Psychology Factsheets

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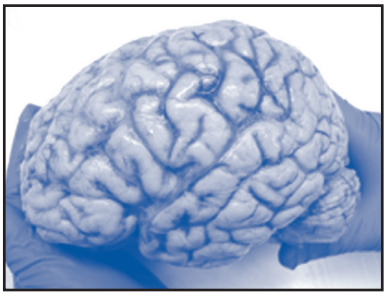
Neuroplasticity and Functional Recovery of the Brain After Trauma

The focus of this Factsheet is **neuroplasticity** and functional recovery of the brain after trauma. Keywords can be found highlighted throughout the text and all of the definitions can be found in the glossary at the end. Additionally, a worksheet is included with examination style questions, which can help you to develop your responses.

The examiner will expect you to be able to explain what neuroplasticity is and how the brain is able to recover after experiencing trauma. You should also be able to evaluate the theories presented and use psychological research to support your points.

A. Neuroplasticity

Neuroplasticity is the brain's ability to alter its structure and function in response to new learning or changes in the environment. Therefore, when it is said that the human brain is 'plastic', it means malleable and able to change. This may seem impossible, but your brain is constantly changing from the moment you are born. Each time you learn or experience something new, **synaptic connections** and **neural pathways** are formed and the more that you use them, the stronger they become. The less you use the neural pathway, the weaker it becomes, until eventually the pathway gets deleted in a process known as **synaptic pruning**. This demonstrates how the brain is constantly changing as an individual learns and then, subsequently forgets. It is during infancy that the brain experiences its most rapid changes, in response to everything a child learns from walking and talking to learning the faces and recognising the voices of its caregivers. It was previously thought that the brain could only change during this **critical period** of infancy. However new research suggests that the ability for the brain to adapt remains with the individual for the rest of their life.



Exam Hint: *Try to use biological keywords throughout your responses to examination questions. Being able to correctly use keywords demonstrates good understanding of the material and is likely to increase your marks in extended answer questions.*

B. Research Evidence into Neuroplasticity

The case study by Maguire et al (2000) demonstrates plasticity in the brain. Researchers examined the unique brain structure of London taxi drivers who are required to learn all of the roads in London and the surrounding areas in order to be able to navigate around them successfully. The researchers completed **MRI scans** of the brains of 16 taxi drivers and 16 non-taxi drivers as a control group. It was found that the average size of the **hippocampus** was significantly larger in the taxi driver group compared to the control group. Additionally, the longer that the taxi drivers had been working, the larger their hippocampus was. This study supports the idea that the brain is 'plastic' as the tough demands of the taxi drivers' job had a physical effect on the structure of their brains.

Maguire et al.'s (2000) research into taxi drivers is one of the most famous

Neuroplasticity has also been demonstrated in many pieces of research, two of which are outlined here.

Elbert et al. (1995) investigated the structure of the brains of musicians, to see how continued practice and environmental stimulation would affect their brain structure. Musicians who played string instruments were given an MRI scan, and their brains were then compared to the brains of the control group, who were non-musicians. It was found that the musicians had a much larger **somatosensory cortex** compared to the control group. It was suggested that the increased sensory processing required by the musicians to play the instruments, resulted in structural changes in the brain, showing support for the theory of neuroplasticity.

Draganski et al (2006) investigated German medical students during an intense period of revision for their medical examinations. The students were given periodic MRI scans throughout the revision and examination period. It was found that during periods of intense revision, the amount of **grey matter** within the students' brains increased significantly and additionally, they were found to have a larger **parietal cortex** and hippocampus. However, three months later, their brains showed no further structural changes.

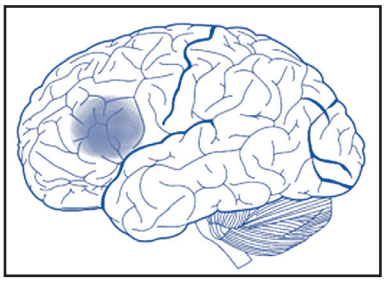
The great amount of information learned within the short revision period could have caused this; the structure of the brain changed based on the environmental input, again showing evidence for neuroplasticity.

