**Biological explanations of aggression and the medicolegal implications**

**Introduction**
Jeffery Landrigan was a difficult child. Adopted at birth, he threw temper tantrums as a toddler, progressing to substance abuse and burglary by the age of 11. At 20, he killed his first victim. Imprisoned, he repeatedly stabbed an inmate and later escaped, committing his second murder. He was then sentenced to death. An inmate noticed a striking resemblance between Landrigan and Darrel Hill, a man on death row in another state. Hill, it transpired, was the biological father of Landrigan – both murderers, sentenced to die. Hill’s father and grandfather had also been criminals. Despite being adopted, Landrigan was a fourth-generation felon. Does this mean that we can inherit behaviours? (Glenn and Raine, 2014)

This essay covers the neural, hormonal, genetic, and evolutionary factors that may play a role in causing aggressive behaviour. Whilst there are flaws within the research, the theories are of some use in the real world. The implications of the discussed theories apply both medically and legally. From a clinician’s perspective, how can we explain, prevent, and treat behaviours that are deemed undesirable and/or harmful? In terms of the law, can the reasons for violent behaviours justify leniency in convicting people if they have no control over their physiology?

**Biological mechanisms linked to aggression**

**Neurotransmitters**
Research into neural factors often highlights serotonin as a key player in aggressive behaviour. Low serotonin is associated with impulsive behaviour, aggression and violent suicide. The neurotransmitter inhibits responses to emotional stimuli that could result in aggressive responses. Studies can either look at the levels of serotonin in people who have a history of violence, compared to those who do not, or can adjust the levels using drugs to see how behaviour may change. Linnoila and Virkkunen (1992) found consistently low levels of serotonin in violent offenders. This suggests that serotonin is important in impulse control. Fenfluramine is a drug that reduces serotonin uptake in the brain and has been linked to increased hostility.
Antidepressants, which primarily aim to raise serotonin levels, have been linked to reduced aggression and irritability. (Bond, 2005)

Dopamine has a less well-established link with aggressive behaviour than serotonin but is still worth a brief mention as it relates to the genetic links discussed later. Amphetamines, which raise dopamine levels, result in aggression (Lavine, 1997) whereas antipsychotics, which lower dopamine levels, are associated with reduced rates of violent crime. (Fazel, 2014)

**Hormones**

Testosterone and cortisol are two steroid hormones linked to aggression. A low positive correlation has been found between testosterone levels and aggression in meta-analyses. (Archer, 1991; Book et al., 2001) However, the methodological problems and differences between the studies mean that the coefficients, which are already low, may need to be lower. For example, Archer et al. (2005) claim that the coefficient in the meta-analysis by Book et al. (2001) should have been 0.08, rather than 0.14. Whilst this is not a strong correlation, there is a breadth of studies that have linked testosterone to aggression, suggesting it plays some role. Further studies include Dabbs et al. (1987), who found higher salivary testosterone in people with a history of violent crime than those with a history of non-violent crime, and Lindman et al. (1987), who found that men who are more aggressive when drunk have higher testosterone levels. Testosterone also has a role to play in evolutionary explanations of aggression, discussed in further detail below. The Challenge Hypothesis, proposed by Wingfield et al. (1990), states that males of a monogamous species (which humans may be loosely classified under) should not have a rise in testosterone above a baseline unless challenged. This surge of testosterone causes aggression in response to a threat that is deemed detrimental to reproductive success, such as threats to status or a dispute over a female.

Cortisol is thought to interact with testosterone levels to mediate its effects. Cortisol increases anxiety and social withdrawal, potentially reducing opportunities to be aggressive. (Dabbs et al., 1991) Low cortisol levels in habitual offenders (Virkkunen, 1985) and violent children (Tennes and Kreye, 1985) suggests that low cortisol increases the likelihood of aggression, in conjunction with testosterone.
Genetics

Research into genetic links to aggressive behaviour relies mostly on twin and adoption studies, looking at differences between people with the same, or similar, genetic makeup. Twin studies rely on the premise that, if aggressive behaviour is inherited, monozygotic twins (with near 100% identical DNA) will both show the trait. Dizygotic twins (~50% identical genes) should show lower concordance rates than monozygotic twins if the trait is genetically linked. It is assumed that the twins will have similar environments to each other, so differences are accounted to their genes. Adoption studies focus on children who are raised by people other than their biological parents (and family). If these children show aggressive behaviours similar to their parents despite not being raised by them, it is assumed that this aggression was caused by genetic factors, rather than through observing their parents, as proposed by some psychological explanations.

