, they fail to learn from negative experiences or social cues (39). If this is combined with serotonin hypoactivity and dopamine hyperactivity, it creates an individual that seeks thrilling and high-risk experiences and feels high levels of pleasure and reward from them, and is unable to learn from its negative consequences or stabilize the emotions that come with it.

Role of hormones in aggression

In the endocrine system, low cortisol and high testosterone have been observed in criminals, which also contribute to their aggressive behaviors (39, 49). Cortisol is the stress hormone that acts as a survival mechanism, preparing an individual for action by boosting blood sugar and sharpening alertness. When a healthy non-offender is about to display aggressive or violent behavior, their cortisol spikes, making them feel anxious or nervous. Chronic criminals have atypically low baseline cortisol (39, 49). Before conducting criminal activities, their body is unable to prepare them - they receive no warning signal. Testosterone, on the other hand, drives physical aggression and dominance seeking. Criminals have been observed to have abnormally high levels of this hormone, also explaining why males display significantly higher rates of early-onset aggression than females. (In women, aggression spikes are correlated with low estrogen during menstrual cycles) (36, 37, 49). However, aggression isn't just driven by high testosterone alone; it is predicted by a high testosterone-to-cortisol ratio. When testosterone is high but the stress hormone cortisol is atypically low, impulse control in the orbitofrontal cortex is heavily reduced.

3. Genetic cause of aggressive behaviour

It is important to note that there are genes that make an individual more vulnerable to displaying aggression before they are even born, but often remain invisible unless catalysed by their environment. One of these genes is the MAOA (Monoamine oxidase A) gene, also known as the "warrior" gene. Possessing the low-activity genotype of this gene severely hinders how the brain regulates chemicals such as serotonin and dopamine, and is often linked to a predisposition for reactive aggression. It is associated with the tendency to act impulsively under provocation or emotional stress. However, this genotype is not deterministic, and simply possessing it does not guarantee aggressive behavior on its own, as it is common in the genetic population. However, when paired with significant environmental triggers, such as intense childhood abuse or trauma, it makes criminal behaviour highly likely (37, 39, 45, 49). Additionally, low activity in the COMT (catechol-O-methyltransferase) gene is linked to prefrontal cortex dysfunction, reducing control over aggressive impulses (37). Lastly, a specific 10-repetition variation in the DAT1 dopamine gene "doubles the risk of adolescents and young adults... of becoming involved in violent and delinquent acts..." (Mendes et al) (37).

4. Role of Biosocial hazards in early childhood in developing aggressive behaviour

Moving to toddlerhood and early development, early biosocial hazards may also predict later aggression and criminal tendencies. Firstly, maternal alcohol during pregnancy physically damages the corpus callosum (37). The corpus callosum is a large bundle of nerve fibres that connects the left and right cerebral hemispheres of the brain. Without this bridge, the child is born with permanent hostility and emotional lability. Additionally, perinatal hypoxia has also been linked to aggression. A severe lack of oxygen during birth damages the hippocampus, which is essential for aggression control as it provides contextual memory and social cues (37). Lastly, if an individual experiences severe malnutrition before the age of 3, particularly, deficiencies in zinc, iron, or tryptophan, their brain becomes permanently stunted. This causes early childhood hyperactivity, intense emotional dysregulation, and heightened aggression (37). Additionally, early childhood poisoning from exposure to heavy metals such as lead, copper, and zinc directly causes damage to brain structures responsible for moral reasoning, impulse control, and emotional regulation, namely, the prefrontal cortex and the anterior cingulate cortex (37).

