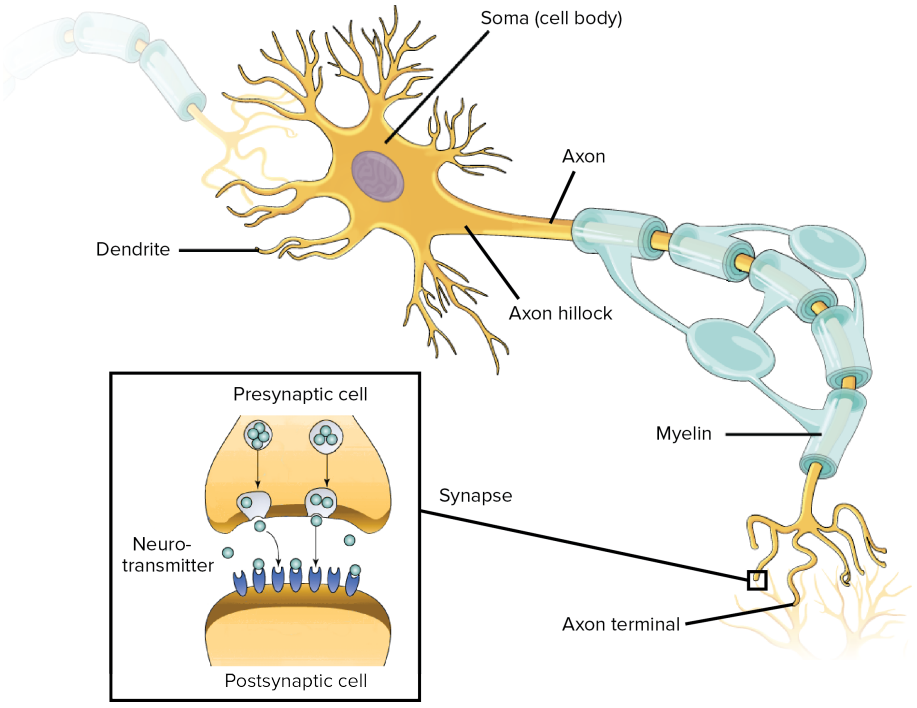
AQA Psychology A-level

Topic 6: Biopsychology

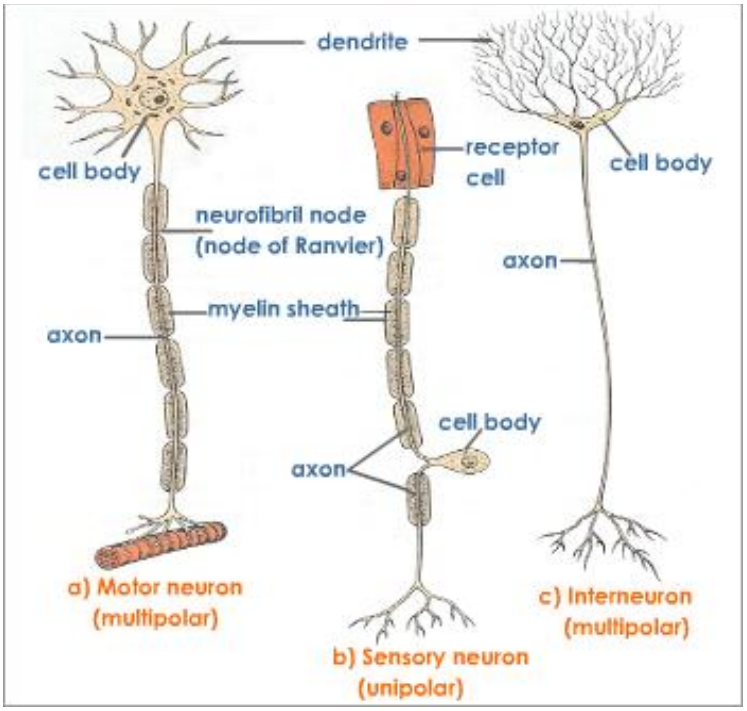
Notes

Part 1 — The Nervous System and the Endocrine System

- The nervous system is made up of the brain and the spinal cord, whilst the peripheral nervous system (PNS) relays messages from the environment to the CNS, via sensory neurones, and from the CNS to effectors, via motor neurones.
- The PNS is further subdivided into the autonomic nervous system (which controls involuntary, vital functions of the body, such as maintaining heart rates and breathing rates) and the somatic nervous system (which receives information from sensory receptors belonging to each of the 5 senses, and results in effectors being stimulated by the CNS, via motor neurones).
- The autonomic nervous system is also subdivided into the sympathetic and parasympathetic branches. These branches work as part of an antagonistic pair during the 'rest and digest' response, and are crucial in producing the physiological arousal needed to maintain the fight or flight response.
- For example, the sympathetic nervous system increases heart rates, breathing rate, causes vasoconstriction and pupil dilation, whilst the parasympathetic nervous system decreases heart rate, breathing rates, causes vasodilation and pupil constriction.
- The endocrine system is the main chemical messenger system of the body, where hormones are secreted into the bloodstream from glands, and then are transported towards target cells in the blood, with complementary receptors. The pituitary gland is considered to be the 'master' gland because it controls the release of hormones from all other glands in the body. For example, the thyroid releases the hormone thyroxine, which increases heart rate and therefore increases the rate of growth. The adrenal gland releases adrenaline which creates the physiological arousal preceding the fight or flight response, through increasing the activity within the sympathetic branch of the nervous system. The fight or flight response is described below:



