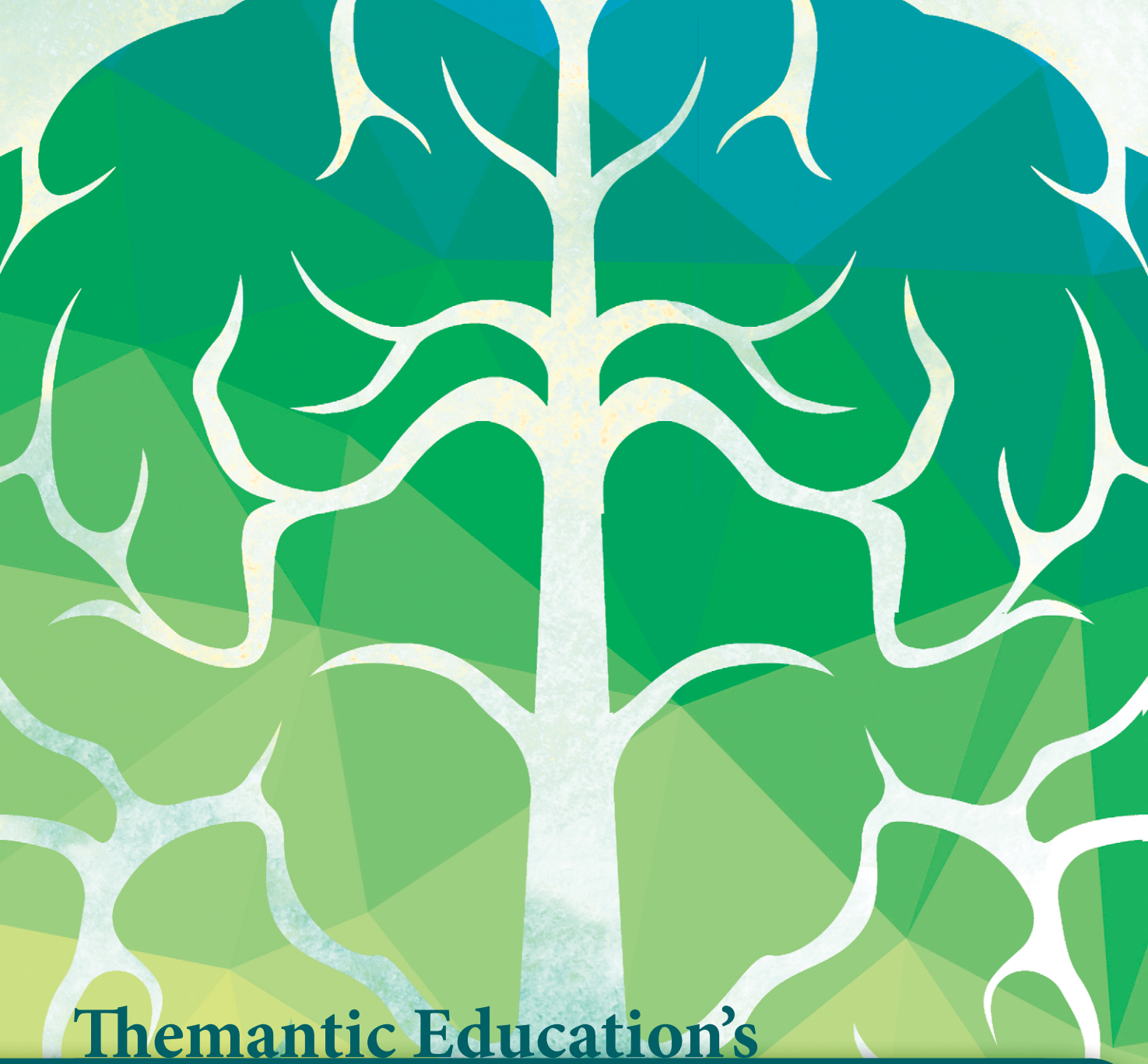

Themantic Education's

IB Psychology

A Student's Guide

PREVIEW

Travis Dixon

Contents

Chapter 2

Criminology

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Introduction

In the middle of the night on August 1st, 1966, 26-year-old Charles Whitman sat down at his typewriter in his house and began typing a letter.

It begins:

"…I don't really understand myself these days. I am supposed to be an average reasonable and intelligent young man. However, lately (I don't recall when it started) I have been a victim of very unusual and irrational thoughts." Later that night, Whitman drove to his mother's house and killed her. Before leaving, he wrote a note and left it next to her on the bed:

"TO WHOM IT MAY CONCERN,

I've just taken my mother's life. I am very upset over having done it. However I feel that if there is a heaven she is definitely there now…"

Later that night Whitman murdered his young wife, Kathy, while she lay sleeping in bed. He stabbed her numerous times in the chest. Before he did this he wrote another letter…"…It was after much thought that I decided to kill my wife, Kathy, tonight after I pick her up from work at the telephone company. I love her dearly, and she has been as fine a wife to me as any man could ever hope to have. I cannot rationally pinpoint any specific reason for doing this." (Austin History Centre)

Later that day Whitman drove to the University of Texas at Austin campus, where he was a student. He had packed a huge case filled with guns, ammunition, food, water and enough supplies to last for a few days. He climbed to the top of the observation tower that looks out over the campus and the city. Whitman killed the receptionist with the butt of a rifle. He then set up his sniper rifle on the tower and began taking aim at innocent people as they walked around the campus.

Charles Whitman. (Image from wikimedia commons)

In two hours of what must have been horrific terror for the people of Austin, Whitman killed 14 people, and injured over 30 others.

What are your thoughts when you hear the story of Charles Whitman?

Whitman's case was and still is a mystery, like many murderers and

PREVIEW

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serial killers who seem to kill without reason. But your job as a psychologist isn't necessarily to judge people's behaviour, it's to investigate the research in order to understand it. In this chapter you are going to be introduced to the fascinating subject of psychology by looking at criminal behaviour.

In understanding how and why people behave and think the way they do, we have to consider multiple factors – including biological, environmental, cultural and social influences. By the end of this chapter, you're going to be challenged to answer this question: How might a variation of the MAOA gene increase an individual's probability of being violent?

If you can keep up with the guiding questions and you understand the significant relationships explained in each section, by the time you reach the topic of genetics you will hopefully be able to answer this really difficult question. In doing so you'll realise that understanding human behaviour is rarely simple.

2.1 The Brain and Behaviour

How might brain damage affect our behaviour?

(a) The Frontal Lobe

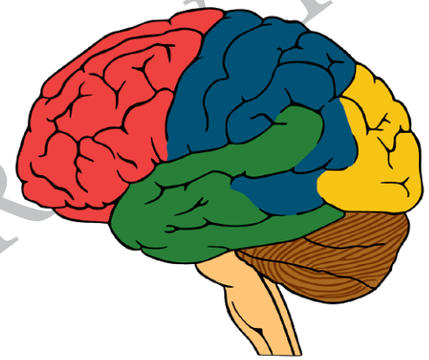
In this first introduction to understanding violent crime, we're going to focus on the most important organ in our bodies – the brain. As you'll remember from the introduction, it's always important that you analyze the evidence when making conclusions about behaviour. Remember that understanding human behaviour and mental processes is about understanding relationships, and research (studies and theories) can demonstrate those relationships.

Numerous studies have shown that there are correlations found between brain function and violent behaviour. Moreover, there are specific parts of the brain that appear to be different in some violent criminals than in non-violent, ordinary people. In order to fully understand these concepts, it's important to have a general understanding of some of the functions of important parts of the brain first.

Localization of Brain Function: This describes the concept of different parts of the brain having different functions.

When discussing the brain in psychology, researchers refer to specific areas of the brain. Different areas of the brain perform different functions, a concept known as localization of brain function.

The brain is generally divided into different lobes, as shown in the image. To begin with, we're going to begin our focus on what I think is one of the most interesting parts of the brain – the frontal lobe.



Our brain is made up of different lobes. For now we are going to focus on the frontal lobe (in red) and later in this chapter you will learn about the temporal lobe (in green).

One important function of the frontal lobe is to regulate our impulsive behaviour and decision making. When the frontal lobe is functioning normally it kind of acts like a "break" on our impulsive behaviour. So when you get really angry at your teacher/parent/friend and you want to yell and scream at them but don't because you know that it might get you in trouble - you have your frontal lobe to thank. Or if you're walking down the street and you see an attractive person and you think, "Wow! They're gorgeous!" and you keep that thought to yourself

– once again, you have your trusted frontal lobe to thank. Teenagers' frontal lobes are still developing and are not fully formed until later in adult life, which might explain why teenagers can be more impulsive and more likely to take risks than boring adults.

But how do we know about the functions of the frontal lobe? Well, how do we "know" anything in psychology? We always have to consult the research. And there is a lot of research on the frontal lobe.

One of the most famous studies of a man who had severe damage to his frontal lobe was that of Phineas Gage. I'm going to tell you Gage's story because it's really interesting and I'll guarantee you that you remember this story for a long time, probably because of its gory details. But I will also say that it's best if you forget about him come exam day. We're going to investigate far better evidence regarding the functions of the brain, and the frontal lobe. I introduce Gage here because it's a fascinating story, but also because it generally marks the beginning of studies into understanding neuropsychology.

Neuropsychology: The study of the complex relationships between the brain and behaviour.

Gage was a railroad worker who was putting dynamite into rocks while working with a team to lay train tracks. As he used a six-foot bar to pound the dynamite powder into the rocks it ignited, essentially making the long steel pole a bullet that fired up through his left eye socket, through the top of his skull and landed about 50ft away. Gage survived and was even conscious while he rode on the cart to the nearest town to get help. He went to see the doctor and probably said something like, "can you help me with this?"

Phineas Gage posing with the steel rod that shot through his frontal lobe.

As a result of the incident, Gage's behaviour seemed to change as he went from being a rather mild-mannered man to "no longer Gage" as his friends said. Reports have even said that he was no longer allowed to be around women because he would often say rude things to them. This was in 1848 and Harlow, the doctor who treated Gage, made a few observations about the change in Gage's behaviour that has made him one of the first and most famous cases that links brain damage to our personality, our "sense of self' and also to our ability to regulate (control) our behaviour (Smithsonian Magazine). It is this final function that we're going to explore further.

Guiding Question:

How does Phineas Gage's case suggest that damage to the frontal lobe affects impulsive behaviour?

Critical Thinking Extension:

Causation v Correlation: Many students make the mistake of jumping to conclusions like, "Phineas Gage's study proves that damage to the frontal lobe causes impulsive behaviour." In order to deduce causation we need to eliminate the possibility of other factors other than the brain damage affecting Gage's behaviour. What other alternative explanations could there be for the change in Gage's behaviour?

If you're interested…

You can find plenty of information about Phineas Gage online, including one article by the Smithsonian Museum's online magazine. The article is called "Phineas Gage: Neuroscience's Most Famous Patient." The neuroscientist Robert Sapolsky also explains the case of Gage in one of his Stanford lectures (available on YouTube) and he says jokingly, that they take your license away if you don't explain Phineas Gage in an introductory psychology class and I took his warning to heart.

(b) The Prefrontal Cortex and Aggression

Aggression: Feelings of anger and hostility towards someone or something, often resulting in violent actions.

Since Gage there has been a lot more research into the functions of frontal lobe, especially the area within the frontal lobe called the prefrontal cortex (PFC). The prefrontal cortex is a more specific area within the frontal lobe. It's at the very front of the frontal lobe; it's the area of the brain just above the eyebrows beneath the forehead. The term lobe refers to the whole section of the brain, whereas cortex refers to the dense outer layer of the brain.