5. Cumulative role of other factors and environment

However, most of these biological abnormalities do not guarantee aggressive behaviors in criminals. It is when a certain environment interacts with an already vulnerable brain that catalyses aggression (37, 39, 45, 49). Early childhood abuse is one of these key catalysts, however, abuse doesn't simply make a child generally angry. Experiencing trauma from a known or close individual (rather than a stranger) significantly alters the psychological trajectory, drastically increasing the likelihood of later perpetration (44). Research on criminals has found the Isomorphism Rule, which demonstrates that the style of abuse a child faces dictates the style of their future adult crimes. A study by Dutton et al in 1992 found that men who experienced physical abuse in their childhood were three times more likely than nonabused men to engage in physical violence as adults. Similarly, men who experienced sexual violence were more likely to engage in sexual violence as adults (40). In fact, another study found that prior victimization of a sexual offense increased an individual's risk of becoming a sexual

offender nearly sevenfold (from 5.3% to 36.3%) (44). Furthermore, physical abuse and emotional abuse create distinct pathways to criminal behaviour and aggression.

Emotional abuse can predict adult crime both directly and indirectly. A child experiencing emotional abuse may display antisocial or delinquent behaviors early on which leads to an adult criminal record. Interestingly, when researchers accounted for childhood antisocial behavior and other factors like gender and socioeconomic status, emotional abuse still significantly predicted adult crime, displaying the direct link. The child experiencing emotional abuse may appear emotionally stable and behave normally and politely all throughout childhood (no antisocial behavior), and still suddenly switch to violent and aggressive behaviors as an adult. Conversely, physical abuse predicts a more simple progression into adult crime, but it is indirect. Research has found that physical abuse can cause a child to develop early-onset antisocial behavior such as aggression or delinquency, and it is this behavior that persists and leads to crime in adulthood. The abuse doesn't have a direct effect on adult crime, but the childhood behavior caused by it (42). It has also been found that exposure to physical violence specifically between ages 13 and 20 is the strongest environmental predictor of later physical offending due to the intense structural brain organization happening during adolescence (44).

Family structure and environment also contribute to adult crime. A higher incidence of violent male offenders have been found to emerge from very large families, especially those where boys outnumber girls. Family environments that are unstable, lacking a father figure, or include inconsistent discipline also often lead to violent juveniles or adults (36).

Another family issue that increases risk is housing instability. Frequent moves, living in social housing, or experiencing homelessness contribute to increasing vulnerability to adult crime as they can disrupt education, relationships, and access to support. Instability can also increase if individuals run away from home. It may increase vulnerability to problems such as drug addiction, unstable employment, and partner violence (43).

Social and socio-economic factors

Social and socioeconomic factors are also highly important in this discussion. In socioeconomically deprived areas with low income, unemployment, and social instability, criminal behavior is increasingly likely to occur. Financial strain and poverty can contribute to child neglect, inadequate home stimulation, and limited opportunities (36, 43). Delinquent behavior is also predicted by social bonds that involve weak attachments to family and school as well as a diversion of social norms (36).

These social and environmental factors play a significant role in predicting adult crime. While the biological complications discussed earlier increase the likelihood of later violent behavior, they have negligible long-term effects in advantaged families. In poor social environments, however, these abnormalities can predict "significant retardations" (Denno, 1990). Therefore, the link between prenatal complications and adult criminal behavior is strongest when combined with a hostile, abusive, or poor social environment (36, 37, 39, 46).

Psychological factors

Research has also shown that psychological factors predict criminal behavior through cognitive biases and social learning theory. Some key cognitive distortions include rationalization, blaming others, all-or-nothing thinking, overgeneralization, jumping to conclusions, minimization, labeling, control fallacies, and mental filtering.

Rationalization is the most frequently cited distortion, and allows offenders to justify as acceptable or logical, often by aligning themselves with perceived social or financial needs. Blaming others involves externalisation to avoid guilt and maintain a "victim narrative" by shifting responsibility for one's actions onto others or external circumstances. Moreover, all-or-nothing thinking involves a rigid, black-and-white worldview with no middle ground, often leading to impulsive, severe responses in perceived dangerous situations.