1. The body senses and becomes aware of a stressor in the environment e.g. the sound of a speeding car.
2. Through sensory receptors and sensory neurones in the PNS, this information is sent to the hypothalamus in the brain which coordinates a response and triggers increased levels of activity in the sympathetic branch of the ANS.
3. Adrenaline is released from the adrenal medulla in the adrenal glands, and is transported to target effectors, via the blood and through the action of the endocrine system.
4. This results in the rectum contracting, saliva production being inhibited and a greater breathing rate. This creates the physiological response needed to sustain the fight or flight response, whose adaptive purpose is to enable us to escape the stressor and so increase the likelihood of our survival.
5. Once the stressor is no longer a threat, as part of an antagonistic pairing, the hypothalamus triggers less activity in the sympathetic branch and more activity in the parasympathetic branch of the ANS. This is also referred to as the rest and digest response, due to the parasympathetic branch decreasing the activity which was originally increased through the action of the sympathetic branch.



Part 2 — Neurons and Synaptic Transmission

- Synaptic transmission is a method of neurons communicating with each other, relaying information to the CNS across sensory neurons and carrying out responses dictated by the brain through sending information to effectors via motor neurons.
- The process of synaptic transmission is as follows:

1. An action potential arrives at the presynaptic membrane, causing depolarisation through the opening of voltage-dependent calcium ion channels, and the consequent influx of calcium ions.
2. The increased concentration of calcium ions within the membrane causes the vesicles, containing neurotransmitter, to fuse with the presynaptic membrane and release their contents into the synaptic cleft through exocytosis.
3. The neurotransmitter diffuses across the synaptic cleft, down a concentration gradient, and binds to complementary receptors on the post-synaptic membrane. This can result in an inhibitory or excitatory effect in the postsynaptic membrane.
4. The resultant action potential will then be transmitted along the axon of the following neuron, resulting in a 'cascade' of neurotransmission!

- Neurotransmitters can either have an inhibitory or excitatory effect. Inhibitory neurotransmitters (e.g. serotonin) reduce the potential difference across the postsynaptic membrane through the closure of the voltage-dependent sodium ion channels, reducing the likelihood that an action potential will be generated.
- Excitatory neurotransmitters (e.g. dopamine) increase the potential difference across the postsynaptic membrane through triggering the opening of more voltage-dependent sodium ion channels, increasing the likelihood that an action potential will be generated.

Part 3 — Localisation of Function in the Brain

- Localisation theory suggests that certain areas of the brain are responsible for certain processes, behaviours and activities.
- The motor area = Separated from the auditory area by the central suclus and found in the frontal lobe, this area is involved in regulating and coordinating movements. Lesions or damage in the motor area result in an inability to control voluntary fine motor movements.
- The auditory area = An area of the temporal lobe, located on the superior temporal gyrus, which is responsible for processing auditory information and speech. Lesions or damage in the auditory area causes hearing loss, whereas damage to specific parts of the auditory area (Wernicke's area) results in Wernicke's aphasia.
- The visual area = An area in the occipital lobe which is responsible for processing visual information.
- The somatosensory area = An area of the parietal lobe which processes information associated with the senses e.g. touch, heat, pressure etc. [1]"These regions receive neuronal input from specific nuclei of the thalamus that correspond with the handling of sensation along the lines of touch, pain, temperature and limb position". Lesions in this area result in a loss of ability to denote sensitivity to particular bodily areas.

[1] Noggle, C.A and Moreau, A.R., Somatosensory Area, Encyclopedia of Child Behaviour and Development, pp. 1416.

- Wernicke's Area = Responsible for speech comprehension and located in the temporal lobe (the left temporal lobe for most people). Lesions or damage (e.g. through stroke and trauma) results in Wernicke's aphasia, which is characterised by the use of nonsensical words (called syllogisms), no awareness of using incorrect words, but no issues with pronounciation and intonation.
- Broca's Area [Brodmann areas 44 and 45] = Responsible for speech production and located in the frontal lobe, usually in the left hemisphere. Lesions or damage results in Broca's aphasia, characterised by difficulty forming complete sentences and understanding sentences, as well as failing to understand the order of words in a sentence and who they are directed towards i.e. I, you, we, him, me etc.
- Overall, the left hemisphere of the brain is associated with language production and comprehension. Therefore, language is an example of a cognitive ability which is both localised and lateralised (to the left hemisphere).

+ Supporting evidence for localisation of brain function = Tulving et al demonstrated, using PET scans, that semantic memories were recalled from the left prefrontal cortex, whilst episodic memories were recalled from the right prefrontal cortex. This shows that different areas of the brain are responsible for different functions, as predicted by localisation theory. This idea was further supported by Petersen et al (1988) , who found that Wernicke's area activation is required for listening tasks, whereas Broca's area is required for reading tasks. This confirms the idea that Wernicke's area is involved in speech comprehension, whilst Wernicke's area is responsible for language production.

+ Supporting Case Studies = Phineas Gage was injured by a blasting rod which intersected the left side of his face, tearing through his prefrontal cortex. [2]"The damage involved both left and right prefrontal cortices in a pattern that, as confirmed by Gage's modern counterparts, causes a defect in rational decision making and the processing of emotion". Such case studies, particularly those showing marked differences after trauma, demonstrate the idea that some areas of the brain are responsible for specific functions. However, with the use of case studies, the subjectivity of the conclusions drawn and the unusual sample, alongside a lack of control over confounding and extraneous variables, must also be considered.

