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Biopac Student Lab® Lesson 11

REACTION TIME I

Introduction

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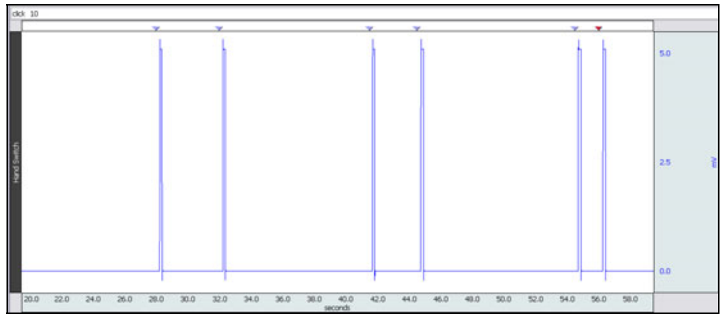

I. Introduction

Elements of the nervous and muscular systems are anatomically and physiologically organized so as to provide for a proper response to a change in the body's relatively stable internal environment or a change in its external environment. The change that elicits a response is called a *stimulus*. The body's reaction to the stimulus may be that of an *involuntary reflex response*, or it may take the form of a *voluntary reaction*

A reflex is an involuntary or automatic, programmed response to a sensory stimulus. Reflexes allow the body to react automatically and involuntarily to a variety of internal and external stimuli so as to maintain homeostasis. For example, touching a hot object elicits an automatic withdrawal of the hand followed by a sensation of pain (Fig. 11.1.) The reflex withdrawal requires no forethought or volition, and even occurs before the brain has been informed of the event.

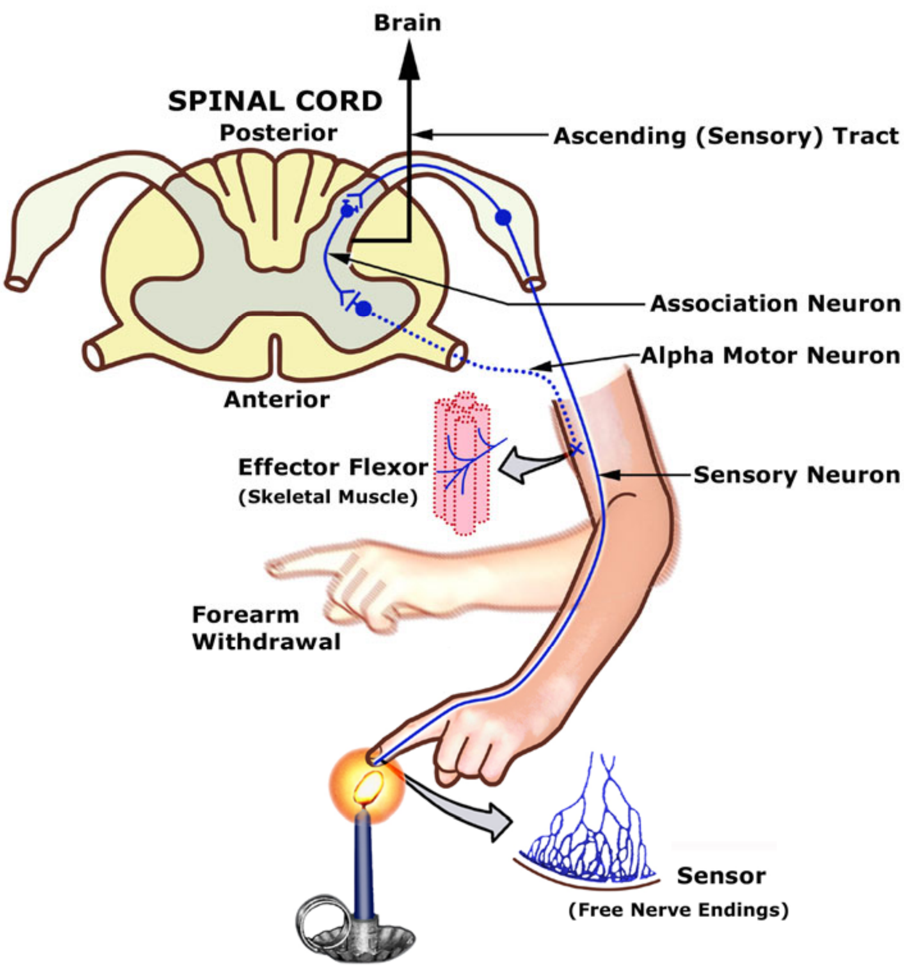

Fig. 11.1 Reaction reflex

On the other hand, the voluntary reaction is, by definition, a willful and therefore controllable response to a stimulus, often modified by learning and experience. A track athlete experienced in running 100 meter races may react faster to the sound of the starter's pistol than a relatively inexperienced competitor.