Exam Hint: *You should always try to use psychological research in your essays. Describing the research will help you to gain A01 marks, whilst using the research to comment on whether it supports or refutes the theory will help you to gain those all-important AO3 marks. Higher level answers often contain multiple pieces of research used as evaluation and as such, this is an effective way to improve your essay technique.*

C. Functional Recovery of the Brain After Trauma

How is it that a child can have half their brain removed and still be able to function normally? That was exactly what happened to EB, an Italian boy who had a brain tumour removed at the age of two and half years. The surgery also resulted in the removal of virtually his entire **left hemisphere**, including his **Broca's area**, and as a consequence he lost the ability to produce speech. Afterwards, he completed an intensive rehabilitation programme and eventually started producing speech again around the age of 5. Danelli et al. (2014) tested him at the age of 17, and compared his language abilities with controls, finding that his **right hemisphere** had compensated for the damage and he was able to produce speech well. Although this is a case study, which causes problems of **generalisability**, this does demonstrate that the brain is able to remarkably repair itself after injury. This is known as **functional recovery**.

Functional recovery of the brain after trauma is about how the brain manages to adapt and repair its structure and functioning after suffering damage, such as in the case outlined above. It has been found that the brain can recover after different types of damage, including head injuries, strokes, tumours and infections, all of which can result in a loss of function. Through neuroplasticity, the brain is able to change in order to compensate for the loss of function. Psychologists are still unable to pinpoint exactly how the brain regains lost functions. Two theories are briefly outlined here.



The location of Broca's area in the left hemisphere, all of which was removed in the case study of EB

It is thought that the brain is able to rewire and reorganise itself by activating and taking over existing, but rarely used neural pathways close to the area that has been damaged in order to regain functioning. Additionally, new synaptic connections may be grown to link these areas of the brain in a process known as **axonal sprouting**.

A second theory is that in some cases of brain damage, the equal but opposite area of the brain to the damaged one may take over functioning, for example, if Broca's area in the left hemisphere is damaged, then the corresponding tissue in the right hemisphere may take over speech production.

Exam Hint: *Although the biology behind functional recovery may seem intimidating, it is important that you are able to explain at least one theory as to how functional recovery of the brain works.*

D. Factors Affecting Recovery of the Brain After Trauma

Although it is possible to regain function after a traumatic brain injury, the extent to which function can be regained can depend on several factors.

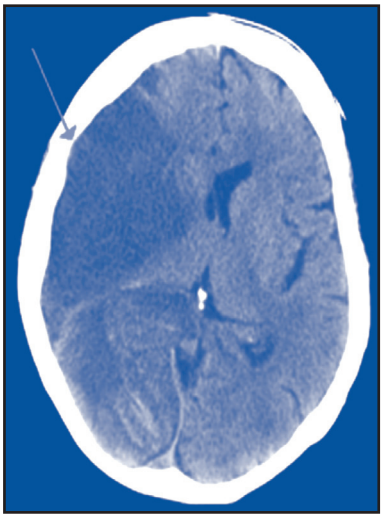
- **Age:** It has already been noted that the brain grows and adapts the most during infancy and is able to adapt throughout a person's life. However, with increased age, the extent and speed of recovery after trauma changes, as neuroplasticity becomes increasingly difficult as a result of the brain's natural deterioration. Marquez de la Plata et al. (2008) found that patients over the age of forty regained less function after brain damage and that the function that had been regained was more likely to decline in the five years following the brain damage compared to a control group under the age of forty. This suggests that age is an important factor in functional recovery.
- **Gender:** Research suggests that women are more able to recover from traumatic brain injury compared to men. This could be because women's brains are less **lateralised**. Ratcliffe et al. (2007) studied over 300 patients with brain damage and tested their responses to rehabilitation, both at the time of the injury and a year afterwards. It was found that women did significantly better a year later, on cognitive attention and language tests; although men performed better on visual analytic skills tests. It was concluded that due to the superior functioning in the women's group, that gender may be a significant factor in determining how well the brain is able to recover function after injury.
- **Education:** Schenider et al. (2014) investigated participants who had suffered head injuries to discover whether their levels of education affected their recovery. It was found that 39% of participants who had completed an undergraduate or postgraduate qualification were left free of disability, compared to just 10% of participants who made a full recovery and had failed to complete high school. It was suggested that people who are more highly educated, have an increased **cognitive reserve**, meaning they are more likely to retain function due to an increased cognitive capacity. This suggests that a person's level of education is influential in functional recovery.