Like Gage's study first suggested, lots of recent research has shown that an important function of the prefrontal cortex is to regulate our impulsive decision making and our emotion. This has been shown partly through studies that show people with prefrontal cortex damage lack an ability to inhibit their impulsive behaviour, may not be able to behave in socially appropriate manners and may be easily provoked into aggression. Studies have also shown that there is a correlation between low functioning frontal lobes and criminal behaviour. (Clark et al., 2008; Blair, 2010)

Understanding the biology behind criminal behaviour is a popular and important field of study. British criminologist Adrian Raine has conducted many studies investigating biological correlates of criminal behaviour. He and some of his colleagues carried out a study in 1997 with the aim of comparing the brains of convicted murderers with those of healthy controls (i.e. people who had never been convicted of violent crime). The results showed that there was less activity in particular areas of the brains of the murderers, including less activity in the prefrontal cortex. (Raine, Buchsbaum & Lacasse, 1997)

Raine's studies, like many others, can show us that the brains of violent criminals are different to "normal" controls. But it only suggests a correlation and leaves a lot of uncertainty. Another way of studying how the brain can influence behaviour is to find people who have existing brain damage in particular areas of the brain and to compare them with control groups.

During the Vietnam War many soldiers received injuries to their brains from a variety of factors (e.g. bullets, explosions, land mines, etc.). The use of brain imaging technology (e.g. MRI – see section on brain imaging technology for more information) allows researchers to pinpoint the exact location of the damage and to find those participants who have damage in areas of specific interest, like the prefrontal cortex.

The Vietnam Head Injury Study (VHIS) is a longitudinal study of over 1,000 American veterans of the Vietnam War that aims to research the impact brain injury has on behaviour. One such report from the VHIS came from investigating the connections between frontal lobe damage and the influence this damage had on the aggressive tendencies of the patients. (Grafman et al., 1996)

Based on prior research, the researchers hypothesized that the prefrontal cortex helps exert control over automatic reactions to environmental provocation. In other words, when something makes us emotional, our prefrontal cortex functions to help stop us from reacting in a violent or aggressive manner. To test this idea, the researchers compared Vietnam War veterans who had suffered brain injuries with healthy controls (people with no brain injury). The veterans were also divided into those who had injuries specifically in the prefrontal cortex, and those who had damage to other areas

Many war veterans end up with brain injuries. The Vietnam Head Injury Study uses this naturally occurring variable to further our understanding of brain function. (Image credit: Fotoshop Tofs, on pixabay.com).

of the brain. MRI machines were used to locate the damage in their brains.

The researchers hypothesized that because of the role of the prefrontal cortex in inhibiting impulsive behaviours (e.g. reacting violently to someone who makes you angry) those veterans with damage in the prefrontal cortices would demonstrate more aggression than those with no damage or damage to other parts of their brain.

The researchers gathered data on a range of aggressive and violent attitudes and behaviours of the participants using self-report forms (e.g. questionnaires) and family observations. This means they measured aggression by asking questions such as, "How often do you react with physical aggression when someone makes you angry?" (Never, Sometimes, Always, etc.) Or, "How often do you swear or shout at people who make you angry?" Etc.

The results showed that those veterans who had damage to their prefrontal cortex had higher levels of reported violence and aggression than the controls or veterans with damage to other parts of the brain. By using MRI technology and being able to compare the three groups in the study, the researchers were able to draw the conclusion that damage to the prefrontal cortex is more likely to lead to aggressive behaviours than no damage or damage to other areas of the brain.

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This is an interesting finding and it's a good basic introduction to the study of the brain and behaviour. However, the issue with this study is that it doesn't tell us how damage to the prefrontal cortex might influence our behaviour: we'll get to that in the next section.

Guiding Question:

How does the Vietnam Head Injury Study show that damage to the prefrontal cortex may affect aggression?

Critical Thinking Extension:

Evaluating Methodology: On the surface, it appears this study may show a relationship between prefrontal cortex damage and aggression. But you have to think critically about the methodology. They measured aggression and violence by using self-report forms, which are the participants' own answers to the questions. When evaluating research methods, we have to think about their effectiveness in investigating the specific relationship we're investigating. So in this study, to what extent are self-report of violence and aggression useful ways of gathering data? In studying aggression, would people always be honest?

If you're interested…

The magazine The New Yorker has an article called "Vietnam's Neuroscientific Legacy" that goes into more detail explaining this longitudinal study on Vietnam war veterans and the significance of its findings.

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Relevant Topics

- Ethics
- Research Methods
- Localization of Brain Function
- Origins of conflict

Practice Exam Questions

- Outline one method used in a study related to localization of brain function.
- Evaluate one origin of conflict.
- Discuss ethical considerations related to studying the brain and behaviour.

Research Methods

When studying the relationship between brain damage and behaviour researchers may use correlational studies. In Grafman et al.'s study the two variables being correlated were the size of the lesion in the brain and the extent of aggressive behaviour. Conducting correlational analyses and finding correlational coefficients can enable conclusions to be drawn between naturally occurring brain damage and changes in behaviour.

Ethical Considerations

When studying sensitive subjects like aggression, anonymity is an important consideration. Individuals who display high levels of aggression, especially in family situations, would probably not want their level of aggressiveness made public. Informed consent is also important when investigating such sensitive issues and using tools like questionnaires: participants would want to know why the researchers were asking such personal questions *before* they participated. Not knowing this information beforehand could lead to stress, embarrassment or frustration.

2.2 The Brain and Decision Making

How might brain damage affect the way we think?

(a) Judgement, Processing and Decision Making

Hopefully you have started to see how the research paints a pretty strong picture of the effect damage to the prefrontal cortex can have on our behaviour. But so far the evidence we've looked at can't really tell us exactly how the prefrontal cortex influences behaviour, only that it does. In order to know exactly how damage to the prefrontal cortex can influence aggression, we need to go deeper inside the brain.

But first, we need to move beyond just the brain, and look inside the mind!

Let's first look at an interesting experimental paradigm that involves a child, a marshmallow and a ten-minute wait with the prospect of two marshmallows. A paradigm is a pattern or typical example of something; in psychology there are many experimental paradigms which means a general design of a study that is often used. This experimental paradigm involves putting a child in a room and giving them one marshmallow. A researcher tells the child that they have to wait ten minutes and then if when the researcher comes back the marshmallow is still there, they'll be given a second marshmallow and they can eat both. Could you imagine the poor little kids having to resist this temptation? Some kids can, and others can't (e.g. Mischel, Shoda, & Rodriguez, 1989; Mischel et al., 2011).

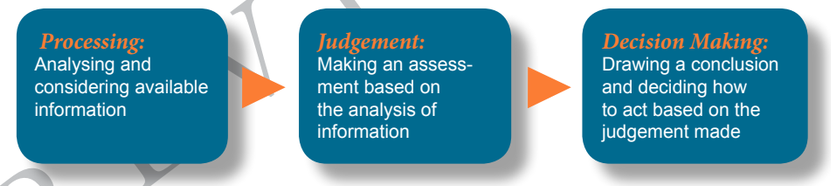
These experiments with marshmallows are typically done on small children because if we tried it on teenagers, the prospect of having two marshmallows might not

If you were a young kid, do you think you'd be able to wait ten minutes for another marshmallow? Try to imagine what kinds of thoughts would be going through a child's head as they wrestle with this problem.

be that enticing. But would you have a hard time waiting to get something you really loved right now, if it meant by waiting you could get more of that awesome thing? We're going to see how the ability to control our initial impulse and to think more about the future is a key function of the prefrontal cortex. As you learn more about this fascinating part of the brain, perhaps you'll be able to hypothesize explanations for why studies have shown that those kids who can wait for two marshmallows are more likely to grow up to be successful in school.

First, let's try to understand the decision making process that might be happening in this scenario. There are many theories of how and why decisions are made, but here we're going to look at a pretty basic one that might help us understand human behaviour a little better. After all, we can't understand behavior (the way we act) without thinking about cognition (the way we think).

Deciding how to behave in a particular situation first involves processing the information available to you before making a judgement about that information and then making a decision. If we think about this in terms of the research we've just seen on the Vietnam veterans, imagine the door bell ringing at dinner time. The family is around the table, everything's peaceful, and then "ding-dong"! Dad reacts by storming across the room and shouting down the hallway, "don't you know it's dinner time???!!!!" But Dad didn't do this without thinking – his brain didn't automatically just make him do it. He had to perform a series of mental processes that lead to his shouting and getting angry. First, he needed to process the information (the door bell ringing, the time of day), then make a judgement (no-one should be knocking at this time) and then make a decision (to shout at the person knocking).



Here we see that to understand the behaviour (e.g. being angry) we have to also understand the thinking. The cognitive processes involved here are processing, judgement and decision making. While this seems like a basic concept, knowing how these three relate to one another is key to understanding the rather complex theory explained in the next section.

Guiding Question:

How might processing be influencing the judgement and decision making of the children in the marshmallow study?

Critical Thinking Extension:
One of the studies you will study later in this section about judgement and decision making involves a gambling task. Think of a type of gambling that you are familiar with (e.g. betting on sports, horse races, playing poker, slot machines, etc.). Can you explain the relationship between processing, judgement and decision making involved in that particular type of gambling?

If you're interested…

There are some interesting TED talks about the marshmallow experiment that you can watch. One is called "The Marshmallow Test and Why We Want Instant Gratification" by Silvia Barcellos.

(b) A Dual Process Model of Decision Making

"Dual" means two, so in psychological theories, a dual theory means there are two factors involved. The following theory about how we make decisions is based on how we process the information available to us in order to make the decision. The less we process the faster we make a decision. Conversely, the more we process the longer it takes for us to make a decision.

So for Dad's example when the doorbell rings at dinner time, some Dads might not process much at all and hear the bell (or knock) and ***snap!*** They get angry. Another Dad might hear the bell ring, become irritated, but then think "maybe that's Grandma coming to tell us how Grandad's operation was."

Kahneman (2003, 2011) has proposed a dual process model of thinking to explain two types of processing involved when making a decision.

The dual process model is a general description of how we process information by using different systems when making decisions.

They are appropriately known as:
- System One Processing
- System Two Processing

When we process information using system one it's fast and automatic. It's also often based on emotion (Kahneman, 2003). In other words, when processing information using system one we make a decision without really thinking about it. So getting angry and snapping at the doorbell is processing information using system one. The information in this example is the doorbell ringing – processing involves thinking about that information.

System Two is "slower…effortful and deliberately controlled" (Kahneman). When processing information using system two, we take our time and consider more factors. So processing the doorbell ringing using system two requires a little more thought, taking into consideration more factors like "who might this be?"

Two Systems of Processing Involved in Thinking and Decision Making

System One	*System Two*
• Fast • Nonconscious • Automatic • Based on experiences	• Slow • Conscious • Controlled • Based on consequences

Let's go back to the kids and the marshmallows. Some kids probably ate the marshmallow straight away as soon as the researcher left the room. But others struggled, they agonized, they fought the temptation. They were probably continually trying to think about the prospect of getting two marshmallows for their efforts. According to the dual processing model of decision making, they were processing using system two, again and again and again for ten whole minutes – thinking about those other factors like how great it will feel to have two marshmallows. Here we see the decision making isn't just applicable to one situation (aggression) and we could apply this theory to many types of behaviours. In fact, findings from the Stanford Marshmallow Experiments have found that kids that can resist the temptation have a higher chance to grow up

to be successful in many ways, including higher SAT scores, lower stress and lower chances of becoming addicted to drugs (Mischel et al., 2011).

Let's look at one more possible example of what this might look like: you're sitting in a test with 20 multiple choice questions and you really want to do well. You're at the front of the class and the supervising teacher has fallen asleep with the answers sitting in front of him. You need to pass the test in order to pass the class and you can simply sneak a peek and see the answers. Processing the information available using system one would involve not thinking past the "need to pass, see answers, get answers!" Using only this system might lead you to look at the answers and copy them into your test so you could pass the class. You've made this decision quickly and haven't thought too much about it. However, using system two processing might override this initial response as you think more carefully about the possible long-term consequences of your actions: "what if the teacher wakes up and I get caught?" "What if I pass but then I might feel guilty for the rest of my life?" "What if they're not even the actual answers?"