Both the reflex response and the voluntary reaction to a stimulus begin with the application of the stimulus to a receptor and end with a response by an effector. Anatomically, the neural pathways (Fig. 11.2) consist of the following essential elements common to both the involuntary reflex and the voluntary reaction:

1. ***Receptor:*** a specialized structure at the beginning of a sensory neuron that receives the stimulus.
2. ***Afferent neuron:*** the sensory neuron that relays sensory information from the receptor into the brain or spinal cord. Afferent neurons terminate within the central nervous system and synapse with association neurons and/or motor (efferent) neurons.
3. ***CNS (Central Nervous System) Center:*** a center in the brain or spinal cord where information is relayed across one or more synapses from the sensory neuron to the motor neuron.
4. ***Efferent neuron:*** the motor neuron that transmits information out of the brain or spinal cord to an effector.
5. ***Effector:*** smooth muscle cell, cardiac muscle cell, pacemaker system cell, secretory cell (in glands,) or skeletal muscle cell that provides the reflex or reaction response.

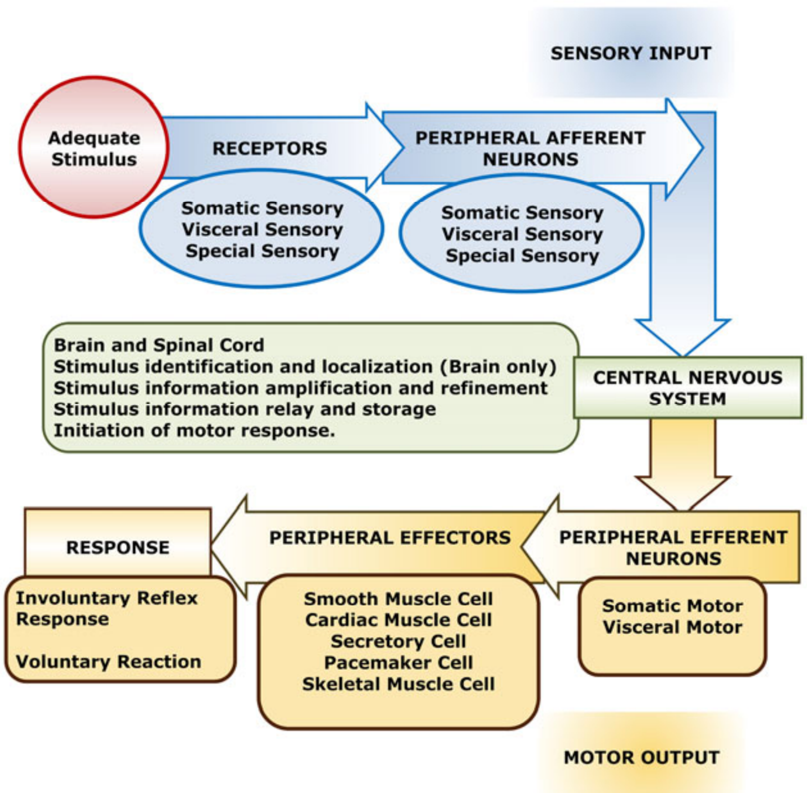

Fig. 11.2 Neural pathways

A discussion of reflexes is presented in Lesson 20, Spinal Cord Reflexes, and the reader is referred to the introductory part of that lesson for addition details. This lesson addresses reaction time in stimulus – response situations where the response is a voluntary reaction to a presented stimulus.

The interval between the stimulus delivery and the response to the stimulus is called the *latent period* or the *reaction time*. Reaction times for a given stimulus – response situation normally vary from person to person. The reaction time of one person repeatedly exposed to the same stimulus – response situation also may change, increasing or decreasing depending on circumstance.

Many factors affect, and thus determine reaction times. Although there may be slight differences from one person to the next, once determined, many of these factors are normally stable and do not change with learning or repeated use. Such factors include mechanisms of receptor function and sensory neuron stimulation, the length and complexity of the reaction pathway, differences between sensory and motor nerve fiber conduction velocities, and so forth. Perhaps the most important of the variable factors affecting reaction time pertain to mechanisms of synaptic transmission. Synaptic transmission refers to the method by which a neuron, termed the presynaptic cell, communicates with or controls another neuron, the postsynaptic cell.