A large Danish study found that, in 14,000 adoptions, adopted boys that had a criminal conviction usually had parents (especially fathers) with a criminal conviction. (Hutchings and Mednick, 1975) In a review of 24 twin and adoption studies, Miles and Carey (1997) suggested up to 50% of aggressive behaviour can be accounted for by genetic factors. These results were repeated by Rhee and Waldman (2002) in a meta-analysis of 51 studies. However, both studies agreed that, whilst genes can make a massive contribution to the development of aggressive behaviour, their influence is moderated by several variables, including the age of the participants and their rearing environment.

Further research focuses on particular outcomes of genetic variation in relation to the monoamine oxidase A (MAOA) enzyme. Brunner et al. (1993) studied a Dutch family known for being violent, with many of the men convicted of rape and arson. They were found to have abnormally low levels of MAOA, attributed to a defective gene. A second study by Caspi et al. (2002) evaluated 500 male children. Those with a gene variant leading to low levels of MAOA were significantly more likely to exhibit antisocial behaviour later on in life but only if they were abused. Those with high MAOA levels that were maltreated and those with low levels that were not maltreated did not generally display antisocial behaviour. This highlights that aggressive behaviour relies on the interaction between genes and the environment.
With a plethora of research linking genes and their sequelae to aggressive behaviour, we could easily make the mistake of assuming that our genome can cause us to commit crime. However, the research claims that inherited temperamentality only places individuals at a higher risk of committing crimes, with a triggering contribution from the surrounding environment. The highest rates of crime in adopted children occur when both the biological and adoptive parents have a history of crime. (Rhee and Waldman, 2002)

Evolution
Though many of us like to separate ourselves from the rest of the animal kingdom, we all evolved from common ancestors and have a drive to survive as a species. Evolutionary explanations rely on the fact that retained characteristics are either beneficial or otherwise not harmful to survival or else they would have been erased through natural selection.

The first broad explanation discusses the causes of violence in interpersonal relationships. Daly and Wilson (1988) consider the various strategies used by males to prevent their female sexual partners from committing adultery. Sexual jealousy stems from the fact that males could never be sure if the offspring of their female partner is theirs. Evolutionarily, this would mean a male would be investing his resources in a child that did not carry his genetic code, therefore male sexual jealousy exists to minimise this risk by deterring a female sexual partner from having sex with other males. This can range from vigilance to outright violence. This includes ‘direct guarding’ by reducing the partner’s autonomy, as well as ‘negative inducements’ such as threats and violence if a male perceives infidelity in their mate. Female victims of domestic abuse often cite jealousy as a key cause of violence directed at them. (Dobash and Dobash, 1984) The rates of domestic abuse double if the female is pregnant and their partner suspects the child belongs to another male. (Burch and Gallup, 2004) Male sexual jealousy accounts for 17% of murders in the UK (Dell, 1984), as well as being the most common cause of killings in domestic disputes in the US. (Daly et al, 1982) In same-sex killings (where the third person is killed), 92% were male-male murders, suggesting that sexual jealousy is almost entirely exclusive to males. Murder of a sexual partner could be an unintended
outcome of physical violence as the purpose of aggression in these cases is to gain control over the (potentially) adulterous partner.

Research into sexual jealousy suggests that it is caused by physiological processes. Imagined scenes of infidelity triggers activation in the amygdala and hypothalamus in men, but less so in women. (Takahashi et al, 2006) However, there is little research that considers the role of moderating factors such as which person is perceived to be responsible for the adultery (i.e. whether or not the male rival initiated the sexual encounters – if they happened).

The second evolutionary theory explains how aggressive displays in groups are an adaptive response to evolutionary threats. Our ancestors used aggression to protect their group, as well as benefitting them.

