Experiment HP-11: Multisensory Reaction Times

Lab written and contributed by: Tracy M. Hodgson, Program in Biological Sciences, Northwestern University, Evanston, IL *and* Martha Cammarata, Department of Biology, North Park University, Chicago, IL

Background

Using Human Reaction Time to Investigate Multisensory Integration

Nearly every experience we have in life is a multisensory one. Understanding speech involves not only listening but also watching the lips and face of the speaker. The enjoyment of food involves all of the senses, not just taste. This laboratory exercise will explore how our brains respond to multisensory stimuli by measuring the reaction time to a stimulus from one sensory modality (a visual, auditory or somatosensory stimulus presented alone), and comparing it to the reaction time to combinations of two or three sensory modalities presented simultaneously.

Sensory neurons from all the senses, except olfaction, synapse with interneurons in the thalamus, a structure in the midbrain. Some neurons in the thalamus respond to stimuli from one sensory modality only whereas others respond to multisensory stimuli. The thalamus participates in the generation and control of eye and head movements that turn our attention toward interesting sensory stimuli. Sensory information then travels from the thalamus to areas within the cortex, where there are other neurons that respond to only one sensory modality (in the visual or auditory cortex, for example), and multisensory neurons in association cortex. These multisensory neurons have been shown to respond best to simultaneous inputs from more than one sensory modality, and allow us to associate various types of sensory information with an "idea", for example: the sight of a tool + the sound of pounding = "hammer".

The multisensory neurons in the thalamus and association cortex help determine what sensory information is relevant, and what can be ignored. A weak sensory stimulus from one sensory modality produces a small response, whereas two weak stimuli occurring together in time and space will produce a much stronger response. Research has shown that these types of neurons follow 3 "rules" when responding to stimuli from more than one sensory modality:

1. Spatial rule: The sensory stimuli must be close together in space (have overlapping receptive fields)
2. Temporal rule: The sensory stimuli must occur close together in time
3. Superadditivity rule: The response of a multisensory neuron to the simultaneous input from two or more weak stimuli is greater than the sum of the responses to each weak stimulus alone.

For example, imagine you are in the park talking with a friend when you see a dog approaching you out of the corner of your eye. You continue to talk to your friend until you hear barking near you. Your head turns toward the sound of the barking and the sight of the dog running toward you, causing you to lose track of what your friend is saying. This scenario is illustrated in the figure on the next page, along with the graded potentials and action potentials produced by a multisensory neuron in the thalamus.

In this lab you will design your own experiments to measure human reaction time to stimuli from one sensory modality (auditory, visual or somatosensory) as compared to combinations of two or three stimuli presented simultaneously (multisensory stimuli).

1. How does the combination of more than one sensory modality affect reaction time?
2. Do certain combinations of stimuli produce a reaction time that is slower or faster than the sum of the reaction times to each sensory modality presented on its own?
3. Does it make a difference if the interstimulus intervals are predictable or random?
4. Can human reaction time be used to demonstrate the spatial, temporal and superadditivity rules of multisensory neurons?

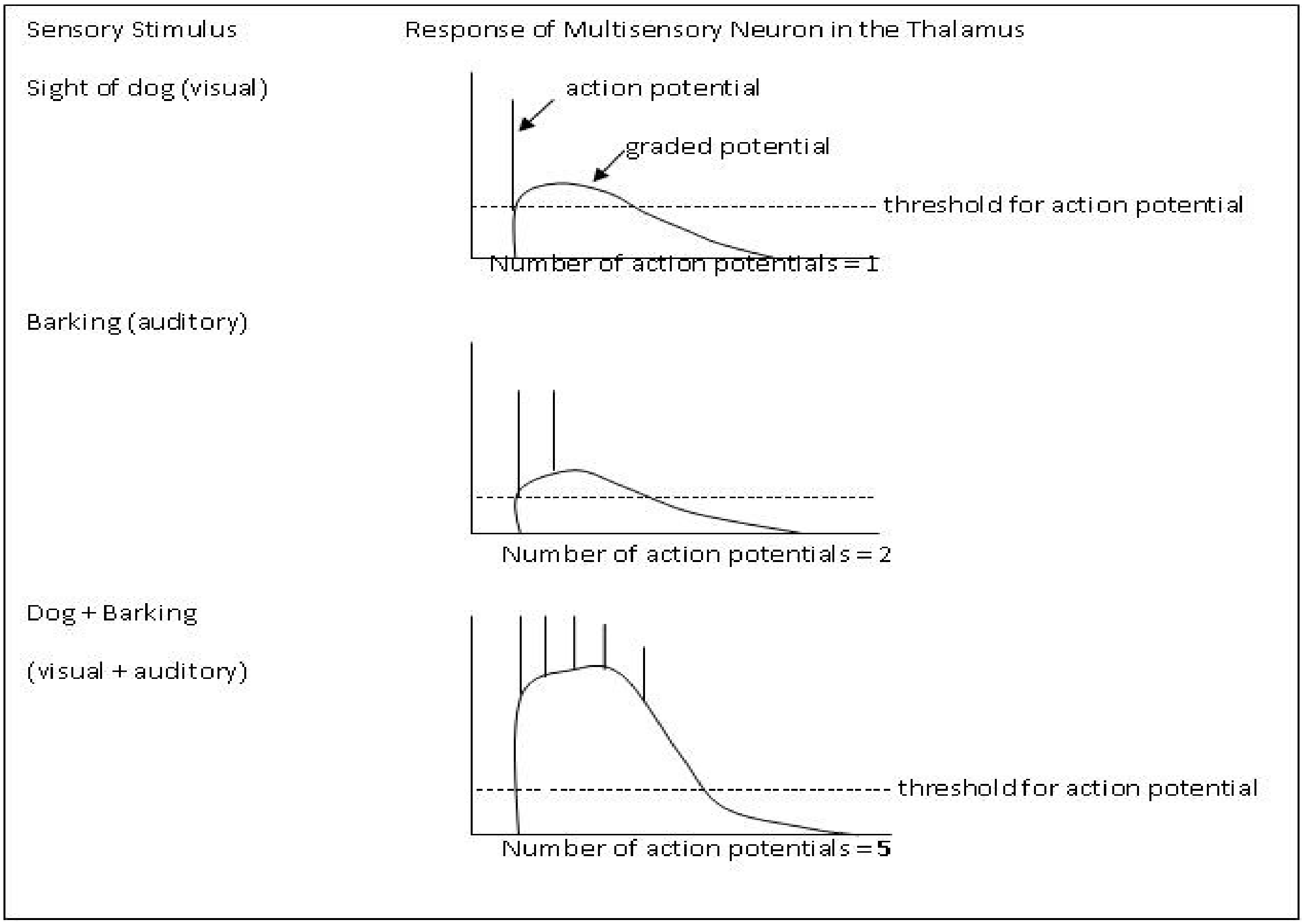

Figure HP-11-B1: Response of a multisensory neuron in the thalamus to either a visual or an auditory stimulus in the top and middle rows (sight of dog or sound of barking) compared to the response to combined visual and auditory stimuli in the bottom row (sight of dog combined with sound of barking).

As shown in Figure HP-11-B1, the solid line represents the membrane potential of the cell. The dashed line illustrates the threshold for firing an action potential in the cell. The vertical lines represent action potentials. The thalamic neuron's response to the combined visual and auditory stimuli illustrates superadditivity, because the response is 5 action potentials, which is greater than the sum of its responses to the auditory and visual stimuli (3 action potentials total).