A *synapse* (*syn*-together, *apsis*-a joining) is a functional connection between a neuron and its effector, usually another neuron. Transmission at an electrochemical synapse occurs when the presynaptic cell releases neurotransmitter molecules which then engage receptors on the postsynaptic cell, eliciting either an increase or a decrease in the postsynaptic cell's excitability. Synaptic transmission may be facilitated (made easier and faster,) or it can be inhibited (slowed or blocked). Changes in synaptic transmission may be acute (short -term) and temporary, or they may be chronic (long-term) and more permanent.

In multi-synaptic voluntary reaction pathways, *interneurons* or *association neurons* receive the information from sensory neurons, process it, and stimulate or inhibit appropriate motor neurons. At each synapse there is a slight delay, called *synaptic delay*, in the transfer of information from presynaptic cell to postsynaptic cell. Typically the delay is about 1 – 10 msec. Complex reaction pathways, including neural control elements, easily may contain more than a thousand synapses. The greater the number of neurons, and hence synapses, that are part of the reaction pathway and its control, the longer the expected reaction time.

However, most synapses are plastic and adaptable. Therefore, to a limited extent, synaptic delays in complex reaction pathways may be mitigated by other factors. For example, transmission at an electrochemical synapse can be facilitated by increased opening and closing of ion-specific channels, increased synthesis and release of neurotransmitters, increased synthesis and insertion of postsynaptic membrane receptors for the neurotransmitter, and increased rate of transmitter removal from receptors. Repeated use, training, and learning increase synaptic strength, that is, facilitate synaptic transmission. This favors faster transmission even in simple reflex pathways such as the withdrawal reflex. Reaction time using a dominant, voluntary, motor pathway, such the one determining handedness, is usually faster than when using the nondominant pathway, in part due to greater synaptic facilitation that develops with repeated use of the dominant pathway over a long period of time.

Postsynaptic motor neurons controlling skeletal muscle, and postsynaptic interneurons in the stimulus – response pathway receive multiple synaptic inputs of two types from presynaptic neurons: excitatory synaptic inputs, and inhibitory synaptic inputs. Upon release, the excitatory synaptic neurotransmitters increase the probability of the postsynaptic neuron generating nerve impulses, and the inhibitory synaptic neurotransmitters decrease the probability. At a given moment, inputs of both types are active and others are quiescent. The postsynaptic neuron integrates simultaneous excitatory and inhibitory inputs and according to the net sum of the positive and negative input, alters the frequency of its nerve impulses. Some processes of learning or conditioning are associated with facilitation of excitatory synaptic inputs and/or inhibition of inhibitory inputs, reinforcing the response to a stimulus and decreasing reaction time.

Other facilitative inputs are activated by brainstem reticular pathways which increase awareness of the cerebral cortex, making a person more alert and attentive to changes in the external environment. It is well known that reaction time for a given task is longer if the task is performed late at night or early in the morning when the person is not as alert as they may be at other times of the day. Increased awareness and attentiveness associated with anticipation of stimulus delivery, especially regular and repetitive stimuli, also activate facilitative inputs to the neurons in the stimulus response pathway and reduce reaction time.

In this lesson, the subject's reaction time will be recorded in four different stimulus – response situations. In each situation, the stimulus will be a recorded audible click, and the voluntary response will be the recorded push of a single button on hearing the sound. In two situations, the stimulus presentation will be fixed interval and the dominant hand response followed by the nondominant hand response recorded. In the other two situations, the stimulus presentation changes to random with the stimulus interval varying from one to ten seconds. Statistical calculations will be used to compare the reaction times for groups of subjects in each of the four stimulus – response situations.

In order to compare the reaction times from the two types of presentation schedules, you can summarize the results as statistics or measures of a population. There are certain statistics that are usually reported for the results of a study: **mean**, **range**, **variance**, and **standard deviation**. Mean is a measure of central tendency. Range, variance and standard deviation are measures of distribution or the "spread" of data.

- The **mean** is the average or the sum of the reaction times divided by the number of subjects (n).
- The **range** of scores is the highest score minus the lowest score. The range is affected by extremely high and low reaction times, so investigators also describe the "spread" or distribution of times with two related statistics: variance and standard deviation.
- **Variance** is determined by calculating the average squared deviation of each number from its mean.
- **Standard deviation** is the square root of the variance.

Using the statistics of mean and distribution, investigators can compare the performance of groups. In this lesson, you will calculate your group statistics but you will not do any formal comparisons between groups.