Adaptive Staircase Procedure

PSY 350 : LAB IN PSYCHOLOGY

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Introduction

The challenge of objectively determining stimulus thresholds in the realm of psychophysics has long been a central problem. Sensory perception, especially in fields like vision and audition, demands a quantitative approach devoid of subjective language to yield reliable results. This necessitates a method that can systematically and accurately pinpoint the point at which a stimulus becomes perceptible to an observer. One of the ways to accurately quantify the point at which the stimulus is perceptible is through an Adaptive Staircase Procedure.

The staircase procedure is a systematic approach that addresses the issue of quantifying stimulus thresholds. It operates through a series of steps: initially presenting stimuli at intensities significantly below the anticipated threshold and then adjusting intensity based on the observer's responses. When the observer detects the stimulus, the intensity decreases, making it more challenging to perceive. Conversely, when no detection occurs, the intensity increases. This iterative process continues until a predetermined criterion, often tied to a specific percentage of accurate responses, is met. At this point, the procedure yields an estimate of the threshold, providing a robust and quantitative solution to the problem of threshold determination in sensory perception studies.

In addition to the staircase procedure, there are alternative methods available for determining stimulus thresholds. One such approach is the method of constant stimuli. In this method, a predefined set of stimulus intensities is presented to the observer in random order, and their responses are recorded. The threshold is then estimated based on how often the stimulus is detected across these different intensity levels.

Another alternative is the method of limits, where the stimulus intensity is gradually adjusted either upward or downward in small steps until the observer switches from perceiving the stimulus to not perceiving it (or vice versa). These alternative methods provide different ways to estimate thresholds and are chosen based on the specific requirements of the experimental design and research objectives.

Method

In this experiment, the adaptive staircase procedure is being used to understand the difference threshold where the participant can detect if the lines on a gaussian grating are tilted towards the left or right.

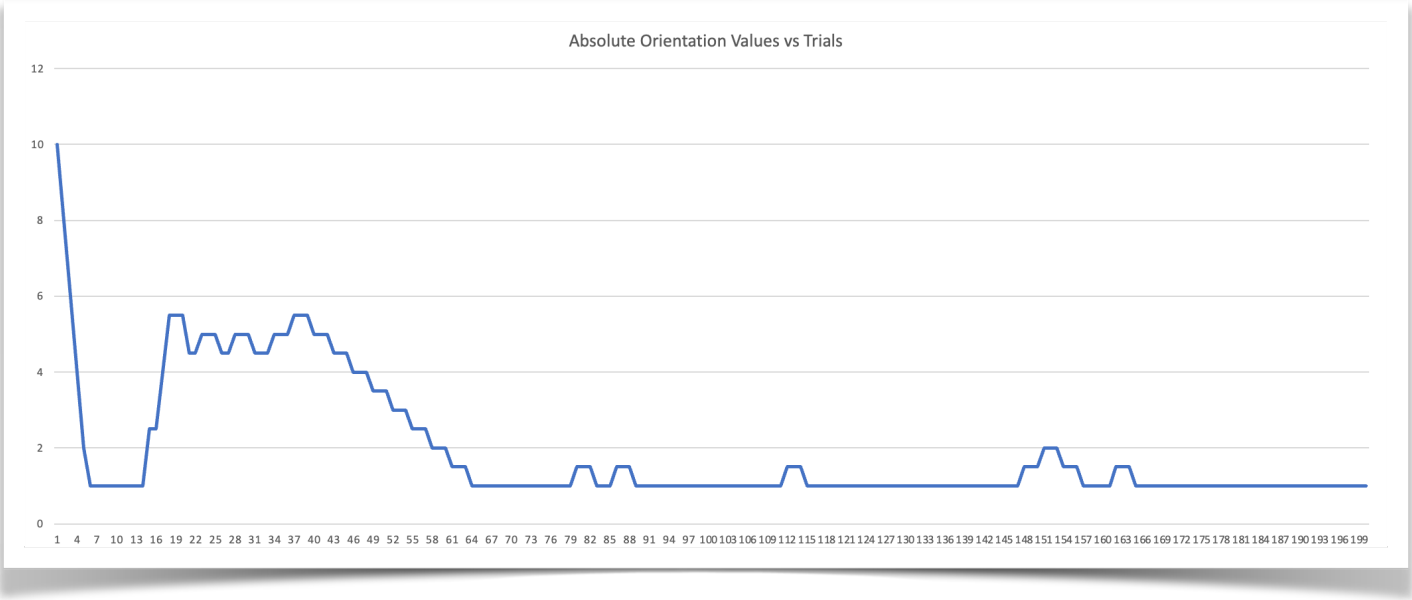
The experiment had 200 adaptive staircase trials where participants would be shown a fixation, in the shape of a cross for 0.5 seconds and then the Gaussian Surface with a spatial frequency of 12 and a contrast of 0.5. The participants had to detect if the orientation of the gaussian surface had a tilt to the left or the right and press the corresponding keys.

