DEFINITION OF NEUROPSYCHOLOGY

Neuropsychology is a branch of psychology that studies how the nervous system (particularly the brain) influence behaviour and mental processes.

Neuropsychology is the study of how the complex properties of the brain allow for the behavior to occur.

Neuropsychology involves:

- the study of the relationships between brain function and behaviour. Neuropsychology seeks to understand how the various components of the brain are able to do their function.
- observation of changes in thoughts and behaviors that relate to the structural or cognitive function of the brain.Clinical neuropsychology makes use of various assessment methods to ascertain function and dysfunction and applies this knowledge to evaluate, treat and rehabilitate individuals with suspected or demonstrated neurological or psychological problems.

BRANCHES OF NEUROPSYCHOLOGY

A neurospsychologist has a choice to focus on a number of different areas. The area a person chooses to focus on will depend on a person's interests and the type of place they would like to work. A person can focus on, experimental neuropsychology, clinical neuropsychology, paediatric neuropsychology as well as cognitive neuropsychology among others.

1. Experimental Neuropsychology: Experimental neuropsychology is an approach which uses methods from experimental psychology to uncover the relationship between the nervous system and cognitive function.

   A neuropsychologist who focuses on experimental neuropsychology will mainly perform research by conducting experiments to increase understanding of the human brain. A neurospsychologist will conduct research into the effects of brain trauma and degenerative diseases as well as looking at ways to help a patient cope with the effects of brain disorders.

By testing a range of cognitive abilities and examining patterns of performance in different cognitive areas, neuropsychologists can make inferences about underlying brain function. Neuropsychological testing is an important component of the assessment and treatment of traumatic brain injury, dementia , neurological conditions, and psychiatric disorders.

Neuropsychological testing can help in planning and developing remedial education, rehabilitation and vocational programs for individuals with neurological or developmental problems.

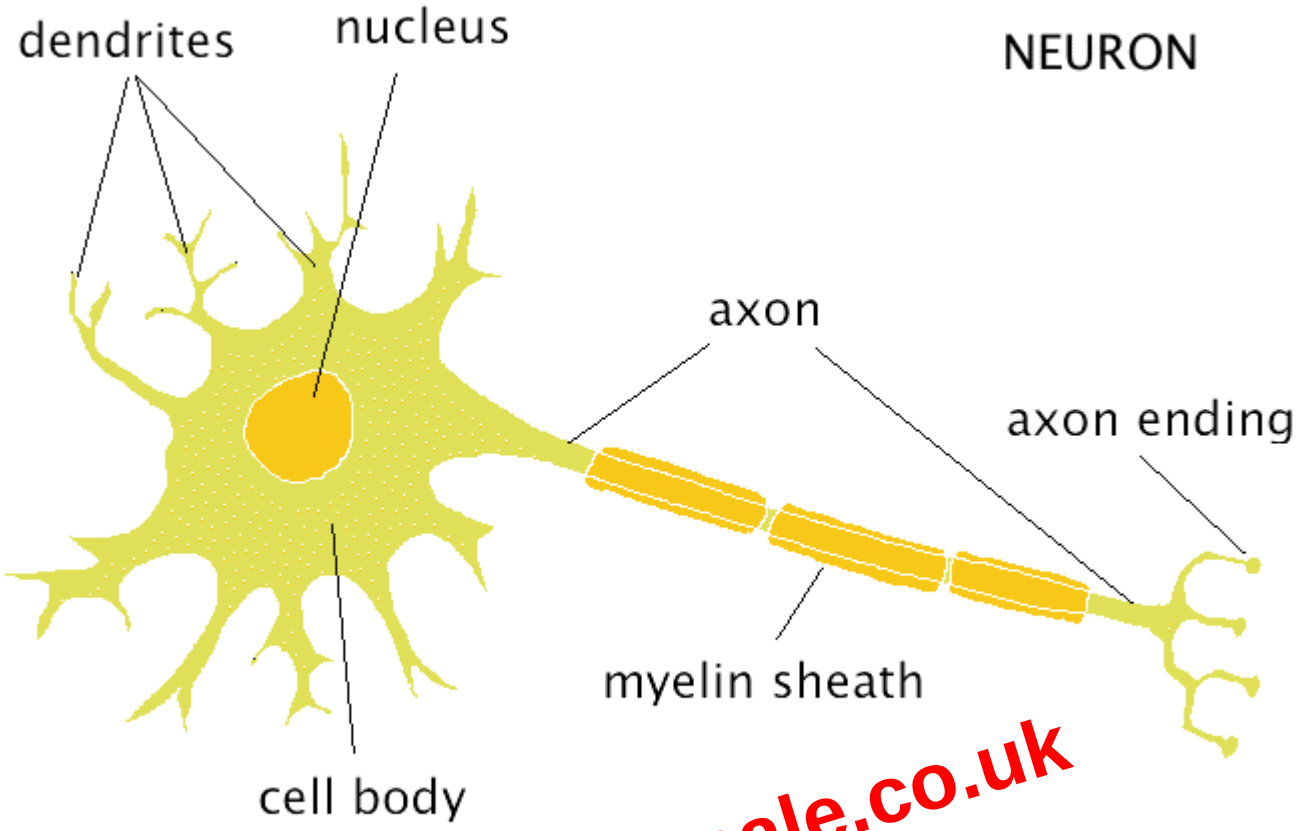
A neuropsychological evaluation is essential for obtaining school-based services, testing accommondations for college entrance examinations and accommodations in one's place of employment.

History of Neuropsychology

Evidence of Early Neuropsychology: Trephanation
Trephanation is the ancient surgical procedure of opening on the human skull by scraping, chiseling, or cutting bone from the skull.

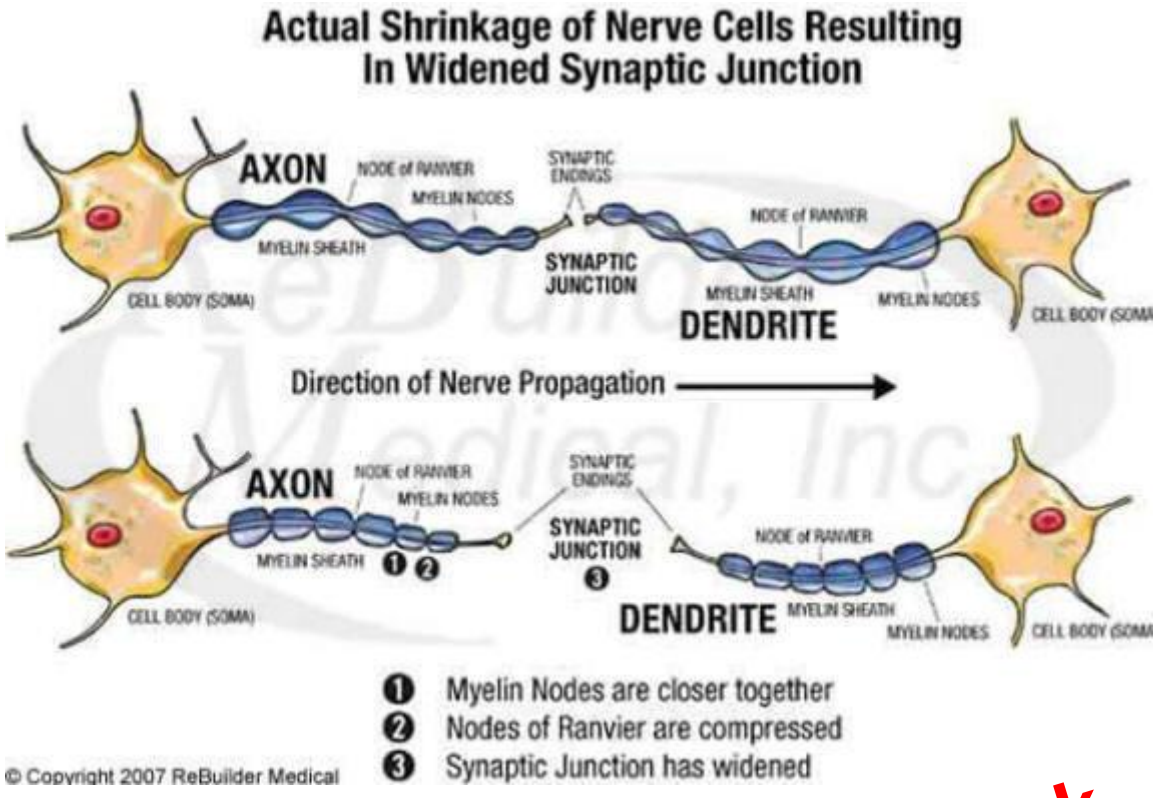
- discovered by archaeologists
- many who underwent trephanations survived - evidence of healing
- many died - no healing; many multiple trephanations
- at times, on damaged skulls - perhaps TBI following hand-to-hand fighting
- at times on intact skulls - perhaps psychiatric disorders
- perhaps a religious rite - to release evil spirits

Verona & Williams (1992) examinied 750 skulls from Peru and measured trepahaned skulls for technique, location, size, healing, and presence of fractures. Results suggest that most trephanations were performed in the frontal and upper parietal regions following injury to the skull from clubs and other weapons of the pre-Columbian era. Scraping and circular grooving had the highest success rates as opposed to straight cutting and drilling. Techniques used were similar to modern-day methods of drilling "burr holes" to relieve pressure and release trapped blood.



What is inside of a neuron? A neuron has many of the same **organelles** such as mitochondria, cytoplasm and a nucleus, as other cells in the body.

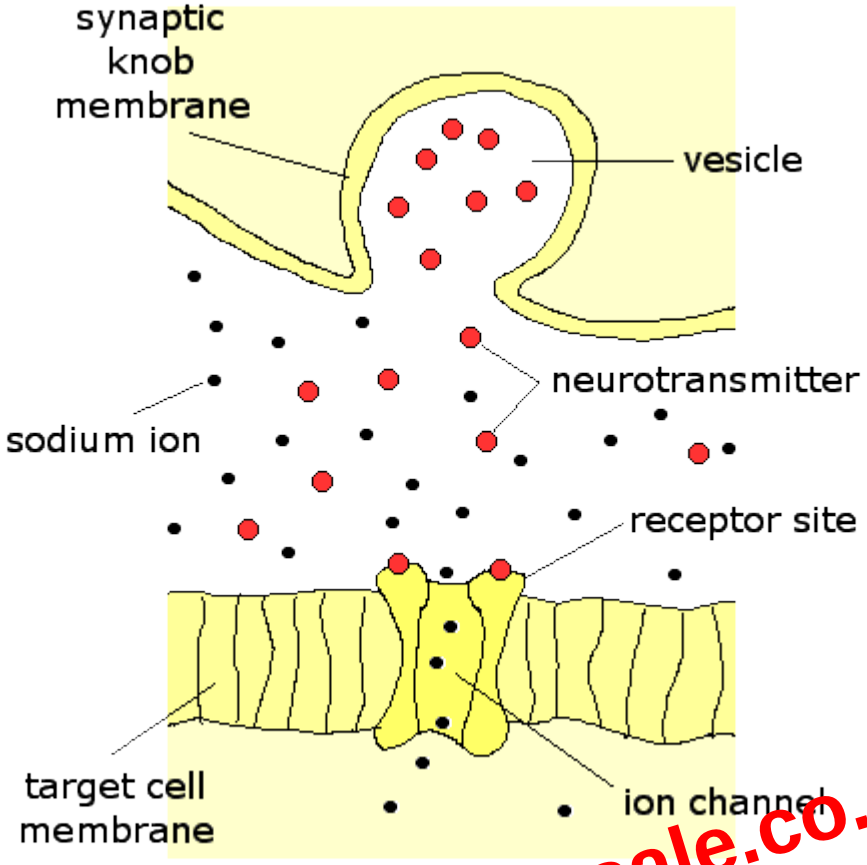
- **Nucleus** - contains genetic material (chromosomes) including information for cell development and synthesis of proteins necessary for cell maintenance and survival. Covered by a membrane.
- **Nucleolus** - produces ribosomes necessary for translation of genetic information into proteins
- **Nissl Bodies** - groups of ribosomes used for protein synthesis.
- **Endoplasmic reticulum (ER)** - system of tubes for transport of materials within cytoplasm. Can have ribosomes (rough ER) or no ribosomes (smooth ER). With ribosomes, the ER is important for protein synthesis.
- **Golgi Apparatus** - membrane-bound structure important in packaging peptides and proteins (including neurotransmitters) into vesicles.
- **Microfilaments/Neurotubules** - system of transport for materials within a neuron and may be used for structural support.
- **Mitochondria** - produce energy to fuel cellular activities.



In this little diagram, the red represents the positive ions going into the axon, while the orange represents positive ions going out. The action potential travels at a rate of 1.2 to 250 miles per hour!

The chemical transmission (from neuron to neuron)

When the action potential reaches the axon ending, it causes tiny bubbles of chemicals called **vesicles** to release their contents into the synaptic gap. These chemicals are called **neurotransmitters**. These sail across the gap to the next neuron, where they find special places on the cell membrane of the next neuron called **receptor sites**.



Electrical transmission occurs by virtue of the fact that the cells are in direct contact with each other: depolarization of the presynaptic cell membrane causes a depolarization of the postsynaptic cell membrane, and the action potential is propagated further. Here transmission of information is always excitatory: the conduction of information always causes a depolarization of the adjacent cell's membrane.

Chemical transmission, albeit more complex allows for far more control, including the ability to excite or inhibit the postsynaptic cell. Here the conduction of information can cause either depolarization or hyperpolarization, depending on the nature of the chemical substance.

The sequence of events that lead to postsynaptic changes is as follows:

1. The action potential signal arrives at the axon terminal (the bouton).
2. The local depolarization causes Ca^{2+} channels to open.

TYPES OF NEUROTRANSMITTERS

There are two kinds of neurotransmitters –
INHIBITORY and EXCITATORY.

Excitatory neurotransmitters are not necessarily exciting – they are what stimulate the brain. Those that calm the brain and help create balance are called inhibitory. Inhibitory neurotransmitters balance mood and are easily depleted when the excitatory neurotransmitters are overactive.

The Excitatory Neurotransmitter System can be related to your car's accelerator. It allows the signal to go. When the excitatory neurotransmitter system is in drive your system gets all reved up for action. Without a functioning inhibitory system to put on the brakes, things (like your mood) can get out of control

EXAMPLES

Excitatory Neurotransmitters

DOPAMINE is our main focus neurotransmitter. DOPAMINE is a special neurotransmitter because it is considered to be both excitatory and inhibitory. It is involved in movement, motivation, and emotion, Dopamine produces feelings of pleasure when released by the brain's reward system, and it's also involved in learning.Dopamine helps with depression as well as focus.

When dopamine is either elevated or low – we can have focus issues such as not remembering where we put our keys, forgetting what a paragraph said when we just finished reading it or simply daydreaming and not being able to stay on task.

Dopamine is also responsible for our drive or desire to get things done – or motivation. Stimulants such as medications for ADD/ADHD and caffeine cause dopamine to be pushed into the synapse so that focus is improved. Unfortunately, stimulating dopamine consistently can cause a depletion of dopamine over time.

Dopamine is responsible for motivation, interest, and drive. It is associated with positive stress states such as being in love, exercising, listening to music, and sex . When we don't have enough of it we don't feel alive, we have difficulty initiating or completing tasks, poor concentration, no

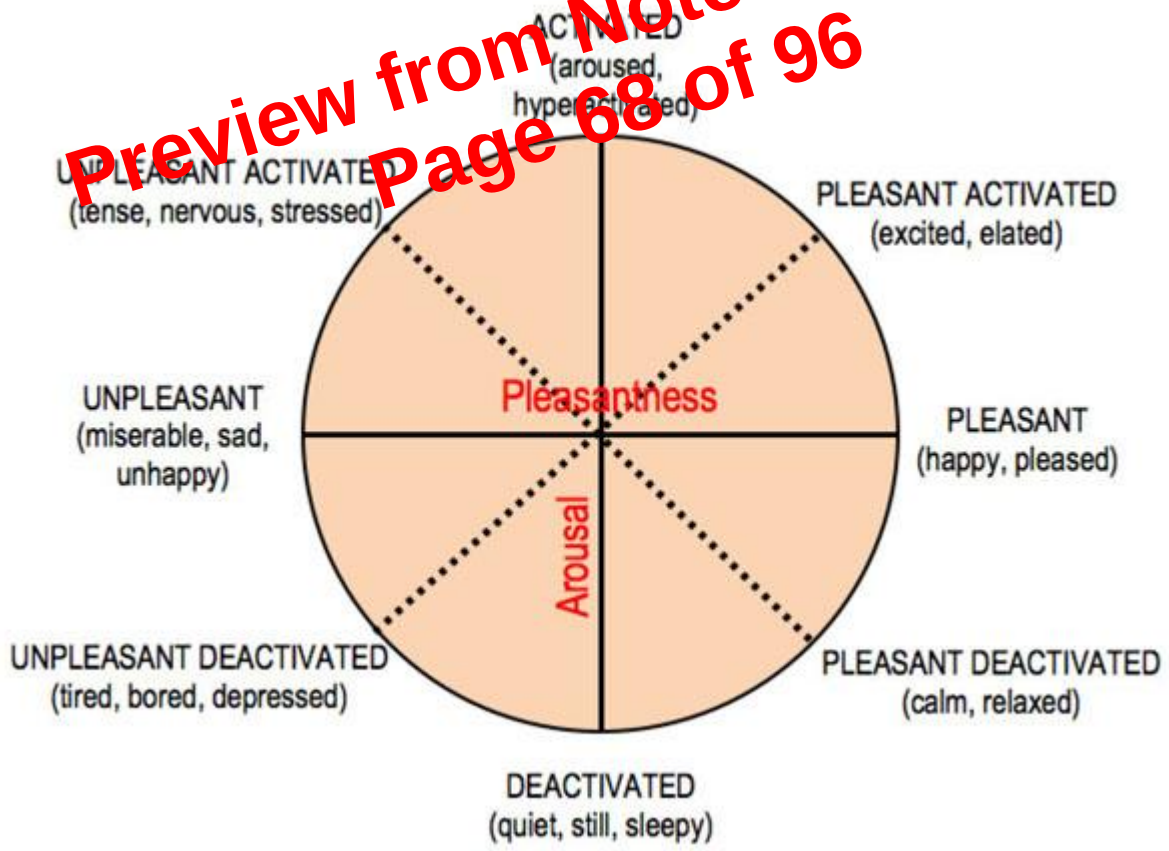
Some other neurotransmitters also facilitate positive social interactions. Endogenous opioids are rewarding and can induce odor and place preferences; they are also released during bouts of affiliative interaction such as suckling, physical contact, allogrooming, and social play.

Opioids are postulated to encourage animals to engage in affiliative social behaviors by inducing a euphoric state (Nelson and Panksepp 1998). The opioid reward system also plays an important role in reinforcing sexual behavior in male mammals (Agmo and Berenfeld 1990).

An important message to be extracted from these summaries of the neurophysiological bases of emotional systems is that each is associated with diagnostic expressions—in other words, communication signals. Food-seeking is associated with expressions of liking, such as smiles and tongue extrusion, and expressions of disliking such as gaping and disgust facial expressions. Fear is associated with screams and fearful expressions; anger with aggressive postures, staring, weapon presentation, and mouth expressions; and panic with cries and expressions of pain and sadness. Care and lust systems are associated with physical contact gestures and smiles; and the play system is associated with invitation postures, play faces, and laughter.

Categories of emotions

A final point is the inevitable urge by biologists and psychologists to categorize emotions, especially in humans, because we have many more described emotions than animals do. Early attempts by several researchers converged on a two-dimensional model, in which emotions are placed on a grid or circle with two orthogonal axes, one representing level of pleasantness (e.g., positive versus negative feelings, or valence), and another axis representing arousal level (high versus low) (Russell 1980; Watson and Tellegen 1985; Thayer 1986; Russell et al. 1989; Larsen and Diener 1992; Yik et al. 1999). **Figure 5** shows a melded version of these models.



LEARNING AND MEMORY

Definitions

According to Eric Kandel (2000) “Learning is the process by which we acquire knowledge about the world.”

Kimble, 1961, "Learning refers to a more or less permanent change in behavior which occurs as a result of practice."

According to Kandel (2000), ". . . memory is the process by which knowledge of the world is encoded, stored, and later retrieved.’’

Learning is a process by which we integrate new knowledge generated as a result of experiences. The product of such experiences is converted into memories stored in our brain. There is basically no learning without memories.

Types of Memory

There are actually two basic kinds of learning and memory. One is ***declarative*** or ***explicit***; the other is ***non-declarative*** or ***implicit***.

EXPLICIT MEMORY

Knowledge of facts–what we know about places, things and people–and the meaning of these facts is explicit memory.

These things must be recalled into consciousness to be used. Patients who have bilateral medial temporal lobe lesions have an inability to learn and remember items of factual knowledge. They can’t remember people that they met the day before. They can’t remember what they did the day before.

Some people will further parcel explicit memories as ***episodic*** (we remember events) or ***semantic***(we remember facts). As Kandel (2000) points out, in either case the content of all explicit memories can be expressed by declarative statements such as “I was here yesterday” (episodic).

IMPLICIT MEMORY

Consolidation-converting the encoded information into a form that can be permanently stored. The hippocampal and surrounding areas apparently accomplish this.

Storage-the actual deposition of the memories into the final resting places– this is though to be in association cortex.

Retrieval-memories are of little use if they cannot be read out for later use. Less is known about this process.

Implicit Memory

Implicit memories are stored differently depending upon how they are acquired. "Fear conditioning" (training that involves use of fearful stimuli) involves the amygdala. Operant conditioning involves the striatum and cerebellum. For example, eye blink conditioning is disrupted by lesions of the dentate and interpositus nuclei of the cerebellum. Classical conditioning, sensitization and habituation involve the sensory and motor systems involved in producing the motor responses being conditioned. Perhaps surprisingly, certain simple reflexes mediated by the spinal cord can be classically conditioned even after the cord has been surgically isolated from the brain. So, it appears that all regions of the nervous system may be capable of memory storage.

STAGES OF MEMORY PROCESSING

Sensory memory

Sensory memory holds sensory information for less than one second after an item is perceived. The ability to look at an item and remember what it looked like with just a split second of observation, or memorization, is the example of sensory memory. It is out of cognitive control and is an automatic response. With very short presentations, participants often report that they seem to "see" more than they can actually report. The first experiments exploring this form of sensory memory were conducted by George Sperling (1963)[1] using the "partial report paradigm". Subjects were presented with a grid of 12 letters, arranged into three rows of four. After a brief presentation, subjects were then played either a high, medium or low tone, cuing them which of the rows to report. Based on these partial report experiments, Sperling was able to show that the capacity of sensory memory was approximately 12 items, but that it degraded very quickly (within a few hundred milliseconds). Because this form of memory degrades so quickly, participants would see the display but be unable to report all of the items (12 in the "whole report" procedure) before they decayed. This type of memory cannot be prolonged via rehearsal.

Three types of sensory memories exist. Iconic memory is a fast decaying store of visual information; a type of sensory memory that briefly stores an image which has been perceived for a small duration. Echoic memory is a fast decaying store of auditory information, another type of sensory

does not seem to store information itself. Without the hippocampus, new memories are unable to be stored into long-term memory, as learned from patient Henry Molaison after removal of both his hippocampi,[8] and there will be a very short attention span. Furthermore, it may be involved in changing neural connections for a period of three months or more after the initial learning.

Processes of Learning

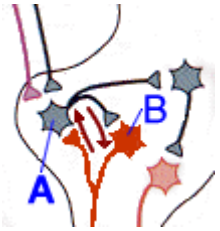


Fig. 18-3 - A reverberating circuit: Neuron A excites B and vice versa. (Kandel, ER, JH Schwartz and TM Jessell (2000) *Principles of Neural Science*. New York: McGraw-Hill.)

Given the definitions for learning and memory, what sort of mechanisms would we expect to find in the nervous system? One early thought was that neurons in "memory" pathways were arranged in reverberating circuits. In such a circuit, one neuron excites another and the other excites the one such that, once the circuit is activated, action potentials run around continuously. An example of this kind of arrangement is shown in Fig. 18-3. Here are shown only 2 neurons in the circuit but any number may be included. If this kind of arrangement accounts for memory, then any event that temporarily stopped activity in the circuit should disrupt memory. Unfortunately for supporters of the idea, electroconvulsive shock, which temporarily stops or resets all electrical activity in the nervous system produces only a significant, transitory loss of recent memory, but no loss of older memories.

Some years ago, the psychologist Donald Hebb (Hebb, DO (1949) The Organization of Behavior: A Neuropsychological Theory. New York: John Wiley) mulled this problem and came up with a principle that has become known as Hebb's rule. Briefly, the principle is "When an axon of cell A . . . excites cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells so that A's efficiency as one of the cells firing B is increased." As we shall see, current thought is an extension of Hebb's rule.

Habituation

What happens in the nervous system to produce habituation? Experiments performed in *Aplysia californica*, the sea slug, were designed to address this problem. Their results are shown schematically in Fig. 18-4. If the siphon of the animal is stimulated mechanically the animal withdraws the gill, presumably for protection. That action is known to occur because the stimulus activates receptors in the siphon, which activates, directly or indirectly through an interneuron, the motoneuron that withdraws the gill. This is a simple reflex circuit. All of this is shown on the left side of the figure. With repeated activation, the stimulus leads to a decrease in the number of dopamine-containing vesicles that release their contents onto the motoneuron. There appears to be no change in the sensitivity of postsynaptic NMDA or non-NMDA receptors. As yet, we don't know why the dopamine release decreases. It is presumed that habituation in vertebrates, including man, occurs by a similar process.

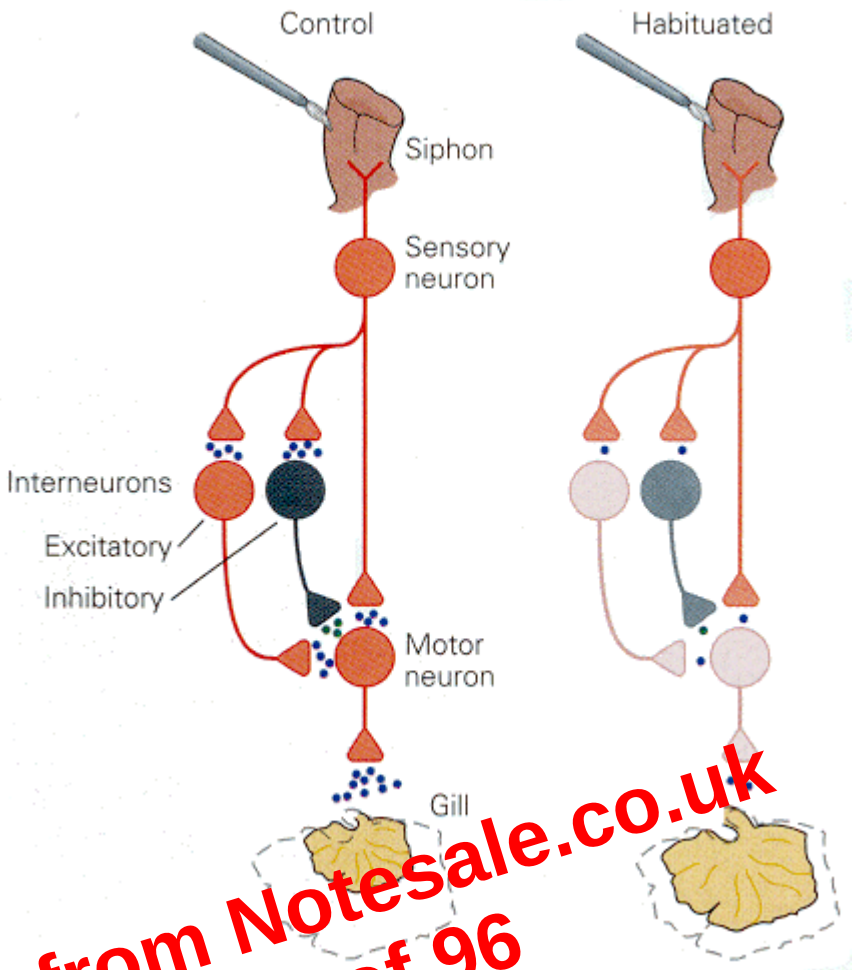


Fig. 18-4 - Simplified neural circuits involved in the habituation process in *Aplysia*. There are about 24 sensory neurons in the siphon; these are glutaminergic. They synapse on 6 motor neurons that innervate the gill and various interneurons as shown. The control condition is shown on the left, the habituated condition on the right. (Kandel, ER, JH Schwartz and TM Jessell (2000) *Principles of Neural Science*. New York: McGraw-Hill.)

Sensitization

In sensitization, a stimulus to one pathway enhances reflex strength in another. An example, again taken from experiments in *Aplysia*, is shown below.

With only short-term tail stimulation, the sensitization will fairly quickly disappear when tail stimulation ceases. However, the sensitization can be made relatively permanent by repeated tail stimulation.

This long-term sensitization (and also long-term habituation) occurs because there are structural changes that occur in the presynaptic terminals (sensory neuron 1, for example). With sensitization, there is an up to 2-fold increase in the number of synaptic terminals in both sensory and motoneurons. Alternatively, with habituation, there is a one-third reduction in the number of synaptic terminals.

LEARNING ACC TO HEBB

Hebb proposes that whenever conditioned reflexes are established in an organism through learning, a new anatomical substratum is established in the brain through a physiological process in which weak or non-existent synapses are strengthened by biochemical modification or by permanent changes in their electrical properties. Learning, according to Hebb's hypothesis, is not simply something impressive upon a passive brain, but a process in which the cellular structure of the brain is permanently modified.

Hebbian theory is a theory in neuroscience that proposes an explanation for the adaptation of neurons in the brain during the learning process. It describes a basic mechanism for synaptic plasticity, where an increase in synaptic efficacy arises from the presynaptic cell's repeated and persistent stimulation of the postsynaptic cell.

Hebb states it as follows:

"Let us assume that the persistence or repetition of a reverberatory activity (or "trace") tends to induce lasting cellular changes that add to its stability. ... When an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased."

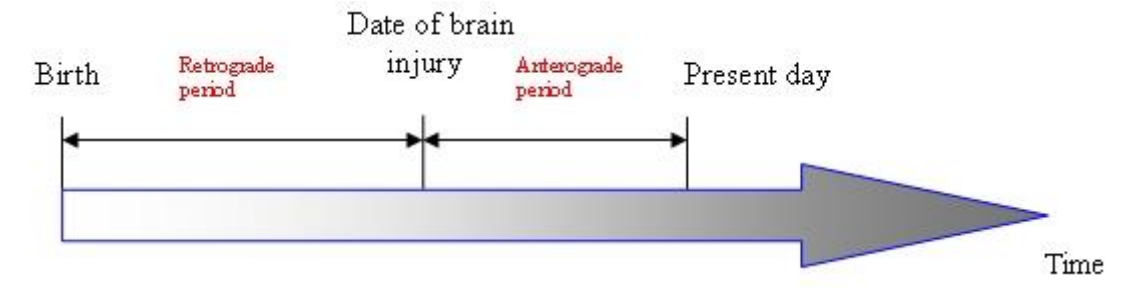
The theory is often summarized as "Cells that fire together, wire together''. The theory attempts to explain associative or Hebbian learning, in which simultaneous activation of cells leads to pronounced increases in synaptic strength between those cells. Synapse is a part of neural cell structure that is believed to store the newly acquired neural network function.

Hebbian learning account of mirror neurons.

Mirror neurons are neurons that fire both when an individual performs an action and when the individual sees or hears another perform a similar action. The discovery of these neurons has been very influential in explaining how individuals make sense of the actions of others, by showing that when we perceive the actions of others, we activate the motor programs we would use to perform similar actions. The activation of these motor programs then adds information to the perception and help predict what the person will do next based on the perceiver's own motor program.

Amnesia[edit]

As already mentioned in the preceding section about the hippocampus, there are two types of **amnesia** - **retrograde** and **antrograde amnesia**.



Different types of Amnesia

Amnesia can occur when there is damage to a number of regions in the medial temporal lobe and their surrounding structures. The **patient H.M.** is probably one of the best known patients who suffered from amnesia. Removing his medial temporal lobes, including the hippocampus, seemed to be a good way to treat the epilepsy. What could be observed after this surgery was that H.M. was no longer able to remember things which happened after his 16th birthday, which was 11 years before the surgery. So given the definitions above one can say that he suffered retrograde amnesia. Unfortunately, he was not able to learn new information due to the fact that his hippocampus was also removed. H.M. therefore suffered not only from retrograde amnesia, but also from anterograde amnesia. His Implicit Memory, however, was still working. In procedural memory tests, for example, he still performed well. When he was asked to draw a star on a piece of paper which was shown to him in a mirror, he performed as bad as every other participant in the beginning. But after some weeks his performance improved even though he could not remember having done the task many times before. Thus, H.M.'s Declarative Memory showed severe deficits but his Implicit Memory was still fine. Another quite common cause of amnesia is the **Korsakoff's syndrome** or also called Korsakoff's amnesia. Long term alcoholism usually elicits this Korsakoff's amnesia due to a prolonged deficiency of vitamin B1. This syndrome is associated with the pathology of the midline diencephalon including the dorsomedial thalamus. **Alzheimer's disease** is probably the best known type of amnesia because it is the most common type in our society. Over 40 percent of the people who are older than 80 are affected by Alzheimer's disease. It is a neurodegenerative disease and the region in the brain which is most affected is the entorhinal cortex. This cortex forms the main input and output of the hippocampus and so damages here are mostly severe. Knowing that the hippocampus is especially involved in forming new memories one can already guess the patients have difficulties in learning new information. But in late stages of Alzheimer's disease also retrograde amnesia and even other cognitive abilities, which we are not going to discuss here, might occur.

Descartes, the soul was produced outside of our physical body even though he suggested that it might actually reside inside the brain. He speculated that the soul was embedded in the pineal gland because he knew it was a structure which, unlike most other brain structures, was not cut in half. For him, the soul simply could not reside in a split brain area. His views gave birth to a critical movement called dualism, the separation of the body and the mind. Dualism continues to influence many thinkers even today.

Since it is commonly accepted that what makes humans so special is our ability to be more conscious than any other species, it is not surprising that this debate has lasted for hundreds of years. Most recently, however, advances in brain science have helped elevate this heated dialogue beyond just rhetoric or ideology. After all, it is clear that the brain is, if not directly producing, at least intimately orchestrating our experience of consciousness. But to make things more difficult, the term consciousness itself has been the subject of ongoing discord. Philosophers, religious thinkers, scientists and even psychologists don't always agree on the definition of consciousness or on what makes us conscious. Moreover, consciousness is used or considered a substitute for many other words that are as abstract and ambiguous as the term itself. For instance, consciousness is often considered a synonym for terms such as "life", "awareness", "attention", "mindfulness", "alertness", "wakefulness", and even "morality". Clearly, the debate on the nature of consciousness is not going to end anytime soon if we continue to struggle with the adoption of a clear and operational definition.

Defining Consciousness

It is only when a construct like consciousness is clearly defined that it can become properly tested and manipulated. Since consciousness is now widely recognized to be directly tied to the existence of states produced by the brain, it seems reasonable to adopt a definition that comes from the field of cognitive neuroscience. According to neuroscientists, consciousness simply refers to the "levels of awareness we have of our immediate experience of sensations and feelings" (Gazzaniga, 2009, p 548). Awareness becomes a key factor in a****sing the quality of such states since it varies greatly based on the relevance or attractiveness of an event, the attention committed to such events, and finally, to our ability to maintain wakefulness during any event. In other words, we become conscious as a result of the existence or manifestation of states created by infinite combinations of those three factors. Finally, it is important to note that states of consciousness have been measured and identified as representative of certain patterns of neurons firing within the brain confirming that consciousness itself is intimately related to neuronal activity. Considering that the brain is always active even when we are asleep, we can convincingly suggest that there is a complex and rich continuum on which we can plot and observe many states of consciousness. Let's review now the factors most responsible for how we become conscious: experience, attention and wakefulness.

Experience

Experience is the moment by moment awareness of events or sensations that are shaping our life. Experience is intimately influenced by prior beliefs encoded as memories in our brains. Though we do not need to be conscious to experience life in general, we tend to remember and learn more from events or sensations that appear most relevant to us and ultimately shape our lives. The more relevant an event is to us, the more conscious our experience of it appears to be. The role of emotions associated with a specific experience is critical in that respect. Work conducted by Richard Davidson (1990) shows that emotions guide our actions and mediate the

way we face experience. We often embrace or withdraw from experience based on the emotional tone we assign to it. Conscious experience expands or augments the immediate sensations we are able to perceive at any given moment. Recent research using fMRI technology has shown that during the rest stage of the brain, the part which has the highest metabolic activity is the Medial Prefrontal Cortex (MPFC). This area is most responsible for producing self-thoughts, an activity directly linked to our ability to develop self-consciousness (Gazzaniga, 2009, p. 604). This strongly suggests that our level of consciousness is indeed related to how much we assign value or relevance to a given experience.

But while we may believe that most of our experiences are the product of objective consciousness, the evidence implies otherwise. We are indeed largely influenced by what is referred to as subjective awareness. Subjective awareness is the personal and true representation of a given moment as produced by our own sensations or feelings. It is only accessible to the individual and not to an observer. It is the essence of our private and personal experience of life. The term qualia is often used to describe the subjective quality of our awareness. Many philosophers argue that qualia is what makes the study of consciousness more an art than a science. However, scientists remain unmoved by the philosophical argument and continue to research ways to map or measure manifestations of any kind of awareness including, from objective to subjective. Because of the availability of better brain imaging technology such as MEG and fMRI, it is now possible to record brain activity both spatially and temporally for the purpose of looking at gaps between the objective measures of awareness (brain activity) and the subjective manifestation as reported by subjects. For instance, it is well known that many functions in the brain including decision-making show great latency between the time when cortical or subcortical activity can be recorded and when the decision is actually made (Libet, 2006), presumably because many cortical functions such as visual processing happen in just a few milliseconds.

Attention

Attention is the quality of how we can focus energy to process a particular stimulus; therefore, it is intimately associated with consciousness. We can control some of our attention willingly, which is known as selective or voluntary attention. We also frequently allow our attention to process novelty or events that command instant responses. This is referred to as reflexive attention. Such responses are managed by subcortical brain structures that operate below our level of consciousness. The speed at which we need to react correlates highly with the degree to which we control our attention willingly. Because of the voluntary or automatic qualities of attention, different neuronal pathways are at play during the production of higher or lower states of attention. The PFC is highly involved in using selective attention whereas reflective attention is directly managed by the brain stem and the limbic system. Within the limbic system, a tiny brain structure called the amygdala has the power to hijack the entire body to process and respond to a fight or flight event. Also, both the lateral geniculate nucleus (LGN) and the pulvinar nucleus of the thalamus play a significant role in mediating attention. To conclude on attention, it should be noted that there is a level of attention that falls somewhere in between voluntary and reflexive called covert attention. Covert attention describes the ability to take notice of information in the periphery of the object or space in which we are placing our attention. This gives us the ability to notice a great deal of activity around the focus of our attention without any kind of intent or awareness.

Wakefulness (Sleep to Awake)

Though it is not clear why we sleep, we do know that we can seriously impair brain functioning or even die as a result of lack of sleep. If our brain needs to sleep in order to maintain its healthy activity of which consciousness is a huge product, then clearly the quantity and quality of consciousness is directly dependent upon our stages of wakefulness.

Brain activity varies during the day. Our most active state produces an electrical current that can be plotted by an EEG machine and is referred to as BETA brain waves. These waves have the highest number of cycles of minutes of any awake state and shows desynchrony in the brain. This pattern of waves indicates that many areas in the brain are firing to attend to numerous cognitive activities. The deeper we fall asleep or the less conscious we become, the more synchronous the brain waves become suggesting that the brain is firing less during cognitive functions. During our sleep though, we experience a phase called REM sleep during which our brain is more active, yet we remain completely paralyzed. It is during the REM sleep stage that we dream, which is yet another state of consciousness that has fascinated humans for thousands of years. Let's mention in closing that some people have the ability to become conscious that they are dreaming, a phenomenon known as lucid dreaming. As a result, lucid dreamers may reclaim the power to move their body with increased consciousness.

By using the definition of consciousness proposed earlier, we can now easily understand that we enter and leave multiple states of consciousness with or without awareness. We can also infer that consciousness is not produced by external stimulation alone. Internal thoughts, ideas, beliefs and even dreams can generate multiple states of consciousness. Since brain scientists are just beginning to map neural activity that correlates with many of those states, the study of consciousness is rapidly evolving. It was proposed a few years ago that there may well be a central brain structure responsible for consciousness (Koch & Crick, 2005). A thin layer of gray matter called the claustrum receives input from almost all regions of the cortex and projects back to almost all regions of the cortex making it a good candidate for being the center of consciousness.