Overgeneralization is another cognitive distortion that involves making broad conclusions or judgements based on single incidents. Recidivists may generalize a few negative experiences to form a belief that society is intrinsically unjust. Furthermore, minimization involves downplaying the significant impact or harmful consequences of one's criminal acts. Moreover, labelling explains how criminals create self-fulfilling processes of deviance, through describing oneself or others with negative stereotypes. Control fallacies involve a flawed perception of power, where criminals believe they are either powerless or they must use crime to reclaim their identity and autonomy from external forces. Lastly, mental filtering involves focusing only on negative aspects of a situation and completely ignoring positive ones, which often stems from early life trauma. The hostile attribution bias is a key cognitive distortion observed, often present in abused children. This bias causes them to permanently misinterpret neutral or accidental social cues (such as someone accidentally bumping into them, or neutrally looking at them) as deliberate, hostile, aggressive threats. This causes them to violently react in what they believe is "self-defense", as their early-developed negative schemas cause them to view the world as permanently hostile (42). Furthermore, social learning theory demonstrates how children observe abusive parents as models imitate their violent behaviors, learning and adopting their abusive conflict-resolution strategies.

Chronic abuse and a consistently violent social environment causes violence to become normalized (42, 43). Furthermore, social disintegration has also been noted as a predictor of criminal behavior. When individuals feel completely alienated from school, family, or society, they experience a psychological fear of disintegration. This is a deep, visceral fear that one's sense of self, mind, or personality is fracturing. This prompts them to turn to violence as a tool to restore a sense of justice, claim an identity, and forcibly command respect (37). These cognitive distortions and biases act as a criminogenic mechanism by legitimatizing behaviour, serving to justify repeated criminal acts and moral disengagement. They also obscure reality as they hinder proper information processing, which leads to skewed decision-making. Additionally, they allow criminals to reconcile violent, criminal acts with a positive self-concept, especially rationalization and minimization, which reduces remorse and causes them to believe they are doing nothing wrong. Violent, aggressive crimes specifically are strongly associated with all-or-nothing thinking, overgeneralization, and blaming others.

Role of diet in aggressive behaviour

Dietary and gut health factors also have a significant effect on aggressive behaviours. Key aspects of diet and nutrition are omega-3 fatty acids, micronutrient deficiencies, sugar and blood sugar imbalances, and gut health and inflammation. Low levels of omega-3 fatty acids can cause increased rates of aggressive and impulsive behaviour in both adults and children. This is because omega-3's are essential in maintaining the structure of brain cells and facilitating communication between neurons, which are important processes for reducing irritability and controlling emotions. Deficiencies in zinc and magnesium, which are both important for neurotransmitter function, can affect mood and impulse control. Zinc deficiency is associated with irritability and aggression, and magnesium deficiency is similarly linked to increased hyperactivity and aggression. Vitamin D deficiency can also indirectly cause mood instability as it is essential for the production of serotonin, a neurotransmitter that regulates and stabilizes mood. Individuals who consume a lot of refined sugars and simple carbohydrates can experience rapid spikes and drops in blood glucose levels, which causes mood swings. When blood glucose levels drop, impulsive behaviour, irritability, and anger increases as the brain is deprived of its primary fuel source (glucose). Lastly, poor gut health and inflammation is linked to mood disorders and can often worsen aggressive tendencies. Imbalances in gut bacteria have been linked to elevated aggression and chronic gut inflammation can trigger inflammatory responses in the brain, which can worsen mood disorders and aggression (52).