The initial value of the orientation is 10, which means the lines would be tiled 10 degrees to the left or right decided randomly. Then the maximum value for orientation is 30 and the minimum value is 1. The staircase procedure was a one up and three down procedure with the following step sizes : 2,1.5,1,0.5. The step type being linear.

The experiment was being built using Psychopy, which helps conducting psychophysics experiment using python. In every trial, the data for orientation and correct response was being recorded alongside other data through Psychopy's inbuilt features. After the experiment, the data was exported to comma separated values (csv), which would be then imported into Ms Excel to understand the difference threshold.

Results

Categorising a reversal as an event, where the participants response go from correct to incorrect and vice versa, we are using the average orientation of last 5 reversals to get a difference threshold. The last five threshold occurred on the following trials : 114, 147, 153, 161, 164th trials where the



average orientation value coming out to be **1.4**. Thus **the difference threshold is 1.4**.

Using last five reversals to calculate threshold acknowledges that perceptual thresholds can exhibit fluctuations due to factors such as adaptation and attentional shifts during the course of an experiment. By incorporating these changes into our threshold determination process, we capture a more comprehensive and ecologically valid representation of perceptual sensitivity. This nuanced perspective contributes to a richer understanding of how participants interact with stimuli over time and, consequently, enhances the interpretability of our findings.

Discussion

In our investigation, it's important to recognize that the staircase procedure, while commonly used, has its limitations when compared to alternative methods. One limitation lies in its tendency to focus on a narrow range of stimulus intensities, potentially missing broader perceptual nuances. Methods like constant stimuli cast a wider net across the stimulus spectrum, offering a more comprehensive view.

Another limitation relates to the assumption of a straightforward relationship between stimulus intensity and perceptual response, which may not always hold true. In contrast, alternative methods, such as the best PEST algorithm, are better equipped to handle non-monotonic response patterns. The staircase procedure can be trial-inefficient, often requiring a substantial number of trials to reach a stable threshold estimate, especially when dealing with complex stimuli. In contrast, adaptive Bayesian methods like QUEST make more efficient use of trials.

Additionally, the staircase procedure can be vulnerable to participant response biases that may develop during the course of the experiment. Bayesian approaches can incorporate statistical models to mitigate these biases effectively.

In summary, the staircase procedure, although widely used, has limitations in terms of limited sampling, assumptions, trial efficiency, and susceptibility to biases. Alternative adaptive methods may offer advantages in specific experimental scenarios by addressing these limitations and providing more accurate threshold estimates.

Citation

Experimental Psychology, 10th Edition, Kantowitz, Elmes, Roediger, Cengage India, ISBN: 9353502837, Year: 2019, Chapter 5.

Cornsweet, T. N. (1962). The staircase-method in Psychophysics. The American Journal of Psychology, 75(3), 485. https://doi.org/10.2307/1419876