**Chapter 2**

**Research Methodology**

The psychophysical approach to research focuses on the relation between physical properties and perception. Using psychophysical scales, individuals rate their psychological experience as a function of a physical stimulus. Several psychophysical methods exist to answer different questions about perception. In the method of limits, stimuli are presented on a graduated scale in order to detect the absolute threshold (smallest amount of a stimulus required for detection) and the difference threshold (smallest difference between two stimuli that can be noticed). In order to prevent participants from predicting the next stimulus, researchers often use the method of constant stimuli, in which the threshold is determined by randomly presenting a set of stimuli, some above the threshold and others below the threshold. Using the method of adjustment, the participant controls the level of a stimulus and “adjusts” it until it feels like it is just at the detectable level. The method of adjustment is useful for determining the point of subjective quality (where a participant experiences two stimuli as identical). In magnitude estimation, participants judge and assign numerical estimates to the perceived strength of a stimulus. However, some perceptual responses are subject to response compression or response expansion in which the rate of change of the perceptual response is not equal to the rate of change of the strength of the stimulus. A mathematical expression known as Steven’s power law attempts to capture response compression and expansion in a single equation. All the aforementioned methods are subject to false positives made by the participant. Therefore, catch trials and forced-choice methods are used to counter such mistakes. In a catch trial, the stimulus is not presented but the participant is still asked if the stimulus was detectable. For the forced-choice method, the participant is asked to report when or where the stimulus occurred instead of just whether or not it was perceived.

Signal detection theory states that in every sensory detection or discrimination procedure there is both sensory sensitivity to the stimulus and a criterion used to make a cognitive decision. In a signal detection analysis, correct responses include correct rejections and hits whereas incorrect responses include false alarms and misses. Judgments of signal detection differ based on the situation, known as the criterion. A lower criterion results in more false alarms whereas a higher criterion results in more misses. The amount of noise in a signal detection system also influences the amount of correct responses and errors. Finally, sensitivity is the ease or difficulty with which a person can distinguish the signal from noise. Receiver-operator curves are used to plot how often false alarms occur relative to how often hits occur for any level of sensitivity.

Introduction

* The **Scoville scale** measures our detection of the amount of **capsaicin,** the chemical present in peppers that gives the experiences of hotness
* The Scoville scale is an example of a **psychophysical scale**, a scale in which people rate their psychological experiences as a function of a physical stimulus.
  + Psychophysical methods entail presenting a controlled stimulus to a participant and asking the participant a direct question that allows the answer to be quantified.
  + The psychophysical approach focuses on the relation between physical properties (e.g., the amount of capsaicin present) and perception (the experience of hotness).
  + Questions asked may vary based on what the researcher is examining, e.g. detection tasks, comparison tasks, magnitude tasks, preference scales
* Many other psychophysical methods will be introduced throughout this chapter and the book.

The Measures and Methods of Psychophysics

Method of Limits

* In the **method of limits**, stimuli are presented on a graduated scale. Participants judge the stimuli along a certain property that goes up or down.
  + For example, a series of tones could be presented, starting at a volume so soft that the participant cannot hear it and then gradually increasing the volume until the participant can detect the tone.
* The method of limits is often used to determine both absolute threshold and difference threshold.
  + **Absolute threshold** is the smallest amount of a stimulus required for detection.
    - Note though that absolute thresholds are not really absolute. They depend on many contextual factors.
    - To determine an absolute threshold, one must use both an **ascending series** and a **descending series.**
    - The point at which people change from detecting a stimulus or vice versa is called the **crossover point**.
  + **Difference threshold** is the same as the **just noticeable difference**, or the smallest difference between two stimuli that can be noticed.
* In the 19th century, Ernst Weber investigated threshold of touch on the skin, specifically the **two-point touch threshold**, or the minimum distance at which two touches are perceived as two touches and not one. This is an example of absolute threshold.
  + To do this, he gently touched a person’s skin with two needles. If one touch is felt, then it is below threshold. If two are felt, then it is above threshold.
  + Two-point thresholds vary across parts of the body.

Method of Constant Stimuli

* In the **method of constant stimuli**, the threshold is determined by randomly presenting a set of stimuli, some above the threshold and others below the threshold.
* The stimulus that is detected 50% of the time and not detected 50% of the time is considered to be the threshold.
* This technique prevents the participant from predicting the next stimulus, reducing errors due to habituation or fluctuations in perception.
* This technique is used by audiologists when detecting hearing thresholds for different frequencies of sound.

Method of Adjustment

* In the **method of adjustment**, the participant controls the level of the stimulus and “adjusts” it (usually with a knob) until it feels like it is just at the detectable level.
* This is intuitive for participants because it mimics normal activities like adjusting volume on a stereo or a dimmer switch on a light.
* The method of adjustment is useful for matching one stimulus to another to determine the **point of subjective equality**, the point where a participant experiences two stimuli as identical.
* The concept of **sensitivity** is closely related to the concept of threshold. Sensitivity is the ability to perceive a particular stimulus and is inversely related to threshold.

