Short Paper 1

The question below is to be answered in one page or less. The answer must be your own work. To calibrate the length of your answer, this is one page of double spaced text with a font no smaller than 12 point. *The short essay is due no later than 1pm on Friday, September 21*. The short essay is to be submitted via Blackboard – UBLearns. Questions about submitting the assignment should be directed to the course TA, Tim Pruitt.

In class and the text, neural circuits were described, including a *linear circuit* and a *convergence circuit*. What are these two types of circuits? What is their role in the wiring of neurons in the retina and how would these circuits influence how we see the world?

Your answer needs to explain, in your own words, all three elements. The scoring is up to 4 points for accurately describing the two types of circuits (2 pts for each), up to 3 for their role in the wiring (organization) of neurons in the retina and up to 4 points for relating this wiring to our experience in visual perception (2 pts for acuity and 2 for sensitivity). (Total of 11 points possible.)

On the following pages are 4 answers provided by students. Though different, each answers all of the parts of the question and was scored an 11.

Example 1

The first step in perception, neural information processing, occurs when cells in the retina code visual stimuli through neural circuits—networks of receptor cells, neurons, inhibitory and/or excitatory synapses. One type of neural circuit is a linear circuit. In this circuit formation, no separate receptors act on a same neuron; each receptor has its own synapse connecting to its own receiving neuron. Because each connection is individual, if a spot of light were to be projected onto a single receptor, the only neuron excited would be that belonging to the stimulated receptor. If the spot of light were to increase other receptors would be stimulated as well, causing their neurons to fire. However, each neuron only receives information from its own receptor cell, so one neuron cannot communicate with others to compile information on the size of the stimulus; though this circuit *does* allow for the distinction between two adjacent light stimuli, offering acuity. A slightly more complex form of neural circuit is a convergence circuit. In this formation, several receptors may all have synapses connecting to one single neuron and several neurons may have synapses connecting to one common neuron. This allows for a single neuron to gather information from many receptors; therefore, obtaining a greater physical picture of the size of the stimulus.

Everything comes into the retina as light energy, but rods, which have greater convergence—therefore mostly in convergent circuits—tend to be in our periphery, which is blurry. So, if we want to see more clearly, we need to focus our vision in the center of the retina, where there are more cones—more often seen in linear circuits—improving acuity and detail. Essentially, this information is sent from the eye through the optic nerve to the LGN, which serves as a filter to sift through the abundance of visual stimuli and moderates which information is sent to the visual cortex. This visual information is processed in the visual cortex, along with other processing areas, ultimately providing a fraction in time of a person's perception.

Example 2

Before tackling the question of what linear and convergence circuits are, I think it is best to examine the difference between the two types of photoreceptors in the retina, rods and cones. The first thing to note is that there are more rods then there are cones (120 million vs. 6 million). The fovea, which allows for sharp or precise vision contains only cones while the peripheral retina contains both rods and cones. Lastly, rods are responsible when in low light situations while cones are responsible in higher light situations

A linear circuit is very basic. It consists of one receptor cell connected to one ganglion cell in the retina. Say for instance you have two receptors A and B and they each are connected to their own ganglion cell, C and D respectively. If receptor A is stimulated only C would fire, D would not because it is connect to B, which was not stimulated. This circuit can differentiate between what receptor was stimulated making this circuit good for detail vision. This is why this type of circuit is found extensively in the fovea, which as stated consists only of cones. So we can conclude that cones have good visual acuity (allowing us to see detail).

On the other hand a convergence circuit has many receptors that converge or come together onto a single ganglion cell. So keeping with the example from above if you have two receptors A and B instead of having two separate ganglion cells there will be one ganglion cell, C, which sums up the excitation it receives (this is known as amplification). This circuit cannot differentiate between receptors making this circuit bad for detail vision. However, because of amplification even with a weak stimulation a ganglion cell can have a powerful response making this circuit good for detecting light. This type of circuit is found extensively in the peripheral retina. Since there are more rods than cones, rods have greater convergence. So we can conclude that rods have better sensitivity to light. This sensitivity makes rods good in dim light settings. So all in all rods have better sensitivity than cones because of the convergent circuit. Cones have better detail vision than rods because of there decreased convergence (more linear circuits).