Age, gender and education are all important factors in determining recovery after brain trauma

Exam Hint: *Looking at the different factors affecting recovery after trauma isn't listed specifically on the exam board specification. However, this is a great way to both enhance your knowledge and extend your ability to reach the higher marks in essay questions.*

E. Neurorehabilitation

The work that has been conducted into neuroplasticity and functional recovery has been key in developing practical techniques for helping brain damaged patients, in what is known as **neurorehabilitation**. After experiencing brain damage, the brain may start to heal itself on its own, in a process known as **spontaneous recovery**. However, after an initial period of improvement, recovery generally slows down, at which point, intervention is required in order to gain back as much functioning as possible. There are several types of neurorehabilitative therapy, but this factsheet focuses on one, known as **constraint induced movement therapy (CIMT).** This is typically used with patients recovering from strokes. Strokes commonly cause one hemisphere of the brain to be damaged, which consequently causes a loss of function on one side of the body. The brain is **contralateral**, meaning the left hemisphere controls the right side of the body, and vice versa. Therefore, if someone experiences a stroke which damages their left hemisphere, they may suffer from full or partial paralysis in their right side. CIMT prevents patients from using their functioning side, and forces them to try to use their paralysed side, in an attempt to make the brain relearn how to work it. Wolf and Winstein et al (2008) investigated the use of intensive CIMT for recovering stroke patients. Patients were required to try and use their paralysed limbs for up to six hours every weekday for two weeks, with their fully functioning hand restrained. Their functioning was measured before and after therapy, and it was found that all patients made improvements. It was concluded that CIMT has benefits in aiding the functional recovery of the brain after trauma.



A CT image showing damage to the left hemisphere three days after a stroke

Exam Hint: *You will be expected to discuss the contralateral function of the brain in relation to hemispheric lateralisation and split-brain research. Therefore, it is worth familiarising yourself with this theory.*

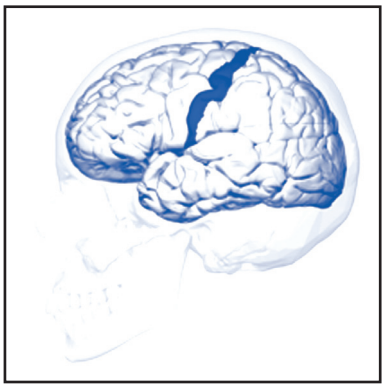
F. Evaluation

As described above, the biggest contribution of research into neuroplasticity has been into developing neurorehabilitation therapies for patients with brain damage. It has been demonstrated to be highly effective in helping patients to recover following a stroke (Wolf and Winstein et al, 2008). This is a great strength of neuroplasticity research.

Although the research outlined above does suggest that the brain is able to regain function after injury, it is also important to note that participant's level of functioning was only tested after their injury. Due to the nature of the case study method, participants were unable to be tested before their brain injury and so we cannot make an accurate estimation of how well they have regained functioning as there is no initial measure to compare it to. This suggests that the results gained on functional recovery research might not show the increased gains that they suggest and as such this is a limitation of the research.

There are also problems with generalisability in all brain damage research. There are a multitude of factors which can affect recovery, including the location and severity of the damage, plus individual differences such as age, gender and medical history which makes each case of brain damage unique. This suggests that results regarding recovery of brain function cannot be widely generalised.