Magnitude Estimation

* In **magnitude estimation**, participants judge and assign numerical estimates to the perceived strength of a stimulus.
  + For example, a tone is presented and the experimenter assigns it a loudness value of 20. Then, the participant must assign subsequent tones numerical values using the original tone as a reference.
* **Response compression** refers to the phenomenon where most perceptual responses do not increase at the same rate as the rate of increase in the strength of a stimulus.
  + For example, doubling the amount of sugar in water will increase a person’s sweetness judgment but not double perceived sweetness.
* Some perceptual characteristics, such as pain perception, have a **response expansion** instead of response compression. That is, as the strength of a stimulus increases, the perceptual response increases even more.
* **Stevens’s power law** attempted to capture response compression and expansion in a single equation:

***P = cIb***

*where P =* perceived magnitude of a stimulus

*I =* intensity of the actual stimulus

*c* = a constant that is different for each sensory modality

*b =* the power to which the intensity is raised

* + The exponent *b* allows response compression and expansion. If *b* is less than 1, response compression occurs. If *b*is greater than 1, response expansion occurs.

Catch Trials and Their Use

* All the methods mentioned so far are subject to false positives made by the participant, either intentional or not.
* **Catch trials** are used to counter these errors. In a catch trial, the stimulus is not presented but the participant is still asked if the stimulus was detectable.
  + If a participant reliably says that she/he detected a stimulus in a catch trial, we can dismiss this participant as unreliable.
* The **forced-choice method** is another method that bypasses false reporting. In every trial, the participant is asked to report when or where the stimulus occurred instead of just whether or not it was perceived.

Signal Detection Theory

* **Signal detection theory** states that in every sensory detection or discrimination procedure there is both sensory sensitivity to the stimulus and a criterion used to make a cognitive decision.
* Two types of correct responses can occur in signal detection analysis
  + A **correct rejection** occurs when a null signal is perceived as null.
  + A **hit** occurs when an active signal is perceived as active.
* Two types of errors can occur in signal detection analysis.
  + A **false alarm** occurs when a null signal is mistaken as an active signal.
  + A **miss** occurs when an active signal is mistaken as a null signal.
* An historical example of a false alarm occurred in 1988 when the crew of a U.S. Navy vessel, the U.S.S. *Vincennes,* mistook an Iranian civilian passenger plane for an Iranian fighter jet and shot down the passenger plane with a missile, killing all 290 passengers and crew.
  + A correct rejection would have been to let the passenger plane keep flying.
  + A hit would have been to correctly identify a warplane.
  + A miss would have been to not detect a warplane.
  + Thus, one of the goals of military surveillance is to maximize hits and correct rejections and minimize misses and false alarms.
* Judgments of signal detection differ based on the situation. This differing judgment on the basis of the situation is called the **criterion.**
  + A lower criterion results in more false alarms whereas a higher criterion results in more misses.
  + In a psychophysical study of vision, the criterion determines the level of stimulation above which we decide a light is present and below which we decide not to indicate the presence of light.
* The amount of noise in the signal detection system influences the amount of correct responses and errors. More noise, more errors. Less noise, more correct responses.
* **Sensitivity**, in signal detection theory, is the ease or difficulty with which a person can distinguish the signal from noise. A mathematical measure of sensitivity is known as ***dˈ*(d-prime) .**
  + High sensitivity leads to more hits and correct rejections.
  + Low sensitivity leads to more misses and false alarms
* Sensitivity and criterion interact in noteworthy ways.
  + If sensitivity is high and criterion is low, there may still be many false alarms.
  + If sensitivity is high and criterion is high, there may still be many misses.
* For any given sensitivity, *dˈ*, there is a range of possible outcomes. To simplify seeing all of these outcomes for a given signal strength, researchers have developed the **receiver-operating characteristic (ROC) curve**
  + The ROC curve is a graphical plot of how often false alarms occur versus how often hits occur for any level of sensitivity.

In Depth: Psychophysics in Assessment: Hearing Tests and Vision Tests

* Assessing vision and hearing loss is an important task, fulfilled by optometrists and audiologists.
* At the heart of these professions are psychophysical principles.
* According to the National Institute on Deafness and Other Communication Disorders, roughly 10% (35 million people) of the U.S. population have some form of hearing impairment. Among older adults, the percentage exceeds 33%.
* Among older adults, hearing loss is likely to be caused by environmental conditions and is particularly common among those who are chronically exposed to loud noise.
* Hearing loss can be divided into two broad categories.
  + **Sensorineural hearing loss** refers to permanent hearing loss caused by damage to the cochlea or auditory nerve. This means hearing loss is due to transduction problems.
  + **Conductive hearing loss** refers to the inability of sound to be transmitted to the cochlea. This means that inadequate levels of sound reach the cochlea.
* To assess hearing loss, the first step is to visit an **audiologist** who will use an **audiometer** to assess hearing loss and creates an **audiogram** to illustrate the threshold for different frequencies. Usually, an audiologist uses the method of constant stimuli combined with the forced-choice method and includes catch trials.
* To assess vision loss, the first step is to visit an **optometrist** who will test visual acuity (ability to resolve an object in focus at a particular distance), usually with a Snellen chart.
* Someone who has difficulty seeing distant objects has **myopia**, a condition in which incoming light does not directly focus on the retina but in front of it.
* Someone who has trouble seeing near objects has **presbyopia**, a condition in which incoming light focuses behind the retina.