Introduction

An adaptive staircase procedure, which adjusts stimulus levels based on the subject’s performance, is a more efficient alternative to traditional methods that require extensive repetitions. The study of sensation and perception involves measuring how individuals detect and discriminate stimuli, a task that is both complex and costly. Psychophysics, a field established by Fechner in 1860, focuses on these measurements by evaluating behaviour as an indirect measure of perception.

Key methodologies for measuring sensory thresholds include the method of constant stimuli, which involves presenting stimuli at varying levels to observe detection performance and derive a psychometric function. This function illustrates how detection changes with stimulus strength, typically using techniques such as the yes-no method or forced-choice methods (e.g., two-alternative forced choice, 2AFC). These methods help summarize performance with parameters like threshold and slope.

Despite the accuracy of these methods, they can be inefficient due to the need for extensive trials across various stimulus levels. To address this, adaptive psychophysical procedures have been developed. These procedures adjust stimulus levels based on the subject's responses, aiming to efficiently measure thresholds and other function characteristics with fewer trials.

Adaptive methods can be categorized into three types:

1. **Parameter Estimation by Sequential Testing (PEST)**: This method adjusts both step size and direction of stimulus changes based on previous responses.
2. **Maximum-Likelihood Procedures**: These fit the responses to an ogival function, using statistical techniques to estimate thresholds and adjust trial placements.
3. **Staircase Procedures**: These involve alternating ascending and descending trials to refine threshold estimates.

Each of these methods aims to balance efficiency and accuracy, reducing experimental time while maintaining reliable results. Modern adaptive procedures, evolving from clinical techniques and research, continue to advance psychophysical measurement by optimizing trial placement and response collection to provide precise and efficient assessments of sensory thresholds.

Method

In this staircase method, the participant was briefed on how they would be performing the task. The participant was informed to click right and left buttons according to the image flashed on the screen. The task setup was create on Psychopy that conducts psychophysics experiments using Python. After the experiment, the data was exported to comma separated values (csv), which later on was imported into MS excel to understand different thresholds. There were few settings made to make this experiment run, like the time of the flashed image, the duration and reaction time, etc. There were 100 trials taken for this experiment where the participant was shown a fixation. The participant had to analyse/detect the image and its tilt if any on the gaussian surface and press the buttons accordingly. Further on the data was collected on the basis of the accuracy in the reactions. The correct responses were used to get the threshold.

Results

Here, the method of reversal was used, where the participant’s response go from 0-1 or 1-0, and recorded it get the threshold by averaging it out. a total number of 5 reversals was take. The trail 95, 94, 92, 90, 88 were taken to calculate the threshold. The threshold for this is 2.9.

When calculating perceptual thresholds using the most recent five reversals, we account for fluctuations that may arise from factors like adaptation and shifts in attention throughout an experiment. By integrating these variations into our threshold estimation process, we achieve a more accurate and realistic depiction of perceptual sensitivity. This approach provides a deeper insight into how participants respond to stimuli over time and improves the clarity and relevance of our results.

Discussion

The adaptive staircase method, commonly used in psychophysical experiments, offers several advantages, including efficiency and precision. It reduces the number of trials needed by dynamically adjusting the stimulus difficulty based on the participant's responses, leading to quicker convergence on the perceptual threshold. This adaptability allows for a more personalized assessment and minimizes participant fatigue by focusing testing on relevant stimulus levels. However, the method also has its drawbacks. It can be complex to implement and requires careful calibration of parameters, and is sensitive to biases such as learning effects or response alterations from participants. Additionally, interpreting the resulting data can be challenging, and the method may not be suitable for all experimental conditions. Despite these limitations, the adaptive staircase method provides a nuanced and responsive approach to measuring perceptual thresholds. The adaptive staircase method, although efficient for estimating sensory thresholds, has several limitations. One key issue is its sensitivity to the initial stimulus level, as a poorly chosen starting point can lead to slow convergence or inaccurate results. Additionally, variability in individual responses or fluctuations in attention can introduce inconsistencies that affect the precision of threshold estimates. Response biases, where participants may exhibit tendencies to be overly cautious or lenient, can further skew measurements. The method also faces challenges if the threshold falls outside the range of presented stimuli or if this range is too narrow. Analyzing data from the staircase procedure can be complex, particularly with adaptive algorithms or multiple staircase sequences.

References

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