What the dual-process model allows us to do when explaining people's behaviour, is to hypothesize (based on the theory) how the person might have made the decision to act. You'll learn in later sections how damage to the brain might influence the ability to use system two processing.

Guiding Question:

How can the system used in processing influence judgement and decision making?

Critical Thinking Extension:
Evaluating Psychological Theories by Challenging Assertions: when learning about new **theories** (e.g. Dual Process Model), it's always tempting for students to think of these as facts and to talk about them as facts because "I read it in the textbook so it must be true." It's true that the dual process model is ***one*** explanation of decision making, but it is not the only explanation. Try to see if you can come up with examples of decision making that can't be explained by this model. I.e. test the theory! This is one way of critically assessing psychological theories: examining to what extent they are accurate in explaining the **phenomenon** in question.

If you're interested…

The American Psychological Association (APA) has many interesting resources related to all fields of psychology. In particular, they have an article available called "Delaying Gratification" which goes into detail about the Stanford Marshmallow Experiments, including research using fMRIs to test the function of the prefrontal cortex when people are presented with something tempting. You might also be interested to read Daniel Kahneman's book, *Thinking, Fast and Slow*.

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(c) PFC Damage and Decision Making

We're now going to examine the role the prefrontal cortex has on our decision making and how it might influence our ability to use the systems outlined in the dual processing model of thinking and decision making in the previous section. The study that we're about to look at suggests that one role of the prefrontal cortex is that it allows us to plan and make decisions based on long-term consequences. In other words, it allows us to process information using system two. We have other areas of the brain that allow immediate responses without much thought, but it's the prefrontal cortex that allows us to exercise control over those initial responses based on consideration of other factors. For example, studies have shown that people who are able to resist temptation and show self-control (using paradigms like the marshmallow test) have higher function in their prefrontal cortex than those that can't (Casey et al., 2011).

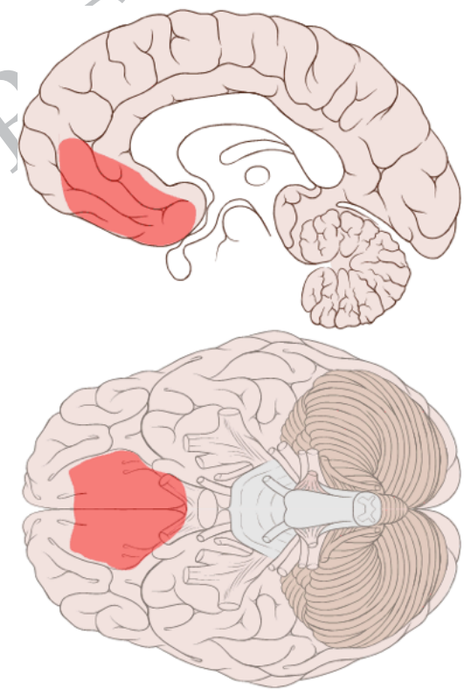
Based on these two systems involved in decision making and what we know about the prefrontal cortex already, it seems plausible that people with dysfunction in the prefrontal cortex may have an impairment in their ability to use system two processing and rely more on system one when making decisions. We could hypothesize about this in the Vietnam Head Injury Study, as I've done so far with the Dad and the doorbell example. But these are just my hypotheses made up in my imagination – we need strong, solid, empirical evidence from studies that can clearly show the connection between our prefrontal cortex and our ability to process information.

Empirical Evidence:
Information and knowledge gathered through observation and experimentation.

Many studies have shown that people with lesions in their prefrontal cortices are primarily guided by immediate rewards and may not think about long-term rewards or punishments (Kim & Lee, 2011).

Within the prefrontal cortex there is a more specific region called the ventromedial prefrontal cortex. The parts of the brain are often named for their location. Frontal – front. Medial – in the middle. Ventral – means on the bottom. So this very specific name – ventromedial prefrontal cortex, means it's in the cortex (outside), in the prefrontal region (front) towards the middle (medial) and the bottom (ventral). We began broadly but you'll begin to see that the brain is so complex and the function is very specific in very specific areas.

If you can't remember ventromedial prefrontal cortex, you can skip out the ventromedial part. But the more specific terminology you can learn and use, the clearer your explanations in psychology are going to be. Many studies have



The ventromedial prefrontal cortex is a specific area within the PFC. It is highlighted in red in the image. (Image by Patrick J. Lynch from wikicommons).

investigated patients who have damage to the ventromedial prefrontal cortex and they have shown an inability to learn from previous mistakes and to continue to repeat behaviours even when they result in negative consequences. Other aspects of their cognitive capabilities (intellect, problem-solving, memory, etc.) remain normal.

Cognitive capabilities: This refers to one's ability to perform cognitive tasks.

Before we consult the research into the relationship between the function of our brain and our ability to process information, it's important to understand how cognitive processes are investigated in experimental situations. Of course we can't see the mind (at least not yet!). I don't know what's happening inside your mind, for instance. So how can we investigate this in psychology? What happens is that psychologists design an experiment and their dependent variable is the behaviour – that's what they measure. So they have to design really clever experiments to see the relationship between the thinking and the behaviour. Their independent variable might be a type of task that they think requires different types of thinking, and then they measure the product of that thinking by doing some kind of test.

To test the dual process model, for instance, they design experiments that require the participant to process two different types of information and then they time how it takes them to respond. While the study in the next section did not have the specific aim of testing the dual processing model, it is a good example of how behavioural measures in studies can provide insight into cognitive processes.

Guiding Question:

How might damage to the prefrontal cortex influence decision making?

Critical Thinking Extension:
One way of abstracting relationships is to apply them to a different context. If you can understand how damage to the prefrontal cortex could influence decision making, how could this relationship explain the correlation between PFC damage and aggression? Or PFC function and future success in things like the IB exams or standardised tests? The ability to devise hypotheses that abstract one relationship to various contexts is a valuable thinking skill and one you should work on developing as you progress through this course.

If you're interested…

There's a book called *The Teenage Brain: A Neuroscientist's Survival Guide to Raising Adolescents and Young Adults*. As you're a teenager, you might like to know how your brain is different now from when you were a little kid and how your brain is going to change over the future years. There is a lot of research in the field of the brains of teenagers, especially that which focuses on why teens tend to engage in more risky behaviours than us boring old adults.

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(d) Processing and Decision Making while Gambling

In the following study researchers measured the gambling behaviour of participants in order to draw conclusions about the role of a particular area of the prefrontal cortex in decision making. Based on previous studies the researchers hypothesized that patients with damage to their ventromedial prefrontal cortices may not consider future consequences of their behaviour. This could be because of the ventromedial prefrontal cortex's role in processing information.

One study compared 17 healthy controls with 8 patients who had lesions in their ventromedial prefrontal cortices. By comparing the healthy controls with the patients with damage, they could focus on one variable – the proper functioning of the ventromedial prefrontal cortex (Bechara, Tranel & Damasio, 2000).

They played what has come to be known as the Iowa Card Game or Iowa Gambling Task (named after the university where the research took place). This has been used in many studies and you can play it for yourself online.

The Iowa Card Game has been used in many studies. Originally they used real playing cards, but changed to having just red and black cards as people tried to overthink the possible patterns.

It's tricky to describe, but basically there are four decks of cards and participant are told they can choose from any deck of cards. They start with $2,000 (*not* real money) and they win money randomly when they pick cards from either deck. But sometimes they might have to pay back money – this is why it's gambling.

There are two decks whereby the initial money won is rather small (e.g. $50) and two decks where the money won is larger (e.g. $100). But the smaller reward deck also has smaller penalties (so you might have to pay back $50 every fifth turn), but the larger initial reward deck has bigger penalties (e.g. you have to pay back $1,250 after nth turn). So in the long run it makes more sense and you'll win more money if you can resist the initial big reward and go for the shorter initial payment with the better long-term gain. There is no real strategy involved[1] except learning to go for low rewards. The game is designed to see how people adjust their thinking (and behaviour) based on learning from experience. Perhaps it's important to note that this was *play* money and they were not really gambling with figures this high – it might have been a very expensive experiment to run if they were!

So there are four decks of cards like below. The cards are just red or black – it's not about what card they turn over that determines how much money they win. There are just two different types of decks: low reward – long term gain (A and C) or high reward but higher long-term losses (B and D). It's important to know that the participants weren't told which deck was which. *They had to learn from experience.*

So the participants had to process information using two systems. According to

Deck A	Deck B	Deck C	Deck D
Win $50 nine out of ten times One out of ten times pay back $50	Choose from here and win $100 7/10 Pay back $100 2/10 times Pay back $1250 1/10 ten times	Win $50 nine out of ten times One out of ten times pay back $50	Choose from here and win $100 7/10 Pay back $100 2/10 times Pay back $1250 1/10 ten times

[1] *In fact, the researchers began by using actual playing cards but they found this to be a confounding variable because people thought too much about the possible patterns and it took too long to realise the obvious difference between the two decks.*

PREVIEW

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This gambling study can show biological evidence to support the dual processing model of decision making. It also demonstrates one localized function of the ventromedial prefrontal cortex.

the dual processing model, system one processing would lead to a fast and automatic decision because it would be based on instinct. Not many factors would be considered except for something like, "Go for high reward!" But system two processing would require more careful consideration – I want money, but actually I might have to pay back more money so is it the best option? More factors would have to be considered.

The results showed that the healthy controls slowly learned to avoid the decks of cards with high rewards but bigger long-term punishments, and opted instead for the low immediate reward but with longer long-term gains (due to less punishments).

However, the patients with damage to their ventromedial prefrontal areas chose the decks with the higher immediate rewards which had long-term punishments. This pattern took a few trials to emerge but generally remained throughout the remaining trials. The patients were less able to consider the long-term factors and consequences of their impulsive decisions, unlike the healthy controls.

Guiding Question:

How does this study suggest that the vmPFC plays a role in system two processing?

Critical Thinking Extension:

Transfer: It's important that you are able to transfer your learning from one context to another. If what you learn in IB Psychology is only ever going to be useful within the context of IB Psychology, this will be a rather big waste of two years of your life. But if you can begin to transfer what you learn and use it in new ways, suddenly what you learn can stay with you for a long time. While the theme of criminology isn't always immediately relevant, and in fact, there's a good chance you won't even mention criminology in your exam answers, it's still valuable thinking practice to be trying to abstract significant relationships and to think about how they might be applied in various fields. As you've learned more about the role of the PFC in system two decision making, could this be relevant in areas of human thinking and behaviour that aren't related to criminology? How could PFC function affect learning or studying or addiction, etc.?

If you're interested…

At time of writing there is an online version of the Iowa Gambling Task available. Playing this game for yourself is a good way to learn about the methodology of the study.

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Relevant Topics

- Thinking and Decision Making
- Ethics and Research Methods (BA and CA)
- Localization of brain function
- Origins of conflict

Practice Exam Questions

- Outline one theory of thinking and decision making.
- Explain two ethical considerations related to research on thinking and decision making.
- Discuss research into localization of brain function.
- Evaluate one theory of thinking and decision making.

Research Methods

The natural experiment is valuable when studying biological correlates in thinking and decision making. Neuropsychology involves the study of the relationship between biological factors and cognitive processes like thinking and decision making, so using the experimental method where participants have naturally occurring brain damage allow researchers to focus on the relationship between particular areas of the brain and cognitive processes.

Ethical Considerations

Debriefing would be an important consideration in studies using the Iowa Gambling Task because participants may be curious to know why they were being asked to gamble. Moreover, the results of the study and their impact on patients with vPFC damage may have particular relevance for them: they would want to know that their decision making might be impaired. This is a significant finding and knowing about it (or not) could have a major impact on their life.

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2.3 The Brain and Emotion

How might our brain affect our experience of emotion?