Chain of risks model of aggression

Lastly, the chain of risk model is highly relevant to this discussion. It is a central concept in the life course perspective that is utilized to explain how early life experiences can set a progression route to a life of adult crime. It describes the additive nature of risk exposure over time, where one detrimental experience tends to lead to another. The framework views pathways to crime as an "integrated continuum of exposures, experiences, and interactions" rather than as separate events. It operates through two main mechanisms - additive effects and trigger effects. Additive effects refer to each individual risk factor (such as neglect, poverty, or violence) that increases the overall risk level for an individual upon exposure. These risk factors accumulate over time, making negative outcomes more likely. A trigger effect is the final link in the chain of risks that can act as a tipping point, after which adverse outcomes (such as violent offending) may occur. This final effect catalyses the accumulated risks that have developed throughout an individual's life. The chain of risk can begin very early in life, including before birth. Prenatal complications, sensitive developmental periods, and maladaptive coping in individuals, as discussed in detail above, can act as additive effects. Furthermore, environmental and social factors can also create the background in which risks accumulate. These include factors discussed earlier as well, such as poverty, financial strain, housing instability, running away, chronic violence, and emotional abuse. These can act as both additive and trigger effects (43). This chain of risk can continue across generations, a concept known as "linked lives". Parental behaviour plays a key role in this phenomena. A child's risk increases when parents display tolerance for abuse or have histories of criminality and substance use. They may also learn maladaptive behaviours through observing how their parents interact with others. Parental behaviours and circumstances become additional links in the child's chain of risk, and as research demonstrates, very powerful ones (43, 45). Studies show a 24.2-fold increased risk of violent offending among children of "homicide recidivists" (45). Although this model describes a pathway towards criminality, it also highlights turning points that could redirect individuals towards conformity and prosocial behaviour. Examples of positive turning points include stable employment, marriage, and parenthood, however, these must be high-quality social bonds and positive relationships to be effective.

Interventions of change in Criminal Mindset and Criminal Behaviour

1. Cognitive Behavioural therapy

Theoretical Basis of CBT

The primary aim of offender rehabilitation is to reduce recidivism by addressing the psychological factors that contribute to criminal behaviour. Modern rehabilitation assumes that criminogenic thinking is caused by dysfunctional thinking patterns and cognitive distortions that impair social abilities and decision-making skills. Some of these distortions, which are discussed in greater detail in previous sections, include self-justificatory thinking, misinterpretation of social cues, displacement of blame, deficient moral reasoning, and a "victim stance" where offenders view themselves as unfairly treated while ignoring their own role in their problems (53). Rather than viewing these distortions as inherent personality traits, modern rehabilitation models treat them as patterns of thinking that are learned and can be reconstructed and assume that biological or social risk factors influence criminal behaviour through cognitive and emotional processes (53)(59). This is why the cognitive social learning model emerges as one of the most common and effective models of treatment for criminals (59). This is an approach that combines cognitive and behavioral principles to reduce criminal behaviour, targeting those same thoughts and learned behaviours that contribute to offending (59). Cognitive behavioural therapy (CBT) falls under this model of rehabilitation (59). It is a "problem focused" and "task oriented" treatment that is regarded as one of the most cost-effective and common recovery strategies for prisoners (54). It targets "procriminal attitudes" (thoughts and values supportive of crime) by correcting cognitive distortions such as those discussed above - inability to read social cues correctly, overgeneralization, entitlement, and impulsivity, among others (54)(55). CBT is deeply rooted in and often used in conjunction with the RNR (Risk-need-responsivity) model (55). This model focuses on matching the intensity of treatment to an offender's risk level and targeting dynamic factors (criminogenic needs) directly linked to criminal behavior (54)(58). Responsivity is an integral part of the RNR model which states that treatments must be tailored to an individual's learning style, motivation, and cognitive abilities (58). CBT is growing as a treatment method and has replaced traditional rehabilitative services like education and occupational therapy in many jail systems (54). It is especially needed now, as there are 3 times more people with significant mental illness found in prisons than in psychiatric clinics – mentally ill individuals are over-represented in the judicial system. CBT is seen as a way to address this while reducing recidivism (54).

