

# METHOD OF SUCCESSIVE INTERVALS

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## Introduction and Core Definition of the Method of Successive Intervals

The **Method of Successive Intervals** (MSI) is a fundamental technique within the field of **psychometric scaling**, primarily employed to measure subjective attributes or psychological dimensions that are not directly quantifiable using objective physical units. This method is foundational in transforming qualitative judgments about stimuli into a quantitative, interval-level scale, thereby allowing for rigorous statistical analysis of human perception, sensation, and attitudes. At its core, MSI relies on the ability of human judges to categorize a range of stimuli into a predefined number of classes, which are deliberately constructed to represent **equally appearing intervals** along the psychological continuum being measured. Unlike methods that require direct magnitude estimation, MSI simplifies the task by asking the participant only to sort or classify.

A defining characteristic of the Method of Successive Intervals is the reliance on defining these intermediate judgment categories either **verbally** or through the use of carefully selected **samples** or reference stimuli. For instance, when measuring the intensity of pain or the degree of agreement with a statement, the experimenter must supply clear semantic labels (e.g., "Slightly Intense," "Moderately Intense," "Extremely Intense") that serve as anchors for the category boundaries. The underlying assumption is that, while the physical difference between stimuli that fall into two adjacent categories may vary, the subjective or psychological distance between the boundaries of those categories is perceived as equal by the observer. The subsequent mathematical modeling then utilizes the frequencies with which stimuli are assigned to these categories to empirically determine the actual scale values and the precise location of the category boundaries on the derived psychological scale.

The objective of MSI is not merely classification, but the derivation of a linear scale where the distances between points accurately reflect the psychological distances perceived by the judging population. This transformation is crucial because raw frequency counts or simple rankings do not possess the mathematical properties required for interval measurement; they do not guarantee that the difference between a ranking of 1 and 2 is psychometrically equivalent to the difference between 5 and 6. By employing rigorous statistical procedures, often based on the assumptions derived from **Thurstone's scaling models**, MSI converts the categorical responses into interval data, allowing researchers to compare the relative intensity or magnitude of different stimuli with confidence. This method thus bridges the gap between the inherently qualitative nature of subjective experience and the quantitative requirements of scientific inquiry, making it invaluable across domains ranging from sensory psychophysics to attitude research in the social sciences.

## Historical Context and Theoretical Foundation

The theoretical underpinnings of the Method of Successive Intervals are deeply rooted in the

scaling theories developed by pioneers of psychometrics in the early 20th century, most notably the work of **L. L. Thurstone**. Thurstone's seminal contribution, the **Law of Comparative Judgment**, provided the necessary framework for converting probability judgments (the likelihood that one stimulus is perceived as greater than another) into interval scale values based on the assumption that perceptions of a stimulus are normally distributed around a mean scale value. MSI can be viewed as an efficient adaptation or extension of Thurstone's foundational principles, designed specifically to handle large sets of stimuli and judges without requiring the exhaustive pairwise comparison required by the original method.

Before MSI, scaling methods often relied on direct measurement or the cumbersome method of paired comparisons. The need for a more practical methodology arose from studies involving complex attitudes or sensations where the number of stimuli (statements, tones, flavors) made paired comparisons logistically infeasible. MSI addressed this by simplifying the judge's task: instead of comparing every stimulus against every other stimulus, the judge only needs to compare the stimulus against a fixed set of predefined category boundaries. This shift maintained the rigorous theoretical foundation of Thurstone's model--specifically the concept that variability in judgment (or **discriminability**) is a measurable quantity--while dramatically increasing the administrative efficiency of the scaling procedure. The judgment variability is assumed to be due to momentary fluctuations in the sensory or affective process, which, when aggregated across many trials or judges, results in a normal distribution of perceived scale values for each stimulus.