(a) Fear and the Amygdala

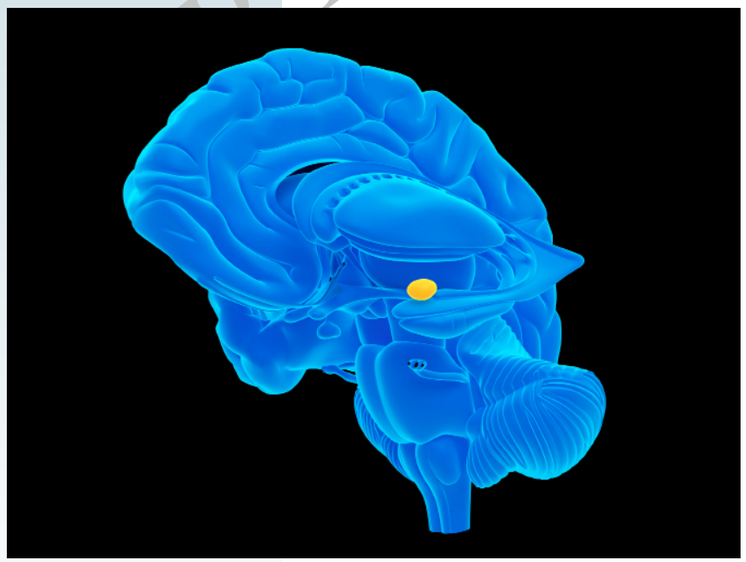
In the previous section you learnt about the frontal lobe and the prefrontal cortex, a section of the outer layer of the frontal lobe. We're now going to look deeper beneath the cortex within the temporal lobe at a part of the brain called the amygdala.

Another important area of study in psychology that involves brain function and mental processes is emotion. Emotions are universal and there's no single common definition of emotion or even types of emotions. For instance, could you objectively tell the difference between people who are "depressed" and people who are just "unhappy"? Or at what point does mild amusement become happiness and then jubilation? The feeling of emotion is a complex human experience and we need to always remember that when learning about it and drawing conclusions from research.

The word amygdala comes from the Latin for almond because the amygdalae are almond-shaped.

In order to understand this complex human experience, we have to investigate the relationship between the brain, thinking and emotion. To do this we're going to first look at the biological factors influencing one particular emotion – fear.

We're going to investigate fear because it's an important aspect of human behaviour that has many implications. Moreover, our response to fear is a type of response to a threat, which is an important idea in understanding violent crime. What may be useful to note is that criminals have been characterized as having a lack of fear and an inability to recognise fear in other people's faces (Herpertz, Werth and Lukas, 2001). For some types of crime, this seems to make sense. For example, if someone cannot feel fear then they may be more inclined to do something dangerous, like participate in a shoot-out with a rival gang or get involved in a street brawl. Not being able to detect emotion in others may also inhibit experiencing empathy for victims. If one can feel empathy they may be less likely to inflict suffering on others.



Unlike the prefrontal cortex on the outer layer of our brain, the amygdala is deep within the temporal lobes of the brain.

There is also a lot of evidence that dysfunction and abnormalities in the amygdala can be found in violent criminals (E.g. Raine, 1997). Later in this chapter you will learn more about possible relationships between fear and crime, but first it's important to understand where fear might come from[2].

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Our experience of fear is reliant on a few things. First, we need something to be afraid of. When talking about any emotion we call this the emotional stimulus. To keep it simple to start with, we'll be looking at *external* emotional stimuli related to fear. In other words, things in our environment that make us scared.

As usual, try to make connections to your own life. We've all felt fear before. When was the last time you were really scared!? What were the physical reactions in your body?

Spiders are an emotional stimuli for many people. Could you hold a tarantula on your hand without feeling scared?

Guiding Question:

How might a lack of response to an emotional stimulus explain violence?

***Critical Thinking Extension*:**

Generalizability: Does a lack of an emotional response explain all types of violence? The ability to think abstractly about relationships involves thinking carefully about the individual components of the relationship you are explaining. In this case, thinking abstractly about what violence means would enable you to assess the extent to which a lack of fear or emotional response might explain all types of violence. Types of violence include punching, stabbing, shooting, rape, etc.

If you're interested…

If the study of criminology interests you, Adrian Raine has a book called *The Anatomy of Violence: The Biological Roots of Crime*. As the title suggests, this book devotes itself entirely to studying the biological correlates of crime. We are merely skimming the surface of this fascinating topic in this course; reading books of this nature in your own time is a valuable way of pursuing your interests further.

[2] *We'll also study fear in more detail when we investigate origins of Post-Traumatic Stress Disorder*

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(b) SM: The Woman with No Fear

Studies on the functions of the amygdala go back as far as the late 1800s. Early studies on rhesus monkeys involved removing their entire temporal lobes. After this removal they found a change in a number of behaviours, including the fact that the monkeys lost emotional reactivity, meaning they didn't react in emotional ways to environmental stimuli. But this involved the removal of the whole temporal lobe – the amygdala is just one part of the temporal lobe. So further replication of these findings was carried out and the monkeys' amygdalae specifically were lesioned and the changes in behaviour were recorded. The results gathered were similar: damage to the amygdalae resulted in emotional blunting, a reduction in emotional reactions (Weiskrantz, 1956).

Numerous animal studies like this have suggested that the amygdala plays an important role in threat perception. But what about in humans? It is very difficult to study damage to such specific parts of the brain as the amygdala in humans. Unlike the prefrontal cortex, that is located near the skull and easily damaged, the amygdalae are located deep within the brain and so it's rarer to find people with damage in this area. Moreover, often when people do experience damage in this area (e.g. through a stroke or disease), they also have damage in other areas. However, there are some rare exceptions and when people with particular areas of brain damage occur, often they are the subjects of case studies. One such patient is known as SM, who the media have called "the woman with no fear" (Feinstein, Adolphs, Damasio & Tranel, 2011).

Most people would find walking through an abandoned hospital in the middle of the night very scary, but not SM. Her study helps to show the important function the amygdala plays in experiencing fear.

Like the monkey experiments, numerous studies on people with damaged amygdalae have shown that lesions in amygdalae of human patients result in a lack of fear. One such study was carried out on a patient called SM, a 44 year old woman with bilateral lesions in her amygdalae that were the result of a genetic disorder. Previous research has shown that she has an impairment in fear conditioning (learning to be afraid) and fear recognition (recognizing fear in others' faces). This was the first study on SM that tried to see if the amygdala played a role in the induction of fear - being made to feel scared. In all other ways SM is a normal person - her scores in IQ, memory, language tests and other tests of general cognitive function are as good as healthy controls.

One way they tested her fear was to take her to an exotic pet store where there were lots of snakes and spiders. These are two of the most common fears people have and from an evolutionary view a healthy fear of these animals is a good thing (because of their potential danger). SM had also told the researchers that she didn't like snakes and spiders and "tried to stay away from them." So they went to a pet store and made notes on her behaviour as they walked around the store. But even though she had told them she didn't like snakes and spiders, SM showed no fear. She held one snake for over three minutes and the researchers noticed that she was curious and inquisitive, touching its skin and its scales, but that she didn't show any fear. In fact, she said things like "This is so cool" and she even kept asking if she could hold the bigger snakes, but the store owner continually told her they were too dangerous.

Fear conditioning means learning to be afraid of something. This serves important purposes for our survival and you'll learn more about this process when you study PTSD.

We can see that SM had no fear of something that most people are afraid of. And to test her fear response further they then took her to a haunted house. Every year at Halloween one of the "most haunted places in America", an old psychiatric hospital called Waverly Hills Sanatorium is turned into a haunted house. So even though it wasn't Halloween the researchers created the Haunted House and to make sure their house was in fact scary they invited a few other people to join the group so they could make comparisons between their fear response to the haunted house and SM's. They noted that while walking through the house SM never showed any fear. "Monsters" would jump out from behind dark spaces and SM never seemed to show any physical signs of fear, but would do things like touch their faces instead. Ironically, she even scared one of the "monsters"!

So this case study suggests that the amygdala might play an important role in the experiences of fear in scary and threatening situations. If we have damage to this area of the brain, perhaps we won't be able to experience fear.

Guiding Question:

How does SM's case study demonstrate the role of the amygdala in experiencing fear?

Critical Thinking Extension:

Generalizability: Thinking critically about research involves assessing to what extent the results from the study can be applied beyond the study itself. One way to assess this is to look at the nature of the subjects of the research. In this case, the subjects in the research mentioned are animals and one woman. To what extent can findings from these studies be used to explain human behaviour? It's important that you provide reasons for your answer: simply saying "one limitation of this study is that it was carried out on animals and can't be generalised to humans" is pointless, and is not demonstrating abstract thinking – it is description. You must show you understand the specific factors involved that influence the generalizability. Part of your explanation, therefore, should include reasons why findings may not be generalised. Can you explain some specific reasons that might influence the generalizability of SM's case study or the animal studies?

If you're interested…

Neurosciencenews.com is an interesting website that has regular stories and articles about the fascinating world of studying the brain. They have an article on SM called "The Fearless SM: Woman Missing Amygdala" in which this case study is explained further.

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(c) The Amygdala and the Fear Response

So you've had an introduction to the amygdala and seen in research that it is a necessary component of fear, it's time to look a little more closely at how the amygdala may cause us to feel fear. In this section we'll focus only on the biological processes involved after we perceive a threat.

With modern technology, we can now see the functioning of the amygdala when people are exposed to scary or threatening stimuli. When images of snakes, spiders, or angry faces appear on the screen our amygdala is activated. One study used a PET scan to compare the responses in the brains of women being exposed to images of snakes or spiders (things they said they were afraid of) and things they weren't afraid of. The results showed that when looking at the snakes and spiders their amygdala activation was higher than when looking at non-threatening stimuli (Ahs et al., 2009).

One function of the amygdala is to perceive threatening stimuli and prepare our body to react accordingly.

Research also suggests that our amygdala plays a particular role in situations when we feel *socially* threatened. A social threat is one that comes from another person or group of people, for example someone swearing at you, challenging you to a fight, etc. It's an emotional stimulus that is separate from a natural threat, such as seeing a dangerous animal or being trapped in a burning building. If someone is threatening us, we might need to defend ourselves: this is why we have evolved to have biological reactions that can facilitate aggression.

If we think back to the theme of our chapter, knowing about a fear of snakes and spiders has little applicability to something like murder. This is why knowing the term social threat is a key concept to understand in this chapter as it is important to really explain what might provoke someone into committing violent crime.

One study that we'll look closely at later in the chapter showed that when people are threatened socially their amygdala is activated. They can see this by putting people in fMRI machines and flashing images of happy, neutral or sad faces and then measuring the activation of the amygdala. When people perceive angry faces their amygdala is activated. But here's my favourite part: the researchers give the instructions to the participants that they are to push a button as soon as they see an emotional stimuli (in this case the picture of the face). FMRI studies show that the amygdala activates before the person has even consciously realised that they have seen a face (e.g. Williams et al., 2004). Studies have also shown that our amygdala may activate upon perceiving a face from a race different to our own (Chekroud et al., 2014). This will be explored when you learn about social influence and prejudice.

Emotion and aggression are closely related because an individual is unlikely to be aggressive without feeling emotional. Emotion includes the physiological arousal associated with the stress response.

How does that happen? When there's something threatening in our environment (i.e. something that might scare us) it is perceived by the amygdala. We have seen this already in the existing research. But in order to understand the physiological response caused by fear (the increased heart rate, heavy breathing, etc.) we need to know what happens after the amygdala is activated. After a threat is perceived by the amygdala a message is sent to another part of the brain called the hypothalamus. The hypothalamus is below the thalamus (hypo = below) and is like a control centre (imagine an air-traffic controller sitting at a large desk with a whole bunch of buttons or switches, or those little people in the heads of the characters in that Pixar film, Inside-Out). As the hypothalamus receives a signal from the amygdala it needs to get the body ready physically to deal with the threat.