— Contradictory Theory = The opposite to localisation theory would be a holistic view of brain function, suggesting that each function requires several brain areas to be activated and that these functions are not restricted to these areas. For example, after removing 20-50% of the cortices belonging to rats, found that no specific brain area or lesion was associated with learning how to traverse through a maze. This suggests that intelligence, or even learning, is too complex and advanced a cognitive ability to be restricted to certain areas of the brain. Therefore, this suggests that localisation theory may provide a better explanation for 'simple', rather than complex, brain functions.

+ Evidence supporting the link between certain brain areas and symptoms of OCD = Dougherty et al (2002) studied 44 OCD sufferers who'd undergone lesioning of the cingulate gyrus (cingulotomy) in order to control their symptoms. After being assessed using the Structured Clinical Interview for DSM-III-R, the researchers found that [3]"At mean follow-up of 32 months after one or more cingulotomies, 32% met criteria for treatment response, and 14% were partial responders. 32-45% of patients previously unresponsive to medication and behavioural treatments for OCD were at least partly improved after cingulotomy". This suggests that not only are certain brain areas responsible for symptoms of OCD, but that an improved understanding of localisation of brain function has practical applications in the development of more advanced treatments for serious mental disorders.

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[2] Damasio, H., Grabowskki, T., Frank, R., Galaburda A.M. and Damasio A.R. (1994), The Return of Phineas Gage: Clues About the Brain from The Skull of a Famous Patient,

[3] Prospective Long-Term Follow-Up of 44 Patients Who Received Cingulotomy for Treatment-Refractory Obsessive-Compulsive Disorder Darin D. Dougherty, Lee Baer, G. Rees Cosgrove, Edwin H. Cassem, Bruce H. Price, Andrew A. Nierenberg, Michael A. Jenike, and Scott L. Rauch, American Journal of Psychiatry 2002 159:2, 269-275

Part 4 — Plasticity and Functional Recovery of the Brain after Trauma

- Plasticity = Refers to the brain's ability to physically and functionally adapt and change in response trauma, new experiences and learning. Neuroplasticity was demonstrated by Maguire et al (2006).
- The idea of plasticity opposes the previous theory that there is a 'critical window' for synaptic and neuronal connection formation, which occured during the first 3 years of life, after which no new neuronal connections would be formed (Gopnik et al).
- We control the strength and number of neuronal connections in our brains through the process of synaptic pruning i.e. [4]"the process by which extra neurons and synaptic connections are eliminated in order to increase the efficiency of neuronal transmissions".
- After studying the brains of London taxi drivers, Maguire et al. found a larger grey matter volume in the mid-posterior hippocampi (and a lower volume in the anterior hippocampi) of their brains, alongside a positive correlation between an increasing grey matter volume and the longer the individuals had been taxi drivers. The researchers concluded that [5]"a complex spatial representation, which facilitates expert navigation and is associated with greater posterior hippocampal gray matter volume, might come at a cost to new spatial memories and gray matter volume in the anterior hippocampus". This may be because the hippocampus is associated with spatial awareness; an ability which taxi drivers must have when they complete The Knowledge test.
- Functional recovery is the ability of the brain to transfer the functions of areas damaged through trauma, to other healthy parts of the brain, thus allowing for normal functioning to carry on. This is enabled through the law of equipotentiality (where secondary neural circuits surrounding the damaged area become activated), axonal sprouting (formation of new synapses and strengthening of axonal connections between damaged and healthy areas), reformation of blood vessels (as part of the haemodynamic response, where activated areas experience a higher blood deoxygenation level) and recruiting homologous areas on the opposite side of the brain.
- This means that function is not always lateralised to specific hemispheres!
- One example of functional recovery would be Ramachandran's research into phantom limb syndrome, which he explained as being [6]"caused by the sensory input from the face skin 'invading' and activating deafferented hand zones in the cortex and thalamus… there appears to be tremendous latent plasticity even in the adult brain". This demonstrates negative plasticity, because the neuroplasticity results in painful or negative consequences.
- A second example of functional recovery would be the case of Jodi Miller, whose entire left hemisphere was removed in an attempt to control her epileptic seizures. However, through the mechanisms of neuroplasticity, she was still able to control the right side of her body through the use of cerebral spinal fluid. This demonstrates positive plasticity, because the neuroplasticity results in desirable or positive consequences.

\+ Evidence supporting the positive and negative effects of neuroplasticity = Much research has been carried out into the phenomenon of plasticity. For example, Ramachandran et al. has demonstrated negative plasticity through providing an explanation for phantom limb syndrome in terms of cortical reorganization in the cortex and thalamus (particularly, the somatosensory area). Positive plasticity has been demonstrated by the case study of Jodi Miller, who has shown the power of recruiting homologous areas on the opposite side of the brain, axonal sprouting and the reformation of blood vessels. Therefore, there is evidence supporting not only the existence of, but also the uses of plasticity.