The model most frequently applied to data derived from the Method of Successive Intervals is **Thurstone's Case V**. This specific case simplifies the mathematical calculations by making two key assumptions: first, that the underlying distributions of judgments for all stimuli are normal; and second, that the standard deviations (variability) of these judgmental processes are equal across all stimuli and all category boundaries. While these assumptions, particularly the equality of variance, are often approximations of reality, Case V provides a robust and mathematically tractable mechanism for calculating both the scale value of each stimulus and the location of the category boundaries on the derived psychological continuum. If the assumption of equal variance is deemed too restrictive, more complex models (such as Thurstone's Case III or IV) can theoretically be applied, although they require more intricate computational solutions and are less commonly utilized in standard MSI applications.

## Procedural Overview and Experimental Design

Implementing the Method of Successive Intervals involves a highly structured experimental procedure designed to elicit consistent and quantifiable subjective judgments. The initial step involves the careful selection and calibration of the **stimulus set**--the specific items (e.g., visual patches, attitude statements, sound frequencies) that are to be scaled. This set must cover a sufficiently broad range of the underlying attribute to ensure adequate representation across the

entire psychological continuum under investigation. Following stimulus selection, the experimenter must define the judgmental categories, typically numbering between five and nine, as this range optimizes data granularity without overwhelming the judges.

Crucially, the experimenter must clearly define the boundaries of these categories using **verbal anchors** or sample stimuli, ensuring that the participants understand the implicit instruction that the psychological distance between Category 1 and Category 2 should be subjectively equal to the distance between Category 2 and Category 3, and so forth. For example, if scaling the pleasantness of odors, the categories might be labeled "Very Unpleasant," "Unpleasant," "Neutral," "Pleasant," and "Very Pleasant." Participants are then presented with the stimuli one at a time, often in a randomized order to prevent systematic order effects, and instructed to assign each stimulus to the single category that best represents their subjective experience of it. The consistency and clarity of these verbal definitions are paramount to the success of the MSI technique, as they form the operational basis for the judge's internal scaling mechanism.

Data collection in MSI focuses on recording the frequency with which each stimulus is assigned to each category. If there are 100 judges and five categories (A through E), the data for a single stimulus will be a count of how many judges placed it in A, B, C, D, and E. These raw frequencies are subsequently converted into **cumulative proportions**. The cumulative proportion for Category C, for instance, represents the proportion of judges who placed the stimulus in Category C or any category below it (A + B + C). This cumulative approach is vital because it allows the researcher to determine the probability that a given stimulus is perceived as falling below a specific category boundary. This probabilistic information is the link required to apply Thurstone's scaling model, transforming the observed classification frequencies into meaningful interval data suitable for advanced statistical analysis and interpretation.

### Operationalizing the Intervals: Verbal Anchors and Samples

The methodological effectiveness of the Method of Successive Intervals hinges critically upon the precise definition and presentation of the judgmental categories, which must be clearly delineated to the participants. As the core definition states, the intervals are defined **verbally** or by the use of **samples**. Verbal definition involves the careful construction of semantic labels for the category boundaries. These labels must be unambiguous, mutually exclusive, and intuitively represent successive steps along the continuum. For attitudinal scaling, labels like "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree" are common, but the psychometric validity relies on the assumption that the psychological distance perceived between "Neutral" and "Agree" is subjectively equal to the distance between "Agree" and "Strongly Agree."

When measuring sensory attributes, where clear semantic labels may be difficult to standardize across individuals (e.g., describing subtle differences in texture or taste), researchers often employ

**reference stimuli** or samples to anchor the categories. In this approach, specific, known stimuli are used to physically define the boundaries. For example, when scaling the perceived brightness of lights, a specific light intensity might be designated as the boundary between "Dim" and "Moderate," and another intensity between "Moderate" and "Bright." These physical samples provide a concrete, non-verbal reference point, potentially reducing the ambiguity inherent in purely verbal descriptions. The judge's task then becomes comparing the test stimulus not just to a word, but to the physical reference sample, deciding whether the test stimulus exceeds the intensity of the sample or falls below it.

