Psychology 1.2 – 6/3/2014
Introducing Neuroscience

Neurons, glia, and mechanisms of communication within the neuron

Glia are important for normal neural function.

Multiple Sclerosis (MS)- A condition that leads to dysfunction in the brain

- MS begins with visual problems, numbness, weakness of the limbs.
- Ultimately leads to paraplegia, slurred speech, problems with vision and eye movements.
- Frequent attacks followed by quiescence or remission.
- Autoimmune disorder that affects the insulation covering the nerve cells (*myelin*).

Complex neural connections are responsible for various phenomena in human activity.

Withdrawal Reflex If there is enough excitation within a given circuit, neurons will produce an involuntary reflex. Somata sensory neuron cuts in close proximity to an interneuron, connected to a motor neuron, which the latter is connected to the bicep muscle. If there is enough excitation, the withdrawal reflex will happen. The interneuron will excite the motor neuron into causing a reflex.

Inhibition- another form of interneuron can inhibit a motor neuron, and prevent a muscular contraction. Whether contraction or inhibition occurs depends on the extent of excitation experienced by neurons and interneurons in the brain and spinal cord. If the e.g. heat of a dish isn't unbearable, an interneuron may inhibit the motor neuron from reflexing, if there is enough time for the brain to process. Whether the motor neuron fires will determine what information it receives from the interneurons. Neurons all connect together with axons.

Neurons

- Cortex, thalamus, spinal cord, skin, and cerebellum neurons.
- Structure- **cell body**, **dendrites**, **axon**- where the neuron will send information out to other neurons in the cell network. The more dendrites, the more connections to other neurons.
- Archetypal neuron- other neurons pass information at the dendrites. The cell body- nucleus possesses the DNA, mitochondria. Axon- information leaves the neuron and gets transmitted ot other neurons through the axon, which touches the dendrites of other neurons. Axon hillock- an electrical signal. Myelin sheath- insulate the electrical signal and prevent it from being lost along the way. The signal is passed along the neural network at the axon terminals.
- Glial cells- Provide physical support, assist with chemical transport to and from neurons, provide insulation, destroy and remove neurons that have died from injury or old age (phagocytosis)
- Astrocyte- provides physical support

- Oligodendrocyte-central nervous system, peripheral nervous system; insulate the axon myelin sheath- very little loss of electrical signal
- Microglia- important for chemical processes in the brain…destroys dead or faulty neurons, the 'housework' cells.
- Schwann cell-natural nervous system, peripheral nervous system; insulate the axon
- Mitochondria- production of neuron.
- See Galvani's experiment on frogs (withdrawal reflex)

Communication within a neuron

- Cross-section- bilayer of fat separates fluids within the neuron and outside the neuron. Prevents fluid from exchanging inside and outside and prevents electrical charge from leaking. Extracellular space has a 0 charge.
- Inside of the neuron has a negative charge compared to outside, known as the resting membrane potential -70mV difference. It is critical for the electrical signals that will propagate down the axon. We can cause a change in the resting membrane potential by inserting an electrical generator. The voltage within the neuron can be caused to change, and can be depolarized towards zero. Polarized = far from zero, depolarization = close to zero.
- The -70 mV charge is extremely important in neuron function.
- Ordinarily, the fatter bilayer restricts any communication between the intracellular cytoplasm and the extracellular space. The inside is more negatively charged than the outside.
- Structures in the membrane allow under certain circumstances transfer of matter within and outside the cell. Ordinarily, ions can't go if they do it is known as **diffusion**- when high concentration moves to a place with low concentration. Many positive molecules on the outside will attract other positive molecules from the inside. Ordinarily, molecules of the same charge will be repelled from each other, and opposite charges attract. If we were to open a gap in the cell membrane, there would be an exchange of ions.
- Extracellular space is filled essentially with salty water, as it contains Sodium (+) and chlorine (-). Potassium (+) and proteins (-) are typically inside a neural cell. Potassium is positive while proteins are negative. In the right circumstances, sodium and potassium can transfer between the membrane.
- *Electrostatic pressure*- cations (+) and anions (-). Positive is attracted inside, and negative is attracted outside.
- Diffusion and electrostatic pressure would cause sodium to rush into the cell if possible. Chlorine is attracted by the positive charge in the outside wall of the cell, while it is repelled from the inside wall of the cell.
- **Sodium-potassium transporters** shift excess form inside to out and transport chlorine in. A large amount of energy supplied by the mitochondria is used simply to 'shunting' sodium from the inside out and pushing potassium back inside. It is essential to have the abundance of sodium on the outside and potassium on the inside for normal neural function. Protein molecules in cell membrane pump Sodium ions out of

the axon, and pump potassium in. Energy (ATP) supplied by mitochondria.

- Depolarization by injecting current- start of the axon hillock has a number of structures that will automatically respond if there is enough depolarization within the neuron. Normally it is the inputs of other cells that cause depolarization, and causes an automatic chain reaction to occur. Along the cell membrane are gates that allow ions to transfer. As long as there is enough depolarization for AP, sodium can rush into the neuron, potassium out, and the electrical charge can occur. The threshold of excitation needs to be surpassed (around -50 mV).
- Depolarization causes sodium gates to rush into the axon. They open and close very quickly. If the sodium is rushing in, at the location will get a slightly positive charge in the otherwise slightly negative axon. Potassium gates automatically open when sodium gates also open. Potassium is forced outside, and becomes more positively charged outside, and more negatively charged inside.
- Constant rapid negative to positive, see-saw-**Action Potential**- The sequence of electrical signal moving down the axon. If the signal is strong enough down the axon, the next set of gates will open, and a new AP will have been produced, however, it is critical that there is the sufficient AP at the beginning of the axon.
- Change of membrane potential over time- There is a threshold of excitation, and when it's crossed, there is an automatic opening and closing of sodium channels and potassium, and rush in and out due to diffusion and electrostatic pressure. Essentially, sodium in, potassium out, when depolarized… this is called the Action Potential, and is the electrical signal that propagates down the axon.
- AP along the axon- at the hillock is where the membrane potential is most volatile. Everywhere that the sodium gates are will experience a change in the resting membrane potential. It doesn't matter how long the axon is, if the current is regenerated all the way down, the signal will continue. The longer the axon, the higher the voltage a signal needs.
- **Saltatory conduction of the AP**- Breaks in the myelin sheath are the NA/K gates, and are known as the Nodes of Ranvier. If the voltage is strong enough, an electrical charge will be renewed at each Node of Ranvier.
- **All-or-none law of the AP**- The AP threshold needs to be reached for NA/K gates to open and for an electrical signal to be generated. Though the incoming signal may have an increased charge, the AP remains the same; therefore, you either have all or none, an AP or not AP. A more intesnse excitation of a neuron doesn't make a more intense AP.
- **Hyperpolarization**
- A neuron can work out how important a signal is on the basis of how many Aps are received; it isn't how 'loud' the call is, but how 'persistent', or how many APS are received. This is known as the Rate Law of the AP.
- **Effects of myelin damage in MS**

You need enough depolarization to regenerate AP down the axon. The signal needs to reach the depolarization threshold.

MS there is a de-myelination of nerve fibres. The more myelin sheath you lose, the more chance that some part down the axon, the more chance there won't be enough charge to create an AP at the next Node of Ranvier. Signals simply stop being transmitted between neurons, and these neuron networks will cease to function. There is a lot of redundancy in neural networks; there may be a number of neurons involved in a function, and you will need a large loss of myelin function to begin to see symptoms of MS within someone.

Summary

- Cells of the nervous system- neurons, glia
- Neural communication in a reflex arc.
- Resting membrane potential- balance of diffusion and electrostatic pressure; sodium-potassium pump.
- Action Potential- voltage dependent ion channels (NA+, K+).
- Conduction of the action-potential- saltatory conduction, all-or-none law, rate law.
- MS- demylineation of axons causing sensory loss and weakness.

Psychology – 1.7- 19/3/2014

The Human Visual System

How light information is processed in the brain.

- Different photoreceptor types
- Responses of thalamic and cortical neurons to bars and edges
- Anatomical organisation of the primary visual cortex
- Neural basis for visual disorders of colour and motion perception; object and face recognition.

The Electromagnetic Spectrum

Transforms radiation on the electromagnetic spectrum to neural messages.

Cells of the Retina

- Ganglion cell layer- Ganglion cell
- Bipolar cell layer- horizontal cell, Amacrine cell
- Photoreceptor layer- cones (colour vision) and rods

Three cone types- short, medium and long waves. Ishihara colour plates test for colour blindness.

Visual Pathways to the Brain

Interactions in the Retina

Centre Surround Receptive Field Structure in the Retina

2 types:

1. ON centre- OFF surround
2. OFF centre- ON surround

Modular Organisation Of Specialised Areas

There is a very highly modular organisation of visual processing composition of the brain.

Hemianopia due to unilateral lesion of the primary visual cortex

Any stoke or blockage will starve a part of the brain of oxygen and it will die. Left hemisphere is responsible for processing the right visual field; if that hemisphere is damaged, the right visual field will be blinded.

Hemiachromatopsia- V4 – dedicated to colour; loss of life in that part of the brain will cause no colour either in just one hemisphere, or both.

MT- ability to see motion- biological motion, waterfall illusion, continuous motion; motion blindness (akinetopsia)- inability to judge motion.

Visual object agnosia- loss of the ability to use visual information to make sense of objects around them.

Neurons are dedicated to recognising faces; look at 'face inversion effect'.

Face blindness (prosopagnosia)- region of damage- right fusiform gyrus; 85 year old man was unable to recognise faces, but was fine with recognising other visual objects. These neurons seem to be only responsive when the pattern of light that falls on the retina is in the same shape of a face.

Light falling on the retina gets transformed into neural signals.