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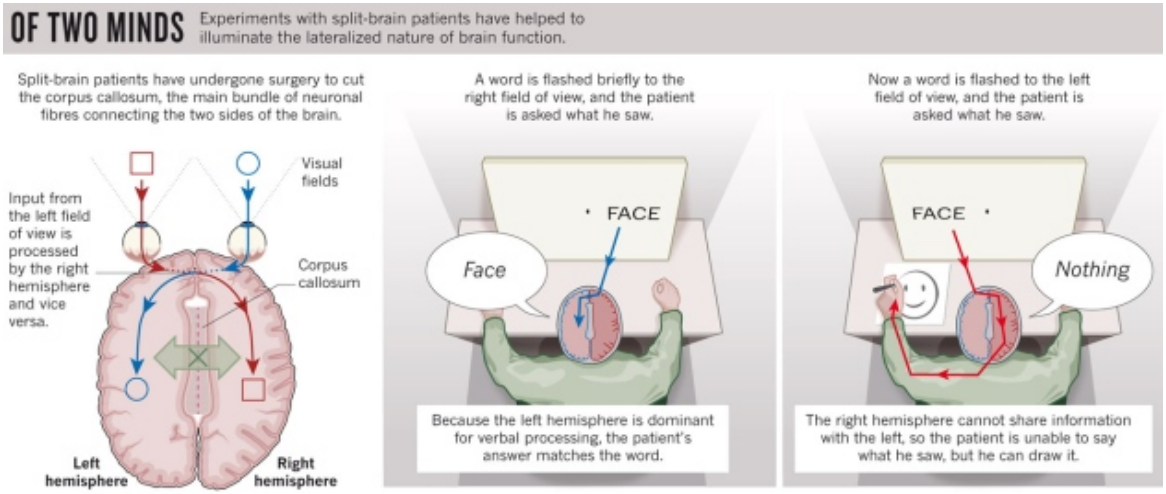
[4] Santos, E. and Noggle, C.A. (2011), Synaptic Pruning, Encyclopedia of Child Behaviour and Development, pp.1464-1465.

[5] Maguire, E. A., Woollett, K. and Spiers, H. J. (2006), London taxi drivers and bus drivers: A structural MRI and neuropsychological analysis. Hippocampus, 16: 1091–1101. doi:10.1002/hipo.20233

[6] Ramachandran V.S., Plasticity and functional recovery in neurology, Clin Med July/August 2005 5:368-373; doi:10.7861/clinmedicine.5-4-368



+ Neuroplasticity occurs in animals too = Hubel and Weisel (1970) sutured the right eye of kittens, who are blind from birth, for a period of 6 months, opening the eyes and several points and monitoring brain activity in the visual cortex. The researchers found that, although the right eye was closed, there was still activity in the left visual cortex, corresponding to the development of occular dominance columns. This was demonstrated by how [7]"during the period of high susceptibility in the fourth and fifth weeks eye closure for as little as 3-4 days leads to a sharp decline in the number of cells that can be driven from both eyes". This therefore supports the idea that areas of the brain receiving no input can take over the function of highly stimulated areas, despite originally having different functions.

+ Cognitive reserve may increase the rate of functional recovery = Cognitive reserve is the level of education a person has attained and how long they have been in education. Research suggests that an increased cognitive reserve increases the likelihood of making a disability-free recovery (DFR) after trauma, due to increased rates of neuroplasticity. For example, Schneider et al (2014) found that of the [8]769 patients studied, 214 achieved DFR after 1 year. Of those, 50.7% had between 12 and 15 years of previous education and 25.2% had more than 16 years. This suggests that individuals who have been in education for a longer time may have developed the ability to form neuronal connections at a high rate, and therefore experience high levels of functional recovery, demonstrating positive plasticity.

— There are limits to spontaneous and functional recovery = Although after trauma the brain activates secondary neural circuits which contribute towards reinstating normal function (law of equipotentiality), the brain can only 'repair' itself up to a specific point, after which motor therapy or electrical stimulation is needed to increase recovery rates. For example, Lieperta et al (1998) found that after constraint-induced movement therapy, the motor performance of stroke patients improved significantly. Therefore, this suggests that functional recovery cannot be relied upon to reinstate normal function.

Part 5 — Split-Brain Research into Hemispheric Lateralisation

- Hemispheric lateralisation = The idea that each hemisphere (half) of the brain is mainly responsible for certain behaviours, processes and activities. This is in contrast with the holistic theory of brain function, which suggests that function is distributed across the whole brain (i.e. is global).

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[7] Hubel, D. H., Wiesel, T. N., (1970), The period of susceptibility to the physiological effects of unilateral eye closure in kittens. The Journal of Physiology, 206 doi: 10.1113/jphysiol.1970.sp009022.

[8] Schneider et al (2014), Function recovery after moderate/severe traumatic brain injury, Neurology, 82(18), pp.1636-1642.

- Each visual field has two sides - left and right. The right hemisphere controls the left side of the body, and vice versa. Therefore, information which we receive from the left visual field is processed by the right hemisphere, which then coordinates a response to affect the left side of the body.
- Sperry and Gazzaniga (1968) conducted split-brain research on 11 epileptic patients. In order to control their seizures, these patients underwent surgical lesioning of the corpus callosum, through a procedure called a cerebral commissurotomy, where information processed by one hemisphere cannot be relayed to the other hemisphere. Therefore, it is possible to expose a single hemisphere to certain stimuli in split-brain patients, and thus infer the functions of each hemisphere.
- The patients had one of their eyes covered, so that information would not be received by both eyes. The stimuli was flashed onto a screen for one-tenth of a second. This prevented both visual fields of the eye being exposed to the information, so only one hemisphere would process it. Therefore, their research was conducted under strictly controlled conditions, through the use of a laboratory experiment. The procedure and results are as follows:

1. Describing what you see = If the stimulus word was exposed to the right visual field, then it would be processed by the left hemisphere and the patient would say the word. This is because the left hemisphere contains the 'language centres' of the brain and so allows for speech. However, if the same stimulus word was exposed to the left visual field, then it would be processed by the right hemisphere and the patient would write the word using their left hand. This is because the right hemisphere contains the visuo-spatial centres of the brain, allowing for the physical act of writing. The patient would not be able to give a verbal description of the word, because the right hemisphere contains no language centres.
2. Matching words or faces = The right hemisphere appeared to dominate the ability to match a list of faces to a given stimulus. This is due to the right hemisphere containing the brain's visuo-spatial centres, thus allowing for the visual identification and processing of the faces.
3. Words presented simultaneously = If two words were presented at the same time, each to one of the visual fields, the patient would say the word presented to the right visual field (processed by the left hemisphere with language centres) and write down the word presented to the left visual field (processed by the right hemisphere and containing visuo-spatial centres).
4. Recognizing objects placed into the hands = If an object was placed into the patient's right hand, they would be unable to identify that it is there, because the information would be processed by the left hemisphere which only has language centres, and no visuo-spatial centres. Therefore, if an object was placed into the patient's left hand, they would be able to identify the object and choose a similar one from a hidden bag, due to the action of the visuo-spatial centres.

— Lack of control with the sample selection = The epileptic patients had been taking anti-epilepsy medications for extended and different periods of time, which may have affected their ability to recognise objects and match words, due to causing cerebral neuronal changes. Secondly, although all patients had undergone a commissurotomy, there may have been differences in the exact procedures e.g. differing extent of the lesioning of the corpus callosum. This would have affected the degree to which the two hemispheres could relay information between themselves. Therefore, these two confounding variables had not been controlled, meaning that the lateralised functions may be examples of unreliable causal conclusions.

+ Clearly demonstrated lateralisation of function = Split-brain research was pivotal in establishing the differences in functions between the two hemispheres, and so opposing the holistic theory of brain function. The left hemisphere was demonstrated as being dominant for language tasks, due to containing language centres, whereas the right hemisphere was demonstrated as being dominant for visuo-spatial tasks. Therefore, this suggests that the left hemisphere is the analyser, whereas the right hemisphere is the synthesiser, and so there are marked differences between the two.

+ Contribution to discussions about lateralisation theories = Such evidence strongly supported the idea of a 'dual mind' where the two hemispheres represent two sides of the mind. Pucetti (1980)

critisised Sperry and Gazanigga's work by pointing out that [9]"visual stimuli impinging on the left half of each eye's retina do not go to the right, but to the left cerebral hemisphere (and vice versa), since the retina is concave and each half retina receives light from the contralateral side of the body". Therefore, it is clear that split-brain research has sparked much debate about the physiological and theoretical basis of brain function and human abilities.

— The differences in function may not be so clear-cut = With evidence making the drastic distinctions that the left hemisphere is responsible for language (analyser) whilst the right is responsible for visual-spatial tasks (synthesiser), this has given the public the false impression that the two hemispheres are 'opposite' in function and that they can receive such labels. However, as suggested by Pucetti (1980), there have been cases of split-brain patients who are left-handed but produce and comprehend speech in the right hemisphere, which opposes the predictions made by lateralisation theory. Therefore, it is important not to jump to conclusions and to appreciate that, through recruitment of homologous areas on the opposite side of the brain, each hemisphere is not restricted to specific functions.

Part 6 — Ways of Investigating the Brain

1. PET Scans = These use radioactive isotopes with a long half-life e.g. Nitrogen-13. As the isotope decays, such as through the emission of positrons, these particles interact and are combined with glucose or water molecules, forming radiotracers. An increased number of radiotracers will accumulate in areas of the brain with high levels of activity, due to the haemodynamic response where such areas have a larger requirement for oxygenated blood. Therefore, such highly active areas will appear brightly coloured on the PET scans, as the emitted positron collides with an electron, resulting in the emission of gamma rays which are detected by the scan.

— PET scans are very expensive and so are not extensively used in public healthcare systems - only for diagnosis purposes.

— Some people may object to the use of radioactive tracers in their blood, due to exposure to ionising radiation which may lead to cancer. Therefore, only one or two PET scans can be carried out on an annual basis.

+ Very useful for the diagnosis and monitoring of progressive, neurodegenerative diseases, such as Alzheimer's (characterised by a reduction in glucose metabolism rates in the brain).

2. fMRI scans = These rely on the haemodynamic response. Areas of the brain with high levels of activity have a larger requirement for oxygenated blood, leading to a higher rate of blood deoxygenation. As measured through the bold response, the deoxyhaemoglobin in the blood in these highly active areas absorbs the signal produced by the scan, so such areas appear brightly coloured on the scan.

+ High temporal resolution as up to 4 images can be produced per second.

+ Can be used whilst a patient is carrying out a task, and so data from fMRI scans can help us to make inferences about brain function and localisation.

+ Does not use ionising radiation, unlike PET scans, and so is safer.

— Poor temporal resolution because there is approximately a 5 second difference between neuronal activity and the produced image.

3. EEG scans = Through the use of electrodes attached to the scalp, EEG scans measures and amplifies the electric activity across the whole brain i.e. action potentials being transmitted across the axons of neurons.

+ Particularly useful in investigating the characteristics of the different stages of sleep, as demonstrated by Dement and Kleitman.

+ Much higher temporal resolution than fMRI scans, and so more appropriate for the monitoring of ongoing cerebral states and activity.

— Lower temporal resolution compared to fMRI scans, with particular difficulty in differentiating activity between adjacent areas.

+ Useful in the diagnosis of epilepsy, which is characterised by random bursts of activity.