The hypothalamus is involved in activating the fight-flight response (Steimer, 2002). It sends a signal to the adrenal glands, which are small glands that sit on top of your kidneys and trigger the release of adrenaline into our blood stream. You may know

a little bit about this hormone in our bodies, or just you have heard the word before. The term "adrenaline junkie" is a popular one to describe people who love doing those extreme sports like bungee jumping, sky diving, parasailing, jetboating, white-water rafting, etc. When we receive adrenaline in our bodies our heart races, blood pumps faster, we get more oxygen, and we get more instant energy. The reason these sports increase adrenaline is because they trigger in us a natural fear response as we haven't evolved to be used to the feeling of jumping head first off a 200metre high bridge!

But this response serves an important evolutionary purpose: when we are threatened and feel afraid, we need to have the energy to either stand our ground and fight or to run away really fast to escape danger. This is why it's known as the fight-flight response. Another name for this is the stress response.

Understanding the role of the amygdala in emotion is relevant for the study of criminology, as well as origins of prejudice and possible causes of PTSD.

We'll explore more about the significance of this later.

Many people like to participate in sports that activate our stress response. Are you an adrenaline junkie?

Guiding Question:

How does perception lead to the physiological arousal associated with fear?

Critical Thinking Extension:
Assumptions: This explanation of fear being a product of the physiological processes activated by the perception of emotional stimuli in our environment doesn't include explanations of how we can generate emotion internally. Can we feel fear without having to perceive a fear inducing stimulus? What about other emotions: do you think the explanations of the physiology of fear can be applied to emotions like sadness, anxiety and joy?

If you're interested…

There are many different theories of emotion that you can read about if you're interested. One particular theory of emotion from the 1960s is called "The Two Factor Theory." This theory was originally included in this chapter but its relevance to the current IB Psychology syllabus was questionable and it's a rather complex theory with a more complex experiment associated with it so it was removed. However, if you're interested it does provide an explanation of how emotion could be influenced through internal cognitive processes.

Relevant Topics

- Localization of brain function
- Emotion and Cognition
- Evolution
- Techniques used to study the brain
- Ethics and Research Methods (BA)
- HL Animal studies

Practice Exam Questions

- Contrast two studies related to localization of brain function.
- Describe one technique used to study the brain and behaviour.
- Discuss techniques used to study the brain and behaviour.
- HL To what extent are animal studies models useful in understanding human behaviour?

Research Methods

Case studies on individuals with unique characteristics are valuable for psychologists investigating relationships between the brain and behaviour. It is rare to have people with bilateral amygdala damage and so the findings from case studies using patients like SM can be used to corroborate findings from animal studies.

Ethical Considerations

The right to withdraw would be a particular consideration involved in the unique methodology of SM's case study as they were deliberately putting her in potentially stressful situations. Participants should always be given the right to withdraw, but this is of particular relevance when the methodology involves potentially high levels of anxiety.

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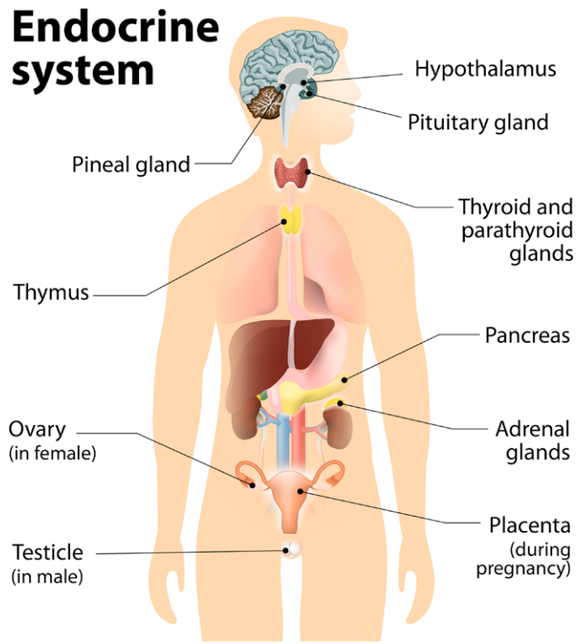
2.4 Hormones and Behaviour

Why are men more aggressive than women?

(a) Testosterone and Aggression

So far we've talked pretty generally about the brain and areas of the brain. It's time now to delve a little deeper into the actual chemical functioning of our body and our brain so we can develop our understanding of how biological factors can influence our behaviour.

A key biological factor in psychology is the endocrine system, and its role in releasing hormones in our body. Hormones are chemical messengers that are transported through our blood as a result of activation of different glands in the endocrine system. These chemicals perform a number of functions on our physiological processes. Put simply, they are chemicals that can spark physical reactions throughout the body. We've already looked briefly at the way one hormone (adrenaline) might play an important role in the experience of emotion through its impact on the physiological processes involved in emotion.



Testosterone is the male sex hormone and is produced in the testes (and in the ovaries to a lesser extent in females).

Testosterone is another hormone that has been studied extensively and particularly in relation to its influence on aggression. Many studies have shown that criminals in prison have high levels of testosterone (e.g. Dabbs et al., 1997 as cited in Batrinos, 2012). More evidence that suggests testosterone might affect aggression can be found in numerous animal studies. These studies follow a similar experimental design as the monkey studies on lesions in the amygdala, but typically they remove the testicles from male animals (often rats) and compare the differences in their aggressive behaviour before and after castration.

An example of this can be seen in Albert et al. (1986). In this study they wanted to investigate the effects of changing testosterone levels on the aggressiveness of male rats. They placed rats in cages and identified the alpha males. An alpha male is the leader of the colony. In animals, this is typically the biggest and strongest. The term can be applied to any animal group, including humans. So the researchers identified the alpha males and they measured their aggression levels when there was a nonaggressive rat placed in the same cage. They measured aggression by recording behaviours such as biting.

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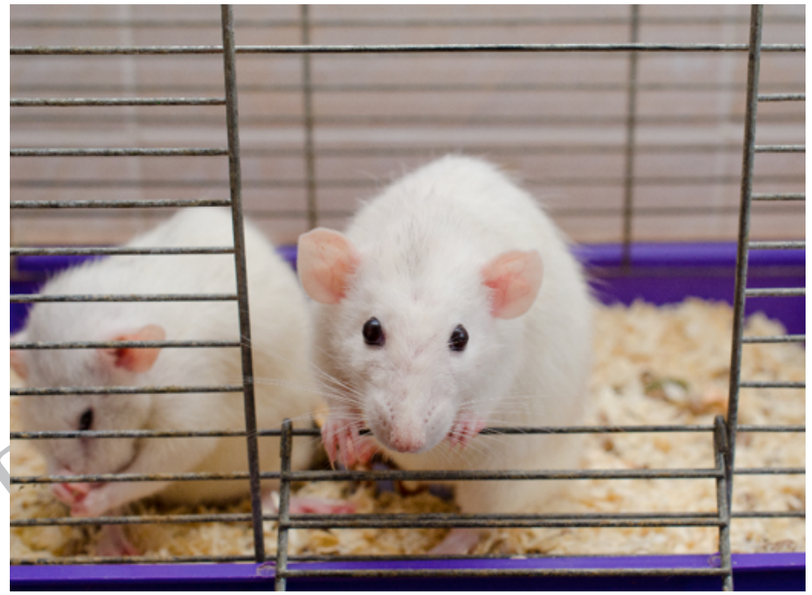
After they measured the aggression levels they divided the alpha males into four separate groups to undergo four separate surgeries:

A. Castration
B. Castration followed by implanting of tubes with testosterone
C. Castration followed by implanting of empty tubes
D. A "sham" castration followed by implanting of empty tubes (this means they would have cut open the rat and sewn it back up without actually removing the testicles).

They then measured the change in aggression when nonaggressive rats were introduced to the cage. Those that had the operations that reduced testosterone levels (e.g. Group A and C) had a decrease in aggressiveness (e.g. attacking and biting) but those that had the operations that kept testosterone levels in tact (Group B and D) didn't have a significant change in aggression levels.



By experimenting on rats, researchers are able to determine correlations between biological factors and behaviour. Albert et al. were able to manipulate levels of testosterone and conclude that levels of testosterone affect aggression.

You can see the advantages of using a laboratory experiment to manipulate variables in Albert et al.'s study. By measuring effects of aggression on manipulations of testosterone levels, a clear cause-effect relationship can be determined.

This evidence by itself demonstrates a correlation between testosterone and aggression. It was followed by a second operation so that those that had the surgery that decreased testosterone had another operation that increased testosterone (e.g. Group C had their tubes filled with testosterone). Those alpha rats that had their testosterone replaced showed returned levels of aggressiveness similar to those in the "sham" castration group.

Moreover, the researchers observed that when a subordinate male (one that is not the alpha) is placed in the same cage as an alpha rat that has been castrated the lower rat (subordinate) becomes the dominant (alpha) rat in the cage. Also, when a rat that had the sham operation is put in a cage with a castrated rat, the sham operation rat shows higher levels of aggression. This suggests that testosterone may facilitate behaviour associated with social dominance in rats.

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By comparing the before and after changes of aggression, as well as comparing the results of the different operations, this experiment suggests that testosterone levels influence aggression. The researchers concluded that the role of testosterone in aggression influences social dominance in that those rats that have reduced testosterone lose their place as alpha males.

Much like with the monkey studies, we can see here how animal studies can show us that there is a relationship between testosterone and aggression, but it doesn't tell us much more than that. We want to go deeper into understanding aggression. Moreover, rats and humans are pretty different animals with different brain structures, so can we really generalize from an aggressive rat in a lab to a serial killer?

Guiding Question:

How does Albert et al.'s study show a causal relationship between testosterone and aggression?

Critical Thinking Extension:
Analysing Questions: If you are asked to "explain how testosterone influences behaviour, the above research is rather limited. It suggests that testosterone does influence aggression but it doesn't provide much insight into how it does. However, if you are asked to explain how research suggests testosterone influences behaviour, the above research can be used in a very good explanation of how the research demonstrates testosterone's role in aggression. However, it's limited to animal studies so the generalizability to humans needs to be questioned. Analysing the demands of the question in order to identify the explanation/s required to demonstrate your understanding is really important, especially in exam situations.

If you're interested . . .

While rather gory and gruesome, and especially unsettling for boys, there's a rich and fascinating history behind castration that could be worth researching. Castration is used extensively in farming to control livestock while a castrato is the name given to the singing voice and the boy who had that particular singing voice through castration. This was a popular practice in Europe as was chemical castration to treat homosexuality. One famous case of the latter was that of the famous mathematician Alan Turing.

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(b) Aggression: An Evolutionary Adaptation

In the previous section we investigated some basic evidence that suggests testosterone influences aggression. In order to explore more deeply *how* high levels of testosterone could increase aggressive behaviour we need to look again at the way many factors may be involved in this complex behaviour.

Albert et al.'s the study did identify an important concept: social dominance. The role of social dominance and having a strong position within a social group is one that we will explore throughout the following sections. So before we investigate the connection between testosterone and aggression further, perhaps we may need to take a moment and reconsider our thoughts on aggression. In modern society being overly aggressive is generally considered bad because it's anti-social. But has this always been the case? A big part of understanding functions of the brain and other biological components is that we have to think about things from an evolutionary standpoint. The development of our cortices, for instance, enabled us to develop language, make tools, form social groups, etc., which helped us rise to the top of the food chain. We've also seen that the amygdala plays an important evolutionary role in perceiving danger and preparing our body physically to deal with the danger. This is another adaptation that has helped us to survive.

Natural selection is the process of organisms better adapted to their environment surviving and passing down their genes to their offspring. Over time, this results in significant changes in a species.