CBT Techniques and Treatment Process

Cognitive behavioural therapy rehabilitates offenders by helping them identify and replace dysfunctional and maladaptive thinking patterns, such as entitlement or hostile interpretations of others, with more adaptive beliefs, helping them improve self-regulation overall (59). It also teaches practical skills such as problem-solving, self-control, moral reasoning, and effective and positive social interactions (53)(59). Rather than focusing solely on the offence itself, CBT addresses the underlying cognitive processes that influence how offenders interpret situations, make decisions, and respond to conflict (53)(59). One of its central components is cognitive restructuring, which involves teaching offenders to identify biased, distorted, and "risky" thoughts by practicing self awareness and self-monitoring of thoughts, which helps in eventually changing these thought patterns (53). CBT also incorporates cognitive skills training, which involves learning thinking skills like interpersonal problem-solving, critical reasoning, goal setting, and perspective-taking to help offenders cope with situations where they would typically respond with criminal behaviour (53)(54). In addition, personal accountability is encouraged by shifting offenders' focus from external factors and the belief that those circumstances cause their criminal behaviour to their internal thought patterns and choices they make (53). These techniques are delivered through a structured treatment process that lasts between 5 and 10 months, involving weekly 50-minute sessions that include homework to ensure the offender's active participation (54). It has 6 key phases - psychological evaluation, reconceptualization, skill acquisition, integration/application learning, maintenance/generalization, and follow-up review (54). Psychological evaluation is the initial assessment phase where the psychologist identifies the specific behaviors that need improvement and establishes a baseline for their frequency, length, or severity (54). Next, reconceptualisation prepares the offenders to restructure their thought patterns by helping them understand their behaviors and problems through a cognitive lens (54). The third phase, skill acquisition involves helping offenders learn to change their coping mechanisms of criminal behaviour and maladaptive habits by learning thinking skills they could use instead like interpersonal problem-solving, critical reasoning, goal setting, perspective-taking, and moral reasoning (54). The next phase, integration, is where the participant practices the new skills acquired and learns how to use them in real-life situations they may encounter (54). The maintenance phase involves ensuring that the newly learned adaptive behaviors are maintained and consistently practiced over time, and generalized across various social settings (54). Lastly, follow-up post-treatment review is the final review conducted after the treatment period to decide if the intervention was effective and if the target behaviors have remained at or below the goal baseline level (54). During these phases, the therapist typically monitors whether the intervention is working by checking if the "critical behavior" identified in the first phase persists above or below the established baseline (54).

CBT-Based Rehabilitation Programmes

The principles of cognitive behavioural therapy are implemented through a range of structured rehabilitation programmes designed to address different aspects of criminal behaviour (53)(55). One of the most widely recognized is Aggression Replacement Training (ART), which involves targeting automatic thoughts and the misinterpretation of social cues (53). It focuses on teaching offenders to monitor their automatic "hot" or hostile thoughts and substitute them for more accurate interpretations and consider non-hostile explanations for others' behaviour (53). It involves 3 key components – skillstreaming, anger control training, and moral education (53). Skillstreaming involves teaching offenders prosocial behaviours through techniques such as modelling and role-playing. This helps them learn and practice positive social interactions (53). Anger control training involves teaching offenders self control. They are taught to identify and record their anger-causing experiences, recognize the "trigger" thoughts that lead to that anger, and apply specific anger management techniques (53). Lastly, moral education aims to advance offenders' moral reasoning by using a discussion format to expose them to moral dilemmas (53). Another established programme is Reasoning and Rehabilitation (R&R), which is a prominent, manualized CBT program created by Ross and Fabiano in 1985 (59). It focuses on modifying the impulsive, egocentric, and rigid thinking patterns frequently found in offenders, with modules on problem-solving, critical thinking, social interaction, social perspective-taking, impulse control, self management, conflict resolution, and negotiation (59). The standard program structure involves 38 two-hour sessions delivered in a group format (59). Similarly, Cognitive Self-Change encourages offenders in group settings to analyse the cognitive distortions and flawed belief systems that cause criminal behaviour using "thinking reports", which are detailed accounts of the thoughts and feelings an offender experienced before, during, and after a violent incident (59). After that, they practice "self-risk management" by creating alternative prosocial thoughts and skills to reduce the likelihood of violent behaviour in the future (59). Structured, multi-modal programs such as the Violence Prevention Programme, which integrate arousal management, conflict resolution, and relapse prevention have also shown significant success (59). More recent programmes, such as Thinking for a Change, Thinking Skills Programme, and Building Better Relationships, continue to apply these same cognitive-behavioural principles while adapting them to specific offender populations and criminogenic needs (55).