Xenophobia is the fear and hatred of those different from us and is documented in virtually all species that are highly socially organised. (Wilson, 1975) Although altruism towards each other is favoured by natural selection, there is an evolutionary advantage to intolerance of strangers. By rejecting strangers, our ancestors did not risk exposing themselves to attack or illness, sparing themselves and their offspring. Exaggerating negative stereotypes is less risky than underperceiving threat for those wanting to protect themselves. (MacDonald, 1992) This may be one of the underlying causes of racism and other intolerances that are still prevalent in society.

Territory protection can also explain aggressive displays. Aggressive behaviour was more adaptive for our ancestors who would have had to protect their land and its associated resources that were key to survival. Being territorial is associated with higher testosterone levels, as found in football players in ‘home’ games where they carry the burden of defending their own ‘land.’ This surge of testosterone at ‘home’ games also makes a team more likely to win than if they were playing ‘away.’ (Neave and Wolfson, 2003) The claim that this is due to spectator support has been disputed by Moore and Brylinsky (1993), who showed that teams perform better without spectators at ‘home’ games.
A more extreme situation relating to aggression is war. Though risking your life may seem evolutionarily disadvantageous, it can provide status which then elevates their reproductive fitness, resulting in more chances to mate and produce offspring. (Divale and Harris, 1976) The inordinate risk displayed by members of a group during warfare signals their commitment to their group. The most obvious sign of this is scars and mutilation. By being perceived as dedicated to their group, our ancestors would have been able to reap the benefits from anything won in war against another group (mates, food, shelter). (Irons, 2004) Scars and piercings inflicted within the group would also minimise abscondion to other groups and force a person to be committed to their group, increasing the group's chance of survival. (Thorpe, 2003)

Limitations within the research

Inconsistency

Different biological explanations could be incompatible. Low levels of MAOA are associated with aggression (Brunner et al., 1993) but the enzyme also breaks down serotonin so a deficiency in MAOA would also correspond to a higher concentration of serotonin. However, low levels of serotonin are associated with aggression. (Linnoila and Virkkunen, 1992) The research has yet to specify if these things exist in different areas in the brain or if they are linked within the same pathways. This shows that the mechanisms are not yet fully understood and can only offer ideas of factors that influence our behaviours, rather than concrete explanations.

Correlation

Though many factors are associated with aggressive behaviour, they have not been established as a cause of it. In fact, the relationships could be reversed or bidirectional. Couppis and Kennedy (2008) found that high levels of dopamine associated with aggression could be a consequence of the behaviour, rather than the cause. Reward pathways in the brains of mice become engaged in response to aggressive events and dopamine positively reinforces this. This could explain why people intentionally seek out aggressive encounters as it can provide them with a rewarding sensation.
Sampling bias and data collection

Most research focuses on people with convictions of violent crime. This is only a minority of aggressive behaviour as not all aggression results in a conviction. This means the population sample may not be representative of the entire population of people who show aggressive behaviour. Often, the convictions may be for a one-time offence and may not necessarily be the most serious or persistent offenders. This could be why the evidence for the heritability of aggressive behaviour is sometimes weak.

Much of the collected data on behaviour relies on surveys and/or retrospective data. These are not the most objective methods and are subject to various issues, from forgetfulness to social desirability. People may lie to make themselves seem more or less aggressive, depending on how they feel they should answer, or how they want to be seen.

Non-human animal research

The results of experimentation on non-human animals corroborate the findings in research on humans. For example, Raleigh et al (1991) found that vervet monkeys with lower levels of serotonin displayed more aggression. Popova et al (1991) found an increase of serotonin concentrations over generations in species that had been domesticated and bred for their docile temperaments. The problem with this, aside from the ethical debate of using animals, is that it reduces a social behaviour that is infinitely complex in humans down to a simpler physiological process just because there is a well-established link in other species. Whilst we may not be massively superior to other species, it is fair to say that the explanations given by biologists are insufficient. After millennia of human civilisation, do we really have no control over evolutionary traits? Do we exist only to survive and procreate?