Similarly, aggression may be an adaptive behaviour because it enables us to defend ourselves when we are threatened. Shows of aggression don't always mean actually making physical contact. Sometimes shows of aggression without resorting to *physical* violence could be enough to defeat the threat. Dogs show aggression through gnarling and growling, for instance, and many males show aggression by clenching fists, puffing up their chests and offering verbal assaults. These signs of aggression might be important in maintaining our social dominance (i.e. maintaining a high social status). Social status refers to your rank in society. In cavemen times social status might mean being the toughest and the best hunter, which would mean you would have access to more resources. Social status in a modern, industrialized society might mean having a high-powered and high-paying job. In both of these situations, shows of aggression might help to retain status. Status is achieved in many ways across social groups, cultures and genders, so the value of aggression in these situations will vary from situation to situation. Having and retaining social status is key to our survival, because it ensures that when the food and berries are shared around the tribe, we'll get our fair share (we need to eat to live!). If we look weak and we're scared it might be easier for our foes to defeat us, take our hunk of mammoth meat or copulate with our mate.

Having and maintaining social status is important because it can increase chances of getting resources that are key to survival and passing on genetic material.

Displaying signs of aggression may serve an evolutionary advantage. By being aggressive and willing to confront threats and competitors, an individual may be able to keep or improve their social status.

Evolution is about survival of the fittest, but what this means is not who can run the fastest; it doesn't mean fit in that sense. In general biological terms it means the organisms that have the best characteristics (physical and otherwise) for their environment and so are most likely to be able to pass on their genetic material. In animals we pass on our genes by procreating (having babies). Much like other biological aspects in our psychology course, evolution is another one we have to skim over. The key concept for you to understand is that genes will be more likely to be passed on if they affect us in a way that increases our chances of survival and/or reproduction. This may be through an influence on our behaviour. Thus, some behaviour can be explained through understanding how biological traits are a result of evolutionary pressures. That sounds complex, but it is the key to understanding evolutionary explanations of behaviour. The process of evolution works by mutations (small changes) happening in the genetic material that are passed on from parents to kids. If a mutation helps an organism to survive, it increases the chances that it will be passed on and so over hundreds of thousands of years those slight mutations add up to mean significant changes. The process of evolution, therefore, is a slow one that takes tens of thousands of years.

Understanding the evolutionary advantage of aggression is important because it helps to explain the effects of testosterone on the amygdala that will be explored in the following sections.

Once more we find ourselves delving deep into the biological aspect, which is fascinating, but we must stop ourselves at some point and begin focusing on the psychology (i.e. the relationships between the biology, the mental processes and the behaviour). The key idea from this section to understand is that our brains have evolved to allow us to think and behave in ways that are likely to increase our chances of survival. Displaying aggression is one of those behaviours because in situations when we are being challenged or threatened, reacting aggressively is a valuable function as it can help us maintain our social status.

Evolutionary explanations of behaviour should include how the behaviour might help an individual to survive and/or pass on their genetic material.

Guiding Question:

How might aggressive tendencies be an evolutionary adaptation?

***Critical Thinking Extension*:**

Hypothesizing: In the following sections you are going to learn more about how testosterone impacts the brain and how this might be an evolutionary adaptation. However, you won't always be provided with the follow-up explanations to questions you may have, so devising your own hypothesis can be valuable in exploring concepts and conducting your own research to further your knowledge and understanding. You can also hypothesize in "discussions" in essay answers in exams. Based on what you have learned already about aggression and criminology, can you make a hypothesis as to how and why testosterone levels may affect particular parts of the brain?

If you're interested…

If human biology and evolution interests you, Desmond Morris' book *The Naked Ape* is a recommended read. In this classic non-fiction text, Morris talks about the human species as if they were like any other animal being observed from a biological perspective. It's really quite interesting reading about humans from this perspective.

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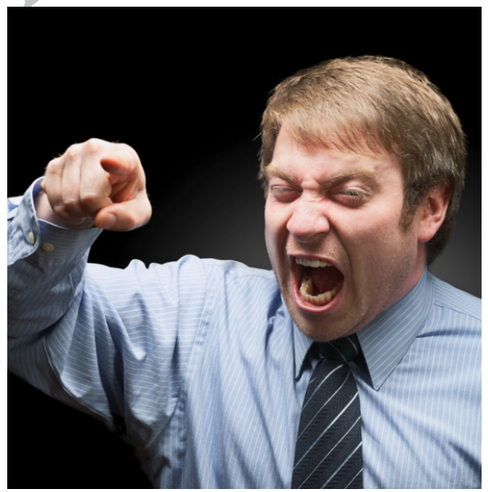
(c) Testosterone and Social Threat Part I

Studies using fMRIs have shown that levels of testosterone in our body can affect the functioning of the amygdala, which is a key piece in the testosterone and aggression relationship. So it seems plausible that aggression might be an evolutionarily adaptive behaviour and so the role of testosterone actually helps to ensure our own survival in times of social threat by reacting with the amygdala. If the amygdala can stimulate the process of pumping adrenaline in our body to get us ready to fight (i.e. act aggressively), it is plausible that the testosterone may impact the function of the amygdala to stimulate this reaction.

This can be seen in one study where the researchers gave 16 healthy young men doses of testosterone on one day and a placebo the next. In both conditions they showed them images of various types of faces, including neutral, sad and angry faces. While they viewed the images their brains were being scanned in an fMRI, much like the similar studies already discussed earlier in the chapter. The results showed that when participants were injected with testosterone they showed increased reactivity of the amygdala and the hypothalamus when they were viewing images of the angry faces. Testosterone was not shown to have the same influence when observing other types of emotional faces. (Goetz et al., 2016).

This study reinforces what we've learned in earlier sections about the amygdala: it plays an important role in social threat perception. Seeing an angry face is threatening and we need to be aware of someone who might be ready to do us harm, whereas a sad or neutral face, while activating perhaps a different emotion, doesn't require us to get ready to fight. The activation of the hypothalamus also suggests that the body will release adrenaline as the hypothalamus triggers the adrenal glands during the fight/flight response.

Perception means to become aware of something. We perceive information in our environment through our sensory organs. Social threat perception means becoming aware of a social threat.



A social threat is when another person, or group of people, pose a potential challenge to us in a way that may be scary, frightening or dangerous. Testosterone's impact on the amygdala at times of social threat may be an evolutionary adaptation.

This study quite simply shows that the function of the amygdala can be affected by testosterone levels. Saying aggression is caused by increased activation of the amygdala leaves a lot of questions unanswered. Just because we have more activation in our amygdala doesn't really help explain clearly how that might lead to aggression. We could say that when seeing an angry face the testosterone increases the activation of the amygdala and the hypothalamus will trigger the adrenal glands to release adrenaline and we will be ready to fight, but it does provide a rather overly simplistic explanation because it misses an important component: cognition.

Aggressive actions and reactions in situations are not simply robotic performances based on biological functions. As we've seen, we can't ignore mental processes when providing a full explanation of human behaviour, so it is important that these are also explored. This will be the subject of the next section.

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Guiding Question:

How might testosterone levels affect our "fight" response?

Critical Thinking Extension:
Application, Causation and Correlation: Prison populations have been shown to have high levels of testosterone. Does this suggest **causation** or **correlation**? Perhaps people arrive in prison because they have high testosterone levels and this was what led them to commit violence acts. Or, prisons are such environments where there are many alphas who are competing for social dominance in that highly competitive environment. It's not hard to imagine testosterone levels spiking in situations where you place many alpha males in a cage (literally, in many cases) where they are left to establish their own social structures.

If you're interested…

There is a plethora of research on the role of testosterone in social situations, especially those involving competition. Numerous studies have investigated the role of testosterone in sports matches and how even the observation of victory and defeat can affect spectators' testosterone levels. This would be well worth investigating, if you are interested.

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(d) Testosterone and Social Threat Part II

In order to investigate the relationships between perceiving a social threat, testosterone and the amygdala, Radke et al. (2015) designed a pretty complicated, but clever experiment. They hypothesized that the amygdala wasn't just involved in the *perception* of the threat, but the effect of *motivation* to deal with the threat was an important aspect to consider. Now we're getting a little closer to making the connection to aggression. If someone threatens us personally (i.e. they're a social threat) from an evolutionary perspective we need to be able to respond to the threat to keep our social status. If we are in danger of being harmed, we need to be able to protect ourselves. In other words, in real life when we're threatened we feel motivated to defend ourselves and our social status. In the following study, the researchers suggest that it isn't just about experiencing emotion that sparks the activation of the amygdala, but it is about motivation to respond in some way. The results suggest that testosterone works by increasing the activation of the amygdala when we are motivated to retaliate to a social threat, which in turn prepares our body physically for that defense.

While Goetz et al. showed that testosterone affects the amygdala, Radke et al. can show how motivation is an important influence as well. The influence of motivation is key in being able to link the amygdala activation with aggression.

In this study half of the participants (54 healthy females) were given a small dose of testosterone and the other half were given a placebo. As in similar studies, lots of pictures of faces that were either angry or happy were shown one at a time while the participant lays down in an fMRI scanner. For each face that appears on the screen, the participants have to "avoid" or "approach" the face. As they have to lie perfectly still in the fMRI, they avoid/approach the face by moving a joystick with their hand. When pushed one way the stick will make the face gradually appear larger (approach) and when moved another way it will make it gradually appear smaller (avoid). The "approach" is when the face is made to look like it's coming towards the person (i.e. it gets bigger), and vice-versa for avoidance. The faces appeared on the screen one at a time and the participants followed the instructions (approach or avoid). The motivation factor was the following of the researcher's instructions to approach or avoid the faces (which is important to note: the participants didn't get to choose to avoid or approach, they were instructed). While in the scanner the activity of the participants' amygdala and prefrontal cortices were measured.

Remember that emotion, amygdala activation and aggression are all related. The activation of the amygdala enables experiencing emotion through its role in the stress response. High levels of emotion could easily lead to aggressive reactions to social threats.

In this experiment, motivation was defined as following the experimenters instructions.

The results showed that the group with testosterone had more activation in their amygdala when they were *approaching angry faces* when they were told to do so and the activation was higher than when they approached happy faces. So here we can see that perhaps in a situation that involves a social threat (an angry face) and we are motivated to defend ourselves against that threat, testosterone levels play an important function in increasing the activation of our amygdala which will result in more emotional and physical readiness to react aggressively. The activation of the amygdala may help us get physically prepared for the confrontation by triggering the release of adrenaline into our bodies that will give us the instant energy to fight. And the role of testosterone may be to help prepare for that confrontation, as shown by the fact that the testosterone condition had higher amygdala activation when they were moving the joystick forwards and making the angry face become larger.

But while testosterone might influence aggression at times when we are socially threatened by increasing the activation of the amygdala when we are *approaching* a threat, that alone doesn't yet give us the full picture of how that might lead to acting in a violent manner, like punching or shooting someone.

The study showed that there wasn't a significant difference in the activation of the prefrontal cortex across groups. We've looked at the key role in the prefrontal cortex in being able to process information and make judgements based on long-term consequences, and so it's important not to overlook this function when you are explaining

acts of aggression that have serious consequences. If we have high levels of testosterone, perhaps we won't necessarily react aggressively when we're threatened because we'll be able to regulate that emotional reaction and we'll be able to think through our decisions. However, individuals with existing damage or low functioning of the prefrontal cortex may not be able to do so, which could explain why studies have shown low prefrontal cortex activity and high levels of testosterone in prison populations. In this section I hope you've realised even more how behaviours like violence, aggression and crime are complex and that drawing broad conclusions that ignore specific factors leads to erroneous statements and uninformed opinions.

Radke et al.'s study showed that testosterone impacted the amygdala when participants were motivated to approach the angry face. How might this help explain the connection between testosterone and aggression?

So in this section we've gone further with our understanding of the amygdala and seen how the many correlations shown between testosterone and aggression could be explained through the effects it has on other parts of the brain. We've also introduced the value of using evolutionary explanations for biology to help with our understanding of human behaviour.

You've also been introduced to the idea that human behaviour involves one more element that we haven't explored much until now: social influences. We will explore this later in the chapter, as humans are naturally social animals and it is our sociability that can impact our behaviour and mental processes in many ways. It's important that when we're applying our understanding of behaviour to explanations of violence that we have to try to test our abstract understandings by applying them to real life examples. This thought process is imperative if you are to develop a full understanding of the applications, and limitations, of psychological research.