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[9] Puccetti, R. (1980). On Saving Our Concept of a Person. *Philosophy, 55*(213), 403-407. Retrieved from http://www.jstor.org/stable/3750822

4. Post-mortem examinations = These involve a comparison of the patient's brain with that of a healthy, neurotypical brain. Any differences (e.g. lesions, damage, abnormally large or small areas) are assumed to have caused the neruological problem the patient faced in their lifetime.
— Incorrectly makes the assumption that differences compared with the neurotypical brain must be the explanation for neurological or cognitive deficits. Prolonged drug use, stress and genetic factors may be other plausible explanations.
— Ethical issues arise because informed consent cannot always be obtained before the patient dies or from the family. The patient may be unable to give informed consent e.g. HM suffered from deficits in his short-term memory, and so would not remember having signed the document.
+ Particularly useful for advancing medical knowledge, and being the basis of further research into certain areas of the brain e.g. Broca used a post-mortem examination on his patient Tan, which led to the identification of Broca's area and was the foundation of further research into the theory of the localisation of brain function.

Part 7 — Biological Rhythms: Circadian Rhythms

- Biological Rhythms = [10]"Periodic biological fluctuations in an organism that corresponds to, and is in response to, periodic environmental change". These include changes in core bodily temperature, attention (such as a circadian trough at 6 AM) and the sleep-wake cycle. Biological rhythms can be endogenous (controlled by internal clocks e.g. the suprachiasmatic gyrus) or exogenous (controlled by external, environmental factors e.g. exposure to sunlight). The three types of biological rhythms are circadian, infradian and ultradian.
- Exogenous zeitgebers = External changes in the environment which affect or 'entrain' our biological rhythms.
- Circadian Rhythms = A type of biological rhythm which completes one full cycle every 24 hours e.g. the sleep-wake cycle. Like other biological rhythms, it is affected by both endogenous pacemakers and exogenous zeitgebers.
- The main example of an exogenous zeitgeber would be light. Changes in light exposure can trigger desynchronisation of a 'pre-set' sleep-wake cycle.
- This was extensively studied by Siffre (1962), who descended into a cave on July 16th 1962, completely devoid of natural light. He finished his experiment on September 14th, believing it to be August 20th! This demonstrates that prolonged exposure to a strong exogenous zeitgeber such as light, the sleep-wake cycle becomes disrupted and there is a disconnection between psychological time and the clock. His sleep-wake cycle did not conform to a cyclical 24 hour-period, but was around 24 hours and 30 minutes, with Siffre himself determining when to sleep and when to eat. Therefore, this demonstrates that [11]"there was an internal clock independent of the natural terrestrial day/night cycle". This describes a 'free-running' circadian rhythm i.e. one which is not affected by exogenous zeitgebers.
- A second example of a free-running circadian rhythm was demonstrated by Aschoff and Wever (1967). 55 participants were deprived of natural light whilst spending 4 weeks in an underground bunker. The researchers found that [12]"all subjects showed free-running circadian rhythms, with the average periods of wakefulness and sleep ranging from 23.9 to 50.0 hours. 36 subjects remained internally synchronized during the whole experiment".
- Therefore, these findings demonstrate that although the free-running circadian rhythm is more than 24 hours long, as a society we have specific exogenous zeitgebers which entrain the rhythm to conform to a 24 hour cycle.

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[10] `Biological Rhythm', Encyclopaedia Brittanica, Date Published: 14.05.15, Access Date: 07.08.17, https://www.britannica.com/science/biological-rhythm

[11] 'Caveman: An Interview with Michel Siffre' (2008) , J.Foer and M.Siffre, Cabinet, Issue 30: The Underground Summer

[12] Aschoff, J., Gerecke, U. and Wever, R. (1967), Desynchronization of Human Circadian Rhythms, The Japanese Journal of Physiology, 17 (4), pp.450-457

— Individual differences in circadian rhythms = Circadian rhythms may not and do not always have to conform to cyclical 24 hour periods. For example, Dr. Espie, a Professor of sleep medicine at Oxford University, delayed the starting time of Monkseaton High School to 10 AM, instead of the usual 8AM. The researchers noted that [13]"GCSE results went up from 34% of pupils scoring 5 A*-C grades including English and Maths, to 53%. For disadvantaged students, the rates of scoring 5 A*-C grades increased from 12% to 42%". Therefore, this is a real-life example of how the circadian rhythms of teenagers specifically are not always in line with that of adults, and so an appreciate of this can improve educational attainment.

— The confounding effect of artificial light = As demonstrated by Czeisler et al (1999), artificial lighting can create shifts in circadian rhythms by up to 6 hours. Siffre's research was conducted at a time where researchers believed that artificial lighting had no effect on biological rhythms. The use of artificial light meant that over 2 months, Siffre could have entrained his own circadian rhythm through signaling sleeping and waking times by using the light, meaning that the conclusions made about his 'free-running' circadian rhythm may not be entirely accurate.

— Detrimental impacts on health in shift workers = [14]Karlsson, Knutsson and Lindahl (2001) found that shift work was associated with obesity, high triglycerides and low concentrations of HDL cholesterol, which the researchers suggest may demonstrate a link between the desynchronisation of circadian sleep-wake cycles in shift workers and the consequent disruptions in the biological control of metabolism (and therefore core body temperature). This suggests that there may be practical uses in an improved understanding of the effects of desynchronisation. This in turn has economical implications, in terms of companies who employ shift-workers making the effort to revise their policies in order to reduce days taken off sick.

— Use of case studies and small samples in isolation investigations = Although Siffre conducted multiple isolation studies, his results may not be able to be generalised to the wider population, especially as individual differences in the duration and stages of circadian rhythms has been shown (i.e. Monkseaton High School), hence his results may lack ecological validity. For example, even Siffre himself noted that as he grew older, his endogenous pacemaker ticked at a slower rate, which may have acted as an uncontrolled confounding variable in his investigations. The same can be said for other isolation studies, such as Aschoff and Wever, where large numbers of participants are unlikely to want to participate. This again limits the extent to which the findings represent the experiences of the general population.

Part 8 — Biological Rhythms: Infradian and Ultradian Rhythms

- Infradian Rhythm = One of 3 types of biological rhythms, with a frequency of one complete cycle occurring less than once every 24 hours. Such rhythms are entrained by endogenous pacemakers and exogenous zeitgebers. Notable examples of infradian rhythms include the menstrual cycle and SAD (seasonal affective disorder).
- McClintock et al (1998) demonstrated menstrual cycle synchronisation amongst 29 women who all had irregular periods. The pheromones from 9 of the women were collected through the use of a pad under the armpit, and then rubbed onto the upper lip of the remaining 20 women, corresponding to the specific days of their cycle. The researchers found that "recipients had shorter cycles when receiving axillary compounds producing by donors in the follicular phase of the menstrual cycle (+ 1.7 +/- 0.9 days) and longer cycles when receiving ovulatory compounds (+ 1.4 +/— 0.5 days).

[13] 'Major study of teenage sleep patterns aims to assess impact on learning', Sally Weale, The Guardian, Published on: 09.10.14, Accessed On: 07.09.17, https://www.theguardian.com/lifestyle/2014/oct/09/study-teenage-sleep-patterns-asses-impact-learning

[14] Karlsson B, Knutsson A, Lindahl B Is there an association between shift work and having a metabolic syndrome? Results from a population based study of 27485 people Occupational and Environmental Medicine 2001;58:747-752.

- Seasonal affective disorder is an example of the influence of endogenous pacemakers on the circadian sleep-wake cycle. SAD is an infradian disorder caused by disruption to the sleep-wake cycle, and commonly occurs in the winter. Longer nights means that more melatonin is secreted from the pituitary gland, via the endocrine system, which changes the production of melatonin, leading to feelings of loneliness and depression.
- Ultradian Rhythm = One of 3 types of biological rhythms, with a frequency of one complete cycle occurring more than once every 24 hours. A notable example are the stages of sleep, where a full sleep cycle takes 90 minutes to complete.
- Stages 1 and 2 represent the 'sleep escalator' where the participant can easily be awoken, stages 3 and 4 coincide with deeper and slower delta waves (compared to theta waves during the sleep escalator), whilst stage 5 represents REM sleep. REM sleep is closely associated with dreaming and characterised by movement inhibition and a sensory blockade. The stages of sleep have been demonstrated by Dement and Kleitman.

+ The stages of sleep have clearly been demonstrated = Dement and Kleitman (1957) studied 33 adults, where their caffeine and alcohol intake had been controlled, in order to remove the effect of these extraneous variables and increase the reliability of the findings. Using EEG scans, the researchers found that [15]"discrete periods of rapid eye movement potentials were recorded without exception during each of 126 nights of undisturbed sleep". Since participants were able to accurately recall their dreams when awoken during REM sleep, the assumption was made that dreaming is associated with REM sleep. Therefore, there is clear evidence supporting the idea of a distinct set of sleep stages.

— Menstrual synchronisation is not always present in all-female samples = For example, Trevathan et al (1993) noted that he had found no evidence of menstrual synchronisation in the all-female participants used, which suggests that there are external (extraneous) variables which may affect the timing and duration of their menstrual cycles. McClintock et al. did not control for such extraneous factors e.g. smoking, physical activity and alcohol consumption. Therefore, this raises doubts about the strength of the influence of pheromones, as an exogenous zeitgeber which can entrain infradian rhythms.

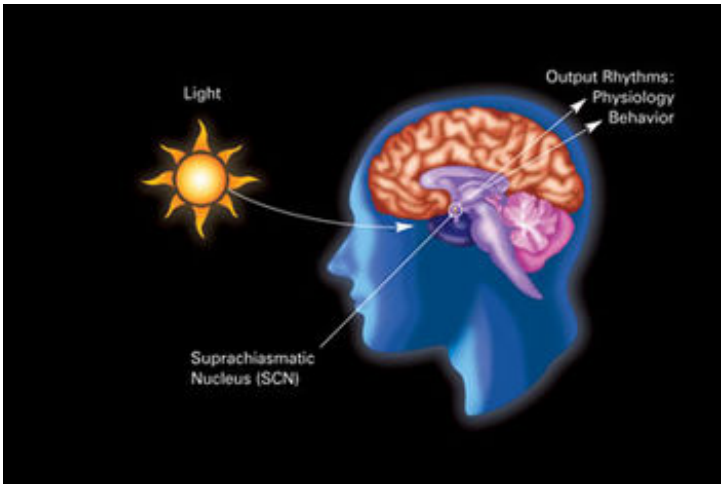
— Dispute over the chemical and hormonal basis of SAD = Gloth et al (1999) found that, when treating sufferers of SAD with either Vitamin D supplements or broad-spectrum phototherapy, "all subjects receiving vitamin D improved in all outcome measures. The phototherapy group showed no significant change in depression scale measures". Patients who'd been given vitamin D supplements also experienced a 74% improvement in their depression measures. Therefore, this suggests that phototherapy is ineffective in treating SAD. Since phototherapy involves exposure to bright light in order to increase the rate at which the pineal gland secretes melatonin, this implies that melatonin and serotonin levels have little parts to play in the development of SAD and in the entrainment of circadian sleep-wake cycles.

+ Animal studies supporting the role of pheromones = The link between the pheromone release and animal behaviour has been extensively supported. For example, Luo et al (2003) studied the effects of pheromonal signals in the olfactory bulb of mice and concluded that [16]"mammals encode social and reproductive information by integrating vomeronasal sensory activity specific to sex and genetic makeup". Therefore, this suggests that endogenous pacemakers have a critical role in the entraining of biological rhythms in animals, whose findings can then be generalised to humans.

Part 9 — Endogenous Pacemakers and Exogenous Zeitgebers

[15] William Dement, Nathaniel Kleitman, Cyclic variations in EEG during sleep and their relation to eye movements, body motility, and dreaming, Electroencephalography and Clinical Neurophysiology, Volume 9, Issue 4, 1957, Pages 673-690, ISSN 0013-4694, http://dx.doi.org/10.1016/0013-4694(57)90088-3.

[16] Luo, M., Michale, S.F. and Katz, L.C (2003), Encoding Pheromonal Signals in the Accessory Olfactory Bulb of Behaving Mice, Science, 299 (5610), pp.1196-1201.



•Endogenous Pacemakers = Internal bodily regulators of biological rhythms, affecting or 'entraining' such biological rhythms to conform to certain cyclical periods e.g. one cycle every 24 hours for circadian rhythms.

•The suprachiasmatic nucleus (SCN) receives information about day light and day length from the eyes, where such information has been processed by the visual area in the occipital lobe and relayed to the SCN via the optic chiasm (from one hemisphere to the other). The SCN then processes this information and triggers different rates of release of melatonin from the pineal gland. Increased melatonin release triggers decreased serotonin production, creating feelings of sleepiness during the night time, where there is little exposure to light. Conversely, during the daytime, when there is high exposure to light, the SCN triggers the pineal gland to release less melatonin over a longer period of time, resulting in increased serotonin production, creating feelings of wakefulness.

- The effect of the SCN was demonstrated by DeCoursey et al (2000), who surgically lesioned the SCNs of 30 chipmunks, and compared their circadian rhythms in their natural habitat with 17 controls. The researchers found that the vast majority of the experimental group had been killed within the first 80 days after being returned to their habitat and [17]"episodes of nocturnal movement were detected within the permanent dens by radio telemtric data logging, especially in supra-chiasmatic nucleus-lesioned animals".
- Ralph et al extracted SCN cells from hamsters which showed abnormal sleep-wake cycles, and inserted these cells into healthy hamster foetuses. The researchers found that [18]"the restored rhythms always exhibited the period of the donor genotype, regardless of the direction of the transplant or genotype of the host. The basic period of the overt circadian rhythm therefore is determined by cells of the suprachiasmatic region".
- Exogenous Zeitgebers = External environmental changes, affecting or 'entraining' biological rhythms to conform to certain cyclical time periods.
- Social cues are examples of exogenous zeitgebers which entrain biological rhythms. These include set meal times and bed times, which signify when to wake up and when to fall asleep. This means that in order to avoid jet lag, it is useful to accustom yourself to the set sleeping and eating times of your destination, to avoid desynchronisation of an already 'pre-set' circadian rhythm.
- A second example of the effect of an exogenous zeitgeber would be the role of light in entraining the sleep-wake cycle, as demonstrated by Siffre et al (1967) and Campbell and Murphy (who produced deviations of 3 hours in the participant's sleep-wake cycle by shining light onto pads on the back of their knees, showing that light does not always need to be detected by the eyes in order to entrain biological rhythms).

— The influence of the SCN may be overestimated. For example, Damiola et al. demonstrated that the circadian rhythm of mice liver cells could be influenced to experience a 12 hour discrepancy, leaving the SCN unaffected. These so-called 'peripheral oscillators', also present in the adrenal gland and lungs, are collections or systems of cells which act independently of the SCN, each having their own biological rhythm. Therefore, the SCN is not so important as once thought.

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[17] DeCoursey, P.J., Walker, J.K and Smith, S.A (2000), A circadian pacemaker in free-living chipmunks: essential for survival?, Journal of Comparative Physiology A, 186 (2), pp.169-180

[18] Ralph, Martin R; Foster, Russell G; Davis, Fred C; Menaker, Michael., Transplanted Suprachiasmatic Nucleus Determines Circadian Period, Science; Washington247.4945 (Feb 23, 1990): 975.

— There are considerable ethical issues with the use of animals in such research, particularly if they are deliberately put in harms way as was the case with Decoursey et al, thus breaching the BPS ethical guideline of protection from psychological and physical harm. Although this does not impact upon the utility or validity of the findings, a cost-benefit analyses would have to be conducted to assess whether such ethical costs outweigh the benefits of an improved understanding of exogenous zeitgebers and endogenous pacemakers. A second problem occurs with the limitations of generalising findings from animal studies to humans, particularly due to differences in physiology and the number/types of circadian rhythms, thus limiting the ecological validity of such findings.

— There have also been recorded cases where exogenous zeitgebers and endogenous pacemakers have failed to entrain or alter circadian rhythms, as demonstrated by Miles et al (1977) who reported the case of a man with a sleep-wake cycle of 24.9 hours, which could not be changed through the use of either stimulants or sedatives. Therefore, this suggests that the influence of exogenous and endogenous factors may be overestimated!