Warfare as a genetic trait

LeBlanc and Register (2004) have considered that war may not be an evolutionary trait, but a circumstance of the environment. When humans shifted to a nomadic setting, they were tied to their agricultural and fishing sites. Walking away from danger is easier when you are a hunter-gatherer, but when you have more to lose by leaving an area, you have more to fight for, and fighting was a rational response in
this case. Rather than being compelled by nature, aggression may be a result of developing populations and diminishing food supplies.

**Gender**
Research into aggressive behaviour has focussed mainly on males, meaning that the current explanations may not apply to females (or people with intersex conditions). Although testosterone is strongly associated with aggression in males, Archer et al (2005) found that the association between testosterone levels and aggression was stronger for females than males. Baucom et al (1985) took a different approach and found that females with higher testosterone levels had a higher occupational status due to more assertive behaviour. Additionally, Eisenegger et al (2011) found that testosterone may make females 'nicer' to others, depending on the situation; testosterone increases status-seeking behaviours and aggression is only one type of this.

The evolutionary explanations fail to explain why women can also commit acts of violence such as abuse and murder. In fact, women are twice as likely to kill out of jealousy than men. (Felson, 1997) In evolutionary terms, females have much less to gain reproductively, even in war, so the role of the 'woman warrior' is unclear. (Adams, 1983)

**Individual differences**
Beyond gender differences, evolution cannot explain why people react differently to the same situation. For example, whilst aggressive mate-retention methods are used by some, others will cope with sexual jealousy by drinking alcohol or other (less violent) strategies. (Buss and Shackelford, 1997) Evolutionary explanations often divorce free-will from biology, assuming that we cannot override a built-in survival mechanism, when we manage it every day, and have managed it as a species for countless generations.

**Heteronormative bias**
The fundamental flaw in evolutionary explanations is that they only focus on heterosexual relationships. Evolution relies on reproduction which was not accessible to cisgender homosexual couples, but this does not mean that
homosexual relationships did not exist. Regardless of personal feelings on the topic, gay people exist and have relationships. Like any heterosexual couple, these can vary from healthy to abusive. Evolution cannot explain why sexual jealousy, in either males or females could result in violence, rendering this explanation somewhat futile beyond explaining why men abuse women.

Polyamory
Around the world, romantic-sexual relationships exist beyond two people. This can be cultural or individual and can include marriage (polygyny and polyandry). As with heteronormative biases, evolution cannot explain why violence does not consistently occur in these relationships despite the ample opportunity for jealousy.

Application beyond research
Although the limitations of the research are many, there is still some usefulness to the theories.

The Challenge Hypothesis (hormonal explanations)
Klinesmith et al (2006) found that males who were given a gun were more aggressive to each other than those who were given a child’s toy in the study. They also had raised salivary testosterone. This supports the challenge hypothesis and has important implications in gun and knife crimes. If these are more readily available, they are more likely to be used. By having tighter controls on weapons and who can access them, we decrease the chance of their involvement in crime. However, this can easily mislead people into blaming the gun for shooting someone, when the person using the gun must also be held accountable for their actions. After all, not everyone who picks up a knife in the kitchen will go on to stab another person.

Xenophobia (evolutionary explanations)
Understanding xenophobia and its role in prejudice can help to educate populations that are privy to racism. For example, schemes such as ‘Bhoys Against Bigotry’ and ‘Football unites, racism divides’ have been deployed to tackle the racism that is rife in some football fans. Whilst no one should be prevented from loving and supporting
their team, we all must work to make sure we do not allow prejudices to stop other people from also enjoying the sport.

**Mate-retention (evolutionary explanations)**

Raising awareness of the strategies used by romantic and/or sexual partners to keep their partner from cheating can help people alert their family and friends before violence even occurs. By seeking or being offered help earlier on, we may be able to reduce the amount of physical harm that people may suffer at the hands of their partners. This is especially important in the domestic abuse of men as they are less likely to report it or even recognise it. (ONS BCS, 2016)

**Implications for the Clinical Setting**

Claiming that aggressive behaviour is a result of biological mechanisms has many implications, clinically and legally. It is important to treat this topic with sensitivity as it deals with cases such as rape and murder and may be interpreted as removing the blame, either wholly or partially, from the perpetrator.