Effectiveness of CBT

Overall, research suggests that CBT is one of the most effective approaches for reducing criminal behaviour and recidivism, although its success significantly depends on how it is implemented (53)(59). Meta-analyses consistently demonstrate positive trends, with one review of 58 studies reporting a mean reduction of 25% in recidivism, increasing to more than 50% when programmes are delivered under best-practice conditions (53). These "best-practice conditions" include low dropout rates, close monitoring of treatment fidelity, and sufficient training for providers (53). Additionally, including anger control and interpersonal problem-solving components in a program has shown to be associated with significant reductions in recidivism (53). Research has also found that programs with no specific "brand name" (e.g - Moral Reconation Therapy or Reasoning and Rehabilitation) have been significantly more effective than others, it is the general CBT approach that leads to positive outcomes (53). Additional evidence from large-scale evaluations has found significant reductions in recidivism from other CBT-variant interventions (59). For example, in a large-scale evaluation involving 1,444 prisoners, the Reasoning and Rehabilitation program demonstrated a 36.4% reduction in recidivism for program completers compared to a control group (59). The program was noted to be particularly effective for prisoners with histories of violent or sexual offending (59). Cognitive self-change, another CBT-variant program was also effective in recidivism reduction - 2 years after the program, the treatment group had a 50% recidivism rate, significantly lower than the 71% rate of the matched control group (59). Furthermore, In another study of 500 participants, it was found that only 8.5% of those who completed the Violence Prevention Programme showed violent recidivism. A matched comparison group that didn't receive treatment had an almost double violent recidivism rate of 21.8% (59).

Anger Management Interventions

Although violent crime is not always directly caused by anger, poor anger management often plays a major role in violent offending, so improving it may reduce the likelihood of reoffending (57). Most anger management interventions use CBT, involving cognitive restructuring, arousal management, and social skills training (57). While meta-analyses in general populations show a moderate to large effect on reducing anger problems, studies with offenders show modest results (57). Its success with offenders is most consistent when delivered as a high-intensity program for high-risk individuals (57)(59). One study of high-risk offenders in a 50-hour program found an 86% reduction in violent reoffending (59). For other offenders, studies have found little to no improvement beyond increases in offenders' knowledge of anger management strategies (56)(57). Furthermore, researchers argue that the effectiveness of CBT can decline when interventions move from small-scale "demonstration projects" to large-scale delivery across an entire service (55). There are concerns also raised

about the generalized, "one size fits all" approaches and standardized programs delivered by less-qualified staff, which may lead to lower treatment fidelity and less competence in delivery (55). These findings indicate that while CBT is highly effective and supported by a plethora of empirical evidence, its effectiveness is highly dependent on the quality of implementation and its ability to meet offenders' individual needs, not only the intervention itself (53)(55)(58).