Guiding Question:

How can Radke et al.'s study demonstrate how high testosterone levels may influence aggression?

If you don't understand how testosterone influences the behaviour of aggression, there are other topics covered that will allow you to explain how testosterone may affect behaviour (e.g. competition and attraction).

Critical Thinking Extension:
Ecological Validity and Operational Definitions: An operational definition is how a variable is defined in a particular study. In this example, one operational definition was that of "social threat". In this study they defined this as a face being moved closer or further away on a computer screen. But to what extent does this resemble social threat in a real life situation? A good discussion of the ecological validity of this study would include examples of social threat that this study's operational definition might not apply to, but yet might still result in aggressive reactions. For instance, receiving a threatening email (or Facebook post, tweet or other form of communication) from someone that attacks you personally is still a social threat, but does not involve the perception of an angry face. So ecological validity could be questioned here based on the limited operational definition of the social threat variable. More research into multiple forms of threat and its influence on the amygdala would be required in order to test the generalizability of these conclusions.

If you're interested…

radiolab.org has an interesting podcast called "Forget about Blame?" In this podcast the hosts talk with neuroscientist David Eagleman, who is very much about the biological approach to understanding criminal behaviour. They have some interesting discussions about biological origins of behaviour and culpability.

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Relevant Topics

- Ethics and Research Methods (BA)
- Origins of conflict
- Hormones and behaviour
- Evolution

Practice Exam Questions

- Evaluate one study related to hormones and behaviour.
- Outline one ethical consideration related to hormones and behaviour.
- Discuss one origin of conflict.
- Evaluate one evolutionary explanation of behaviour.

Research Methods

The laboratory experiment is valuable for isolating an independent variable's effect on a dependent variable. In the studies involving injections of testosterone in samples that have been controlled for other characteristics (e.g a history of violence or antisocial behaviour) we can see the effect that the testosterone levels have on brain function. It's important to note the causation here, however: the causation regarding the role of testosterone on the function of the amygdala in particular situations can be deduced. This does not infer a causal relationship between other relationships, such as testosterone and violent crime.

Ethical Considerations

The right to withdraw is an important consideration in any study using technology like fMRIs. These machines are incredibly noisy, cramped and uncomfortable. Participants need to have the right to stop participating if they are feeling uncomfortable. For instance, they may begin to have feelings of claustrophobia.

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2.5 Culture and Biology

How can culture affect testosterone levels?

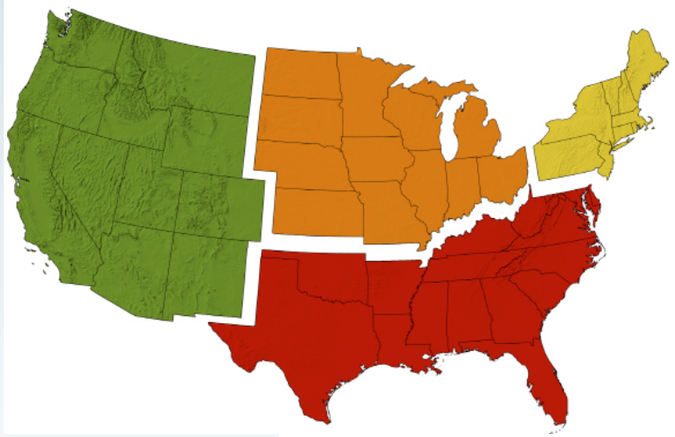
(a) Culture and Cultural Values

In nature we don't have injections that increase our testosterone, so if we want to develop our understanding of how testosterone can influence aggression we need to investigate possible factors that may *naturally* influence testosterone levels.

This has been the source of numerous studies, including some that have shown that testosterone levels can increase as a result of our environment. For instance, if you're watching your favourite sports team play and they win, your testosterone levels may increase more than if they lost (Bernhardt, 1998). And it's not just physical sports, testosterone has also been shown to rise in competitive chess tournaments (Mazur et al., 1992). A lot of research has suggested that testosterone plays an important role in getting the body ready for competition, and that displays of dominance and might facilitate displays of aggression that make someone look and act tougher (Cohen et al., 1996). There are many possible factors that can influence testosterone levels, but in this section we'll look at the interaction of cultural values and social threat.

A cultural value is a term used to describe something that a particular cultural group believes is important. For example, having respect for elders is a cultural value in Japan and is reflected in Japanese language. What cultural values exist in a cultural group you belong to?

A value is something that is believed to be important to an individual; a cultural value is something that a cultural group commonly believes to be important. For instance, in some cultures individual expression and the freedom to make your own decisions is highly valued, whereas in other cultures there might be more of a higher value placed on maintaining good relationships within your family even if this means not doing what you want. So while values are individual beliefs of what is important, these individual beliefs are highly influenced by our social and cultural environment.



The area of the US coloured in red is typically what is referred to when people talk about the "southern states."

Comparisons between cultural values and their effect on our biology, cognition and behaviour was the subject of a study in the United States that compared males from different states in the US (Cohen et al., 1996). The actual details of the study will be explored in more depth in the next section, but in order to fully understand the study it is important to understand its cultural context. The Eastern border of the United States is roughly divided by the "South" and the "North". If you've learnt about American history and in particular the American Civil War, you may already be familiar with the general differences between these two areas within the USA. Cohen et al.'s preliminary research findings suggested that the South is generally more violent than the North and so they wanted to investigate a possible hypothesis as to why this might be.

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Their explanation for the existence for increased violence in the South is based on what they term a "culture of honour". This culture of honour, the researchers claim, exists in the Southern States, but not the North. In the South in the USA when America was a young country (having broken away from England) the main economy was based on herding (farming animals). As there wasn't a lot of law enforcement or government in the South during this time, men who wanted to survive had to rely on themselves. For instance, if someone tried to steal their cows or their sheep they couldn't go to the police as there often weren't any to protect their herds, so they needed to look out for themselves. In order to do this, a man would have to present an image of toughness, a stern façade that showed he couldn't be messed with. However, this wasn't the case in the North as their economy was more industrial with more cities and less farming and agriculture. There was also more law enforcement (e.g. sheriffs and police officers) so Northerners didn't have to take the law into their own hands.

Cohen et al. provide many possible reasons why the culture of honour emerged in southern states in the USA. The idea of herding and law enforcement is just one. You can read the full article to learn about the others.

Interestingly, even though modern society no longer relies on such "Wild West" type behaviour, the values and beliefs associated with the culture of honour seem to have persisted in the South. For instance, Southerners are more likely to condone and approve violence, especially if it is in defense and "…the South exceeds the North only in homicides that are argument-or-conflict related, not in homicides that are committed while another felony, such as robbery or burglary, is being performed." (Cohen et al., p.946). This suggests that Southerners might be more likely to use violence when confronted, perhaps in defense of one's honour.

Cohen et al. hypothesize that being able to defend one's honour is a value that is particular to Southerners because of historical influences. In the next section you'll learn about how this cultural value may have biological effects during times of social threat.

Guiding Question:

Why are cultural values different between Northern and Southern white Americans?

***Critical Thinking Extension*:**

Avoiding Generalizations: Whenever we discuss culture and cultural values it is very tempting to make broad generalizations about a culture and overlook the fact that cultures are made up of individuals and individuals are very different from one another. One way to avoid doing this is to identify a culture you belong to and one or two cultural values that could be said to exist in that particular cultural group, but that you do not hold personally.

If you're interested…

The original article that describes the culture of honour and how it came to be in the Southern States is available online. The language is relatively accessible for high school students so if you're interested in learning about this more, or if the explanation here needs clarifying, you'll be able to find this article online using google and the title: "Insult, Aggression and the Southern Culture of Honor".

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(b) Cultural Values and Testosterone

To test their hypotheses regarding cultural values and responses to confrontations, Cohen et al. devised a fascinating experiment that involved insulting Northern and Southern males and testing their responses, including the differences in testosterone levels. The study compares the reactions of American college students to a situation where they were insulted and challenged. The researchers wanted to compare the reactions of college students from Northern states in the USA (e.g. New York, Massachusetts) and Southern States of the USA (e.g. Texas, Georgia, Kentucky).

Cohen et al. had numerous experiments with subtly different conditions. It's pretty interesting to read the other variations as well. For example, they also measured cortisol levels (a hormone released during times of stress).

There were many different variations of a similar experimental paradigm. In one of the experiments the researchers gathered Northern white male participants and Southern white male participants who were told they were taking part in an experiment on judgement. They took saliva samples in order to measure their levels of testosterone so they could compare the changes in testosterone levels (they told the participants they were measuring blood-sugar levels). After an introduction to the experiment, participants filled out a questionnaire and were told to walk down a long hallway to put the questionnaire on a table. As they walked back from putting down the piece of paper, a confederate of the study was pretending to organise a file cabinet in the middle of the hallway. As the participant walked past, the confederate bumped the participant and called him an "a**hole."

How would you react to someone insulting you? Would you feel a need to defend your honour, or would you be able to brush it off?

The researchers had many dependent variables (which are interesting and you can read more about in the original), but the important one for us is that the testosterone levels of Southern white males increased by 12% from before the experiment began, compared with 4% from the Northern males.

It's important to note that these results by themselves don't show that testosterone can cause aggression. The earlier research showed that relationship. This study provides a possible explanation for why some people might have higher testosterone levels than others.

So our level of testosterone that rises getting us ready for conflict in a social situation may be influenced by our cultural values. Due to the increase in testosterone the Southern white males were more primed for competitive and even aggressive actions. This may be because of their cultural values in that when they are confronted and offended they think about that threat differently because of the value they place on defending their honour. Northerners on the other hand, may find it easier to dismiss the offensive remark, which means there is little increase in testosterone getting them ready to be aggressive.

This could have important implications in the study of violent crime. We've seen how testosterone can increase the body's physiological readiness for aggressive actions and that violent criminals have higher levels of testosterone, but we can't simply put the blame on these biological factors. Our social and cultural environment may affect our values and our thinking, which could in turn affect our physiological processes in certain circumstances. Here we see once more the complex interactions between social, biological and cognitive influences when trying to understand complex human behaviours such as aggression, violence and criminal behaviour.

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Guiding Question:

How might cultural values influence aggression?

Critical Thinking Extension:
Population Validity: Population validity is the extent to which findings from one study can be valid in terms of applying to a larger population (it affects generalizability). This research focused specifically on southern white males. Why do you think they focused only on southern white males? Why not males from other cultures? Based on this limited sample, to what extent can these findings be generalized to other situations where social factors may influence cognition, biology and aggression? Are there other social environments that exist in society today that might pass on values similar to the "culture of honour" which may have similar to effects to the one explained above?

If you're interested…

There's an interesting article called "The Role of Testosterone in Social Interaction" by Eisenegger, Haushofer and Fehr that is available online. This article goes further into explaining the role that testosterone plays in social interactions.

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Relevant Topics

- Ethics and Research Methods (BA, SCA)
- Origins of conflict
- Hormones and behaviour
- Culture and behaviour

Practice Exam Questions

- Explain one study related to hormones and behaviour.
- Discuss one ethical consideration related to hormones and behaviour.
- Describe one study related to culture and behaviour.

Research Methods

Social psychologists like Dov Cohen also use the experimental method. This is another study that is difficult to categorize, but there's definitely a variable (cultural background) that is being studied in relation to another variable (aggression and testosterone levels in response to insult). Experiments in social psychology enable researchers to investigate the effects of social variables on behaviour.

Ethical Considerations

Informed consent would need to be considered carefully in Cohen et al.'s study. On the one hand, you probably need informed consent in order to ensure your experimental design can be approved by ethical review committees. However, they would have had to carefully consider just how much information to provide participants so as to ensure the validity of their results. For example, they can't tell them that an actor will insult them because this would affect the behaviour of the participant and could be a confounding variable. Here we can see that the combination of informed consent and debriefing is often important in research.