It has also been suggested that neuroplasticity is the cause of the disorder **phantom limb syndrome**. This is where people who have undergone limb amputations experience feelings in their non-existent limb, which could range from a mild tingling sensation to extreme pain. This is thought to be a maladaptive consequence of neuroplasticity. It is suggested that when a limb has been removed, the area of the brain controlling it becomes less active and as a result the brain experiences cortical reorganisation in the somatosensory cortex, which causes the abnormal sensations (Ramachandran and Hirstein, 1998). Although it is still argued that there could be other factors influencing the development of phantom limb syndrome, if neuroplasticity is involved, then it demonstrates that neuroplasticity may not always be beneficial due to potentially maladaptive consequences.



The somatosensory cortex is highlighted, the area of the brain implicated in phantom limb syndrome

Exam Hint: *Remember, when evaluating to always ensure that you explain your points. Fewer, more detailed points will always be worth more marks than more, less detailed points, so it is worth taking the time to clearly identify the strength/ limitation, and then explain why it is a strength or limitation.*

Conclusion

The brain is a remarkable organ, and although a few of its abilities have been described in this factsheet, the truth is that psychologists are learning more and more about how the brain changes and functions each day. To that end, to further your knowledge, it is worth staying abreast of contemporary psychological research, as the reality is that there is still a lot more to learn about the brain and neuroplasticity.

Glossary

Axonal Sprouting: The growth of new axons from a damaged or intact neuron to repair any damaged connections.

Broca's Area: The part of the brain responsible for speech production.

Cognitive Reserve: A person's ability to maintain normal cognitive functioning.

Constraint Induced Movement Therapy (CIMT): A type of therapy typically used with stroke patients.

Contralateral: The theory that each hemisphere of the brain controls the opposite side of the body.

Critical Period: The time during infancy which it was once thought was when all the connections in the brain developed.

Functional Recovery: The ability of the brain to repair itself after damage to regain lost functions.

Generalisability: The ability of research findings to be applied to a wider population.

Grey Matter: Tissue of the brain and spinal cord containing lots of neurons.

Hippocampus: The part of the brain thought to be responsible for memory.

Lateralised: Meaning dominance of one hemisphere over the other in regards to a specific function.

Left Hemisphere: The division of the brain which controls the right side of the body.

MRI Scan: An imaging technique that uses a magnetic field to produce an image of the brain.

Neural Pathways: A bundle of nerve fibres that connect different areas of the brain.

Neuroplasticity: The ability of the brain to change, adapt and repair itself in response to environmental changes or damage.

Neurorehabilitation: A medical process designed to improve recovery and functioning after suffering an injury to the nervous system.

Parietal Cortex: One of the four lobes of the brain, mainly responsible for sensation, perception and integrating sensory input.

Phantom Limb Syndrome: A condition wherein amputees still feel sensation in their missing limb.

Right Hemisphere: The division of the brain which controls the left side of the body.

Somatosensory Cortex: The part of the brain which processes sensory input from the skin, muscles and joints.

Spontaneous Recovery: Where the brain improves in functioning on its own.

Synaptic Connections: The connections which permit communication between different neurons.

Synaptic Pruning: The process whereby unused neuronal pathways or synaptic connections are deleted in order to improve the efficiency of neural transmissions.

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Worksheet: Neuroplasticity and Functional Recovery of the Brain After Trauma

Name: _____

1. Define the term neuroplasticity.

2. Briefly discuss research into neuroplasticity.

3. Briefly outline at least one way in which the brain repairs itself after brain injury.

4. Eric has recently graduated at university, and has been involved in a car accident, which has caused him to lose his ability to speak. Donna failed to complete high school and had a stroke at the age of 50, resulting in a loss of function in her right arm. Discuss how different factors may affect Eric and Donna's ability to recover their lost functions.

5. Describe and evaluate the functional recovery of the brain after trauma.