Limitations of CBT

Although cognitive behavioural interventions have demonstrated considerable success in reducing reoffending, contemporary rehabilitation research emphasises that effective treatment must go beyond criminogenic needs and risk levels and be more individualised (58). The programmes must address the ethical, social, legal, and psychological dimensions of an offender's life, and also have clear goals and underlying values; offenders are unlikely to be motivated without these (58). These principles are reflected in the Risk-Need-Responsivity model, 1. focuses on matching the intensity of treatment to an offender's risk level, targeting dynamic factors directly linked to criminal behavior, and adapting treatment to the individual's learning style, motivation, and cognitive abilities (58). However, rehabilitation extends beyond simply reducing risk factors. The Good Lives Model (GLM) argues that lasting behavioral change is more likely when offenders are supported in achieving meaningful personal goals through socially acceptable means (58). It focuses on capability building, and helping offenders achieve primary human "goods" or goals in prosocial ways, essentially making crime incompatible with their new, fulfilling lifestyle (58). Consequently, criminal rehabilitation is increasingly tailored to the unique needs of specific offender populations (58). For example, multisystemic therapy has shown strong evidence of success for treating serious and violent juveniles, therapeutic communities have been developed for offenders with personality disorders, group-based CBT programmes for intimate partner violence and sexual offending populations, specialised interventions for substance- and arson-related offending, and adapted cognitive behavioural programmes for individuals with intellectual disabilities (58). Furthermore, cultural background, gender, and regional context are also highly important factors in designing treatment, and predicting treatment outcomes (58). For example, in the sexual offender population, treatment slightly differs between males and females, with each receiving gender-specific theory, assessment, and treatment (58). An example of a regional strategy for rehabilitation is the Australian approach, which integrates localized knowledge and practices into the rehabilitative framework (58). These findings suggest that rehabilitation is most effective when evidence-based interventions are adapted to the unique characteristics and rehabilitative needs of each offender, rather than delivered as standardized programmes (58).

2. Mindfulness based interventions

In addition to cognitive-behavioural programs, research advocates for the incorporation of mindfulness based interventions such as Tai Chi, meditation, and Qigong into such programs, which have been associated with a "dramatic decline" in recidivism rates according to prison statistics (60). The National Institute of Corrections also recognizes these practices as valuable resources for courts, jails, and prisons (60). Participation in mind-body programs has been shown to improve behavioural control, decrease psychological distress, and prevent violence both within the prison and upon release (60). For example, teaching Tai Chi at the New Mexico State Penitentiary contributed to calming violence following major riots (60). Additionally, prison stress often takes a significant physical and emotional toll on inmates and guards, and can be addressed by practices like yoga, meditation, and Qigong, which help them stay calm and overcome the "strains of life behind bars" (60). These practices also have medical benefits, fixing long-standing ailments in prisoners and allowing them to be healthier and better adjusted (60). It also has a psychological and personal impact. Mindfulness practices help inmates achieve "inner freedom" by teaching them that their mental state is within their control, regardless of their external environment (60). By highlighting this control over their mind, such practices encourage inmates to stop blaming exterior factors for their situation and instead remain vigilant in their own thought processes (60). Benefits have been reported for particular groups, such as reduced trauma symptoms in female prisoners through Transcendental Meditation and improved attention in incarcerated youth through mindfulness training (60).

3. Modern neuroscience-based brain interventions

Neuroscience can also be used to create brain-intervention methods for criminals, such as neurofeedback, deep brain stimulation, chemical castration, and more.

Neurofeedback/neurotherapy (62)

Neurofeedback or neurotherapy is a non-invasive intervention where electrodes record a patient's electrical brain waves. Deficiencies or abnormalities in specific brainwave frequencies correlate with disorders such as depression, emotional disturbances, and learning disabilities (such as ADHD). This recording of brain activity can then be used to make patients play computer-game-like programs to learn to self-adjust their

brainwave activity wherever deficiencies are present. This intervention has been suggested to prevent violence and lower recidivism. Quirk (1995) tested neurofeedback on 77 dangerous offenders with deep-brain epileptic activity in Ontario, successfully reducing recidivism. Additionally, Martin and Johnson (2005) used neurofeedback to enhance a residential detention program for 7 incarcerated male adolescents diagnosed with ADHD. 6 displayed fewer aggressive behaviors, and all showed improved emotional regulation.

Deep Brain Stimulation

Another brain intervention is Deep Brain Stimulation (DBS). This is an invasive, but reversible, technique where surgically inserted electrodes deliver electrical stimulation to precisely targeted, deep regions of the brain (62, 63). Its exact mechanisms remain debated and unclear. Its efficacy in criminology is not as strongly supported as that of neurofeedback, but it has still been proven to be effective in some cases. Franzini et al. (2005) reported that DBS dramatically improved disruptive behaviors and quality of life in medically untreatable, aggressive, mentally retarded patients (though this study did not occur in a prison setting) (62).