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2.6 Neurotransmission

Can chemicals in our brain cause violent crime?

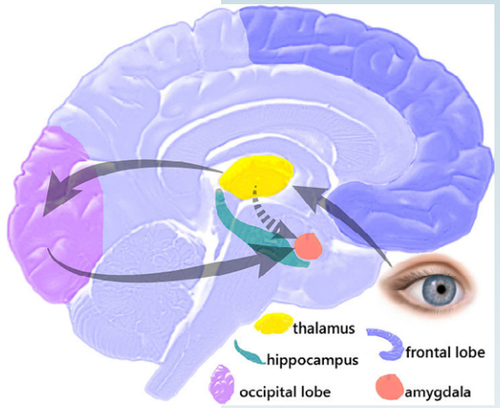
(a) Neurotransmission

We've looked at one type of chemical messenger in the body, hormones, and now we're going to look at a second type of chemical messenger, neurotransmitters. Whereas hormones are chemicals transmitted through our bloodstream, neurotransmitters are chemicals transmitted through cells in our body called neurons. Remember we have *billions* of neurons in our brain. We also have neurons throughout our central nervous system (CNS) and our peripheral nervous system (PNS). The central nervous system is our brain and our spinal cord, while the PNS consists of nerves outside of the CNS. These nervous systems are how we receive and respond to sensory information, like external emotional stimuli.

Understanding the process of how our environment can affect brain function will be helpful when learning about neuroplasticity in the next topic.

Our nervous systems perceive and interpret environmental stimuli through our sensory organs: our ears, eyes, skin, tongue and nose. These organs are responsible for sensory perception: detecting environmental stimuli such as what we see, hear, taste, touch and smell. When an environmental stimuli is detected, our sensory organs send messages to our brain through a process called neurotransmission. Neurotransmission is the process of neurotransmitters being sent from one neuron to the next at a speed of anywhere from one to over 200mph. This rapid transmission of chemicals throughout the nervous system allows you to perform complex behaviours and cognitive processes quickly. In psychology when we're talking about the level of brain *function* or brain *activity* we are referring to the level of neurotransmission happening in particular areas of the brain. This is what brain scanning technology like fMRIs and PETs measure.

Hormones and neurotransmitters are quite similar. In fact, some chemicals can be both neurotransmitters *and* hormones.



This is an illustration of how emotional information perceived through our visual sensory organ (our eyes) may be transmitted through various parts of the brain related to processing emotional stimuli.

When sensory information is detected through our sensory organs, neurons in the stimulated area are activated and send messages along neural pathways through particular areas of the brain. A neural pathway is a series of connected neurons that go through the process of neurotransmission between particular areas of the nervous system. Sensory information is sent along neural pathways to the relevant area of the brain that processes that type of information. For example, you have a particular area of your brain that processes hearing spoken language and a different part for processing written language (i.e. when you are reading). You even have a particular area of your brain that processes drawing, watching and imagining cartoons. This is the concept of localization of brain function that was introduced earlier in the chapter.

I like to think of neural pathways as kind of like roads of neurons. If we continually practice something and have lots of repeated experience with receiving sensory stimulation and responding to it in a certain way (e.g. catching and throwing a ball, typing on a computer, listening to and understanding a new language) the neural pathway will become well-developed and strong, like a big highway of chemical and electrical

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signals being fired through the brain. If we don't use a particular neural pathway often or the sensory perception is new, it's a bit more like cutting a way through an overgrown jungle path. This is why when we begin a new task like learning a new sport, instrument or a language, we feel slow and clumsy – our neural pathways are underdeveloped. We will learn more about this later when we study neuroplasticity.

A neural pathway is a series of connected neurons that send signals throughout different areas of the brain and the body.

Particular neural pathways and areas of the brain also have various levels of specific neurotransmitters. Neuropsychology often involves the correlations between levels of specific neurotransmitters in particular areas of the brain and our behaviour. Here are some neurotransmitters and their correlates:

Neurotransmitter	*Behaviour/Cognitive Process*
Serotonin	Mood, sleep, impulsive behaviour, violence.
Dopamine	Love, motivation, pleasure, learning.
Acetylcholine	Muscle movement, learning, memory.

You can see from the wide range of behaviours that these chemicals are associated with that the relationships between neurotransmission, the brain, and behaviour is rarely simple. In the next section we will look at a very specific relationship: how levels of serotonin may influence violence through its effect on the prefrontal cortex during times of social threat.

The process of neurotransmission can be quite complex. In biology class you might learn more about this process. This topic focuses on how one specific neurotransmitter, serotonin, might affect behaviour.

There are many factors that can influence neurotransmitter levels, including sleep, diet, exercise, medication and drug use, genetics, and other environmental influences. In the next section you will see how perhaps diet, levels of serotonin and violence may be related.

Guiding Question:

How do particular areas of our brain receive relevant information about environmental stimuli?

Critical Thinking Extension:

Over a hundred years of neuropsychological research has shown that our ability to process information and perform cognitive processes is a result of the biological process of neurotransmission. These findings may challenge existing notions of what happens when we die. Our ability to remember, think and feel makes us who we are. So if we lose the biological ability to perform these tasks (e.g. when we die and our neurons stop firing), can we have perceptions and perform cognitive processes in the afterlife? If so, how? If not, what type of afterlife are we going to experience without sensory experience or cognition?

If you're interested…

There is a very famous book of case studies with people with brain abnormalities called *The man who mistook his wife for a hat* by the late, great Oliver Sacks. If you're interested in learning about the brain and how abnormalities and dysfunction in particular areas of the brain can affect our behaviour, this is a fascinating book to read. You can also watch Sacks' TED Talk about hallucinations and the brain. It is in this talk that he mentions the very specific area of the brain responsible for processing cartoons.

(b) Serotonin, Threat and the Prefrontal Cortex

The neuropsychological world of neurotransmission is extremely complex, so in this section we're going to focus specifically on how changes in levels of serotonin may affect our behaviour. Serotonin has been shown to affect many behaviours, but we'll focus on how it might be correlated with aggression and violent crime.

Serotonin is associated with many different behaviours. Impulsive, antisocial and aggressive behaviour are only some of the behaviours that research has correlated with serotonin.

Numerous research studies have shown that violent criminals tend to have low levels of serotonin (e.g. Moi and Jessel, 1995; Scerbo and Raine, 1993). Studies have also shown that serotonin is associated with controlling impulsive behaviour (Pattij, 2008). Hopefully from what you've learned already in this chapter you'll be able to start making predictions about the areas of the brain that might be associated with serotonin levels and impulsive behaviour.

Many experiments using rats and other animals have shown that changes in serotonin levels affect aggression (e.g. Annemoon et al., 2000). But the same problems exist in these studies as with other animal studies we've looked at: they don't show *how* serotonin can affect aggression, they just show that it does. Because of the complex nature of the way serotonin is communicated through the brain and the difficulty of manipulating aggression in a lab, it's been difficult to explain *how* serotonin affects violence. With modern technology, however, researchers can now investigate the relationship between areas of the brain and neurotransmission in ways they couldn't before. The following study provides one possible answer for explaining the relationship between neurotransmission (serotonin levels) and violent behaviour by measuring brain activity in an fMRI when participants' serotonin levels are manipulated and they are exposed to emotional faces.

There is currently no way of measuring serotonin levels in the brains of living people. It is measured using spinal fluid or in this case, assumed by measuring levels of tryptophan.

Passamonti et al. (2012) gathered healthy volunteers for an experiment where their serotonin levels were manipulated by altering their diet. A repeated measures design was used where on one day they were given a drink that lacked tryptophan. Tryptophan is an important amino acid that helps build serotonin and so a lack of tryptophan in the diet will reduce levels of serotonin available in the brain. In the control condition they were given a placebo, which was the same type of drink to consume but contained normal amounts of tryptophan. The expected effect of the reduced tryptophan would be reduced serotonin levels. The participants were then put in fMRIs and their brain activity was measured while they were seeing images of happy, angry and neutral faces. The researchers could see the activation of the brain, including the amygdala and the prefrontal cortex.

A common experimental paradigm involves the use of images of faces that are expressing different emotions. Researchers compare brain activity when processing different types of emotions.

The results showed that there was reduced activity in the frontal lobe during the low serotonin conditions. Importantly, the disruption occurred during the angry faces, but not during the sad and neutral faces. Which means that it's not just any stimulus that is affected by serotonin, but a *threatening* stimulus in particular. The reduced activation of the prefrontal cortex might affect violence through our inability to regulate impulsive actions and/or reactions to social threat. If someone has low levels of serotonin and they are threatened, they may not

Tryptophan is an amino acid found in food. It helps to build serotonin. Passamonti et al.'s study suggests that diet could be a contributing factor to aggressive behaviour.

By reducing the communication between the amygdala and the prefrontal cortex during perception of threatening stimuli, serotonin may affect an individual's ability to regulate their emotional reaction.

Remember that these topics are all interrelated. You should be trying to apply what you already know about topics such as the PFC, the amygdala and emotion to this new topic, serotonin.

have the function in the PFC to enable them to think through their actions and might react impulsively.

The results also showed that there was disruption of the communication between the amygdala and the frontal lobe. The researchers concluded that this evidence supports the idea that the serotonin impacts the prefrontal cortex role in suppressing negative emotions generated in the amygdala as a response to the threatening face. In other words, when we perceive an angry face we might instinctively feel a negative emotion in response to that angry person. This emotional response is instinctively generated in the amygdala and may be the basis of aggressive and other highly emotional reactions. If our PFC is functioning properly we may be able to suppress (reduce) our negative reaction to someone's anger towards us. However, with low functioning PFC our amygdala may activate in reaction to perceiving the angry face and we may not be able to reduce our emotion or behavioral response to the angry face, thus increasing the likelihood of an aggressive or violent reaction.

Guiding Question:

How can the results of Passamonti et al.'s study explain the correlation between serotonin and violence?

Critical Thinking Extension:

Areas of Uncertainty: When applying correlations like the one shown in the above study there are often areas of uncertainty as to the extent to which a single relationship (i.e. between serotonin and perceiving an angry face) can be applied to explain a complex behaviour like violent crime. Often a single explanation is not strong enough, or it could be made stronger by combining another concept. Here we can see that serotonin can influence the prefrontal cortex and the amygdala. After you've explained this relationship, the next could be to explain hypotheses about how the combination of low serotonin and high testosterone might influence aggression. This could be an example of triangulation: using more than one data point to explain a relationship.

If you're interested…

Dr Molly Crockett was a co-author of this study. You can watch her give a TED talk about the importance of being aware of publications of psychological research in the popular media called "Beware neuro-bunk." She also gives another TED talk called "Understanding the Brain" where she talks about the implications and applications of neuropsychology.

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Relevant Topics

- Neurotransmission
- Ethics and Research Methods (BA)
- Origins of Conflict
- Evolution

Practice Exam Questions

- Explain how one study demonstrates an effect of neurotransmission on human behaviour.
- Outline one ethical consideration related to research on neurotransmission.
- Describe one study related to evolution and behaviour.

Research Methods

Much like the testosterone studies, manipulating physiology (as Passamonti et al. have done with tryptophan and serotonin) is an important characteristic in many true experiments that aim to investigate relationships between the brain and behaviour. By designing careful experiments, researchers can further investigate causal relationships between variables like neurotransmitters and their effect on particular areas of the brain in particular circumstances. But remember that just because it causes an effect on the brain, doesn't mean to say it *causes* behaviour.

Ethical Considerations

Whenever participants are going to be ingested with substances (like the drink they had to consume in Passamonti et al.'s study) informed consent and debriefing are important. They should be made to feel confident that the substance they are ingesting will not have any long-term side-effects. Moreover, if they are deceived of the nature of the substance they need to be debriefed about what it was they actually consumed and why.

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