It is important to look at the possible causes of something if we wish to treat or prevent it. Though aggression is not a medical condition, it features in various illnesses and is a symptom that many patients and their families want to reduce. Some medical causes of aggressive behaviour are: autism spectrum disorder (ASD), attention-deficit hyperactivity disorder (ADHD), bipolar disorder, schizophrenia, and brain damage (stroke, head injury) that limits your ability to control aggression. (Healthline, 2016)

Sometimes, the underlying reason for behaving aggressively can be due to stress or frustration in communicating feelings, especially in children. These can often be reduced by acknowledging the underlying reason and making accommodations, such as using different ways of expressing oneself. This is particularly central in conditions where barriers to communication already exist, such as ASD. Beyond advice and psychological therapies to understand the reasons for someone’s aggressiveness, clinicians can also prescribe medications that help. Mood stabilisers can be prescribed in bipolar disorder or schizophrenia that may help to regulate emotions, reducing aggression in those who present with it. (Healthline, 2016)
When aggression is caused by a medical condition, a doctor can try to treat the condition to alleviate the symptom of aggression. However, if aggression continues, or exists outside of a medical diagnosis, how can we treat it? If low levels of serotonin are considered the cause of a person’s aggression, treatment may be as simple as a course of antidepressants. But what other options exist?

If a genetic predisposition is identified, should we screen for it and explore gene therapies? Should we consider rejecting or modifying embryos with identified genes? The answers to these questions are beyond the scope of this essay but may someday be pivotal to people’s lives if these explanations are accepted as medically significant. Treatments built on biological theories will unleash many ethical debates as we are interfering with people’s nature. The next section on legal implications will discuss this in further detail.

Currently, treating medical conditions and offering psychosocial therapies are the main remedies. It is important to consider the societal and environmental factors that trigger predispositions. Psychology can help us tackle these and teach people how to better regulate their emotions. However, the evidence on the effectiveness of these interventions is limited for some populations so other methods may need to be explored. (Ali et al., 2015) Gene therapy for specific genes is developing constantly though may not be available in the near future. To replace a ‘faulty’ gene with one that we think functions better could be used in the reduction of aggression, but ethical debates must be considered, as well as the various logistical issues. (Thome et al., 2011) Removing genes we deem ‘faulty’ from the genepool is effectively eugenics. When the genes relate to socially undesirable behaviours, we are tampering with the uniqueness of human nature, submitting ourselves to a dystopian world in which we are all expected to fit a mould of how to be human.

**Implications for the Legal System**

Glenn and Raine (2014) discuss three aspects of the legal implication of this research: punishment, prediction, and prevention. Prevention has been discussed above so will not be included in this section.
Punishment

Perhaps one of the most far-reaching questions in this area, can someone with a biological reason for committing a violent crime be held responsible for their actions? Glenn and Raine (2014) highlight the case of a schoolteacher who molested his stepdaughter. This was attributed to a brain tumour which was resected. His behaviour returned to normal, but months later, his wife found child pornography on his computer. When this happened, it was found that the tumour had regrown. Its removal returned his behaviour to normal once again. Can this man be blamed when his actions were likely a direct result of a biological factor that he could not control?

In Thailand, a schoolteacher battered his wife to death after he found out she had met with a former boyfriend. This illustrates aggression due to sexual jealousy. The court gave him a suspended sentence of two years, sparking outrage from feminist groups. (Head, 2002) If it is ‘in a man’s nature’ to assault his partner for suspected infidelity, should he face legal action?

The degree of responsibility needs to be carefully assessed in every situation to determine if a person is blameworthy. Glenn and Raine (2014) suggest that criminals are “assessed on a continuum using measures that include neurobiological variables.”

“Although a sensible dividing line needs to be drawn for practical reasons, in theory one can conceive of a set of multiple neurobiological and genetic influences that, combined with social influences, diminish responsibility to varying degrees. To the extent that neuroscience provides reliable methods to document these influences objectively, and assuming that methodologies become less expensive and quicker and easier to implement than hitherto, we anticipate that responsibility will eventually be conceptualized more broadly than it is today.”

Prediction

Even if the relationships between biological factors is only correlational, there may be value in predicting the likelihood of a released prisoner reoffending. (Glenn and
Raine, 2014) However, though we may be able to tell which people are more likely to be aggressive, we cannot precisely say whether they will go on to commit misdemeanours or more serious crimes, even if their history gives us some idea.

It is easier to collect data on someone’s behavioural, social, and psychological circumstances than their biology but if we can do this, should we? In the UK, police can take DNA samples of anyone they arrest, without the person’s consent. Whilst some may argue that it is unethical to use offender’s DNA, some may say we have a moral obligation to use it to enhance probation and parole decisions.

Beyond this, there are far-reaching consequences of applying predictions to non-offenders. Labelling someone as predisposed to aggression can create stigma. Between this and self-fulfilling prophecies, people may face increasing psychological pressures that trigger the pathways resulting in aggression. Sometimes ignorance is bliss. In addition to this, false positive results would put those at lower risk of offending in a position where they are told they almost definitely commit crimes.

Furthermore, by saying our violent behaviours are out of our own control, will people be less inclined to inhibit themselves to follow norms, relying on their biology for mitigation?

An insidious implication of predicting someone’s behaviour relates to eugenics. In a horribly dystopian world, those with less desirable biological characteristics may be forcefully sterilised in an attempt to eradicate aggression. More subtly, those with predisposing factors may be encouraged or feel that they are expected to be more careful if they are planning on having children. Some bright spark may even decide, as our proficiency in altering biology advances, that we should genetically engineer embryos so that they are less likely to be criminals.

**Conclusions**

Whilst this essay is by no means a comprehensive overview of biological mechanisms behind aggression, it gives us an insight into some of them. Despite limitations to the data, there is still some value in the findings. For a clinician, it can be useful to know what biological processes to tackle to reduce aggression. Often,
treating underlying disease processes will be the solution but a myriad of pharmacological and psychological interventions could be explored, if necessary.

It is unlikely that a huge change to the legal system will occur in the near future because of this research, but there is potential for influence, both in deciding how to punish someone, and predicting rates of reoffending.

There is plethora of other mechanisms to be explored. This includes neuroanatomy, epigenetics, and perinatal mechanisms. These can help further influence our practices. Collating these different explanations must also be prioritised. The most useful part is to understand how the environment interacts with these to trigger or worsen behaviours. Though we should be aiming to reduce poverty and abuse anyway, this research may help to promote the need to improve the psychological wellbeing of those who are exposed to more triggers.

Therapeutically, the brain is the biggest target. Even if genes are linked to aggressive behaviour, there is an intermediate process in the brain before any behaviour is acted out. This means that it may be more beneficial to target the brain, rather than use gene therapy (if available). This could be through drugs, supplements or psychological interventions. Omega-3 supplementation is shown in randomised controlled trials to reduce up to 34-36% of serious offending in young people (Zaalberg et al., 2010 cited in Glenn and Raine, 2014; Gesch et al., 2002 cited in Glenn and Raine, 2014) whilst mindfulness has been shown to reduce aggressive behaviour in offenders. (Himelstein, 2010 cited in Glenn and Raine, 2014; Wupperman et al., 2012 cited in Glenn and Raine, 2014) Behaviour cannot be entirely divorced from biology but there are cognitive pathways we do not understand that may be tackled more effectively with psychological techniques.

Some recommendations from this research are:

- Reducing access to weapons (though the topic of further gun control in some countries is still controversial)
- Tackling prejudices in vulnerable groups, as shown in the sporting world
• Minimising environmental risk factors that trigger aggressive behaviours (such as poverty or domestic abuse)

Regardless of where the research takes us, it is important to have thorough discussions about how to ethically implement any changes, or if they should be implemented at all. This is especially imperative for permanent treatments – another era of lobotomies is not the most desirable outcome, for the scientific community or the patient. At all stages, people should have as much autonomy over these decisions as possible, regardless of their criminal status. Many of the proposed questions here are unanswered and may remain unanswered for a long time but working together to understand and reduce aggressive behaviour in a thoughtful manner may help us achieve something that resembles more of a utopia than a dystopia.
REFERENCES


MacDonald, K., 1992. Evolution, the five factor model, and levels of personality. Journal of Personality, 63, pp.525-567.