Chemical Castration

Another potential intervention is chemical castration, however, it is rarely used in practice because physicians are highly hesitant to prescribe it. It is a less direct form of brain intervention, initiated by California in 1996 and adopted by seven other US States and several nations. It uses medroxyprogesterone acetate (MPA/ Depo-Provera), which inhibits testosterone, reducing sex drive by changing how receptors in the brain work. The FDA has also never approved it for the purpose of treating criminal behaviour – it can cause severe side effects like bone demineralization, and the AMA opposes physician participation in court-initiated treatments used for social control.(63)

Mind-reading and decoding

Scientists have successfully used fMRI to decode brain contents in order to reconstruct videos a subject is watching or determine semantic thought categories. Future portable neuroimaging (such as nanoparticle-sized "neurodust") raises the possibility of detecting criminal intent or deception directly. (63)

Prospective Technologies

Future applications may include impulse-restraining drugs, vaccines to block the high from drugs of abuse, precise neurosurgery, and external neuromodulation using magnetism, electricity, or ultrasound (which is safer and cheaper than implanted electrodes).(63)

Ethical, Legal, and Philosophical Concerns

It is important to note that while these modern neuroscience-based interventions provide plausible results in treating criminal behavior, they do raise ethical and human rights concerns regarding their application in legal settings:(62)

a. Scientific Uncertainty and Safety Risks

- DBS: remains highly experimental and has numerous reported negative side effects.
- Neurofeedback: Relatively safe but requires strictly professional therapists to avoid risks.

b. Coercion, Autonomy, and Plea-Bargaining Offenders that are mentally ill and/or addicted often lack the ability to make completely autonomous, uncoerced decisions regarding their treatment. Although some scholars propose offering treatment as a substitute to incarceration (e.g., plea deals), this is highly controversial. Integrating medical treatment into sentencing risks turning therapy into a form of "extrajudicial punishment" or a tool for institutional social control.

c. Philosophical concerns When discussing criminal behaviour, one must be careful to not frame violence and crime purely as "diseases" to physically cure, as that leads to a "therapeutic tyranny". This approach ignores the normative, social, and environmental factors of crime, simplifying a highly complex legal construct into a mere biological defect.

II. Conclusion

Overall, the studies reviewed here indicate that there is no simple explanation for the aggression of criminal populations. Structural and functional differences in the Pro frontal cortex Orbitofrontal cortex and the Amygdala are found consistently in the criminal population, and the severity of the abnormalities is closely linked with the subtype; psychopathic and ASPD+P (Antisocial personality disorder + psychopathy) have the most marked abnormalities while non-psychopathic violent offenders often look similar to non-offenders. This change indicates that the biological vulnerability factor alone is not a good predictor of criminal behavior. Rather – as the chain of risk model shows – it is the interaction of the three components and the compound effect of multiple risk factors that often results in violent behaviour. Abuse in childhood is coupled with neurochemical imbalances, hormonal profiles, genetic predispositions, and early developmental hazards which all contribute to the process of catalyzing criminality. The implications for rehabilitation of this layered causality are clear: due to the wide

variation in the neurological and psychosocial profile of offenders, a uniform intervention is not likely to be successful and individualisation is required. While cognitive behavioral therapy is the most consistently effective treatment for prevention of recidivism, there is strong evidence that fidelity of implementation and individualisation to offender risk and need (as models such as RNR and the Good Lives Model emphasise) is an important factor in its effectiveness. Newer neuroscience-based interventions have potential benefits, yet also create unanswered issues of ethics/legality. Thus, in order to combat the effectiveness of criminal aggression it is better not to seek only a biological or only a social explanation, but to go for a combined, personalised approach to rehabilitation. More evidence based studies are required to confirm effectiveness of personalised approach to rehabilitation.

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