The choice between using solely verbal anchors and incorporating physical samples is often determined by the nature of the attribute being scaled. Verbal anchors are generally preferred in attitude and opinion research, where the concepts are inherently semantic. Physical samples are more common in **sensory scaling** (psychophysics), where precise control over the physical dimension is possible and desirable. Regardless of the method chosen, the definition process directly influences potential scaling biases, such as **end effects** (where judges avoid the extreme categories) or **context effects** (where the range of stimuli presented influences how the verbal anchors are interpreted). Effective experimental design in MSI requires pre-testing the category definitions to ensure they are interpreted consistently and span the entire necessary range of the subjective continuum.

## Mathematical Modeling and Scaling Transformation

The crucial step in the Method of Successive Intervals is the transformation of the raw frequency data--the categorical judgments--into a true interval scale. This process utilizes the principles of the normal distribution, based on the assumption that the location of any specific category boundary is not fixed, but rather varies momentarily in the judge's mind, following a normal distribution of perceptual errors. The calculation proceeds by first determining the **cumulative frequency distribution** for each stimulus across the categories. These cumulative proportions represent the probability that a stimulus is judged to fall below a specific category boundary.

The next step involves applying the **z-score transformation** (or standard normal deviate) to these cumulative proportions. Based on Thurstone's Case V, the observed probability that a stimulus falls below a boundary is converted into a z-score, which represents the distance of that boundary from the mean perception of the stimulus, measured in standard deviation units. For a given stimulus, this yields a set of z-scores corresponding to the location of the category boundaries. Because the standard deviation of the judgmental process is assumed to be constant (the Case V assumption), the system of equations derived from the z-scores can be solved simultaneously to yield two critical outputs: the scale value for each stimulus (its mean location on the psychological continuum) and the scale value for each category boundary.

The final output is a standardized, linear scale where the scale values are expressed in abstract units (often arbitrary, with the mean scale value typically set to zero). This interval scale allows researchers to state not just that Stimulus A is greater than Stimulus B, but also precisely how much greater it is in psychological units. Furthermore, the analysis provides the location of the category boundaries, revealing whether the verbally defined intervals were, in fact, perceived as equally spaced. If the calculated scale values for the boundaries are not equidistant, it indicates that the judges were systematically grouping stimuli differently than intended by the verbal anchors, providing critical feedback on the effectiveness of the initial category definition. This mathematical rigor is what elevates MSI beyond simple ranking or ordinal classification into a powerful tool for **quantitative scaling**.

### Advantages and Limitations of the Method

The Method of Successive Intervals offers significant practical and statistical advantages that contribute to its enduring use in psychological research. Chief among these is its high degree of **efficiency** compared to more data-intensive methods like the Method of Paired Comparisons. MSI allows researchers to scale a large number of stimuli quickly, as each judge only needs to evaluate each stimulus once against the fixed set of categories, rather than making potentially thousands of individual comparisons. This ease of administration makes MSI particularly suitable for large-scale surveys, clinical assessments, and situations where respondent fatigue must be minimized, thereby facilitating the collection of robust data from larger and more diverse populations.

Despite its utility, MSI is subject to several important methodological limitations, primarily stemming from the underlying assumptions required for the scaling transformation. The reliance on **Thurstone's Case V** assumption--that the standard deviations of the discriminability functions are equal for all stimuli--is often a practical necessity, but it may not hold true in all experimental contexts. If the variability of judgments differs significantly across stimuli (e.g., people are much more certain about one stimulus than another), the resulting scale values calculated under Case V may be distorted, potentially leading to inaccurate scale distances. While more complex models exist, they are computationally demanding and rarely used in standard practice, meaning the researcher must often accept the potential error introduced by the equal variance assumption.

Furthermore, the heavy reliance on **verbal anchors** introduces potential psychological biases. The meaning of terms like "Moderate" or "Slight" can vary substantially across individuals and cultures, introducing systematic error that is difficult to isolate. Judges may also exhibit biases such as **central tendency bias**, where they preferentially use the middle categories and avoid the extremes, or they may be influenced by the context of the stimuli presented, altering their internal standard of judgment. While careful selection