Example 3

The visual system allows us to perceive visual stimuli from the environment. The stimuli, electromagnetic radiation with a visible wavelength, are focused by the lens and cornea onto the retina. The receptors at the retina (cones and rods) then convert the light into chemical activity which will produce an electrical signal. Neural circuits are responsible for passing this electrical signal to adjacent neural cell bodies, and then to ganglion cells. The signal is then passes out of the retina via the optic nerve and eventually reaches the visual cortex of the brain. There are different types of neural circuits stemming from the receptors that enable the visual system to operate the highest level.

Linear circuits are neural circuits in which a cell ganglion receives input from only one receptor. The signal that is then passed along nerve is a product of a single receptor and is not influenced by signals from other receptors. This allows us to distinguish between adjacent points of light because each receptor carries a different signal down its own individual neural pathway. For this reason, linear circuits allow for high visual acuity (the ability to see detail). The cones in the fovea exemplify this type of circuitry, and therefore provide the greatest visual acuity.

In convergence circuits, the signals from multiple receptors converge on a single ganglion cell. The synapses are excitatory and are there signals are summed at the ganglion and the resulting signal is passed down the nerve. This allows a weak signal detected across receptors of the same convergence signal to produce a strong response at the ganglion, even if the signal at each receptor is too weak to produce a response by itself. As a result, this type of circuitry increases sensitivity, which improves vision in low levels of light. However, since it can’t be determined which specific receptor/s are stimulated to produce a response convergence circuits have low acuity. In the periphery large amounts of rods converge on a single ganglion cell. While this gives them poor acuity, it is part of the reason they are very sensitive and allow for better vision at night.

Example 4

The two types of neural circuits are convergence circuits and linear circuits. To begin, neural circuits are the combination of sensory receptor cells, inner neurons, and ganglion cells that act together in order to be perceived as a unique stimulus. A convergence circuit involves multiple sensory receptors being wired to a single ganglion neuron. This means that the sensory input from each receptor cell is not sent to the brain as its own message, but instead ends up being summed up to some extent and is converged to fewer neurons before travelling to the brain. A linear circuit is defined by the ratio of one receptor cell firing to one ganglion cell. This means each receptor cell's message in a linear circuit does not get combined with other receptor cell's messages, but instead remains as its own specific message.

In the retina, these circuits play a major role. In the fovea the circuits are all linear, so the convergence is 1 to 1, which means every rod or cone stimulated travels to one ganglion cell, making the message distinct and specific. For rod and cone shaped receptor cells outside of the fovea, it is known that the circuits converge greatly. Convergence averages about 120 to 1 among rod receptors, and this ratio is 50 to 100 times that of the cones. The convergence ratio for cones outside of the fovea is close to 7 to 1. This wiring leads to our present day view of the world.

These differences in wiring between the fovea and the rest of the retina make a large difference on how we see the world. The fovea is the part of the retina that is our main focus, allowing us to see detail. When we look at something, such as a painting, our fovea can detect detail by use of linear circuits. As each receptor sends its own message to the brain, our visual system creates the image we see just as a puzzle is created, each receptor and its corresponding ganglion cell contributing a piece. In the rest of the retina, the rods and cones are wired to converge, and this is commonly known as our "peripherals." Here, our perception is much more sensitive to light because small amounts of light energy can combine causing a neuron to fire. If the dim light met a linear circuit instead, it might not have the energy to fire the ganglion cell on its own. Instead, convergent receptors sum their inputs to create an electrical input above threshold for ganglion cells, allowing us to actually perceive the light. In this region the high convergence is responsible for our lack of acuity. If several spots of light were viewed in a part of this region, they would fall on cones that wire to fewer ganglions thus producing an image in our brain of fewer than the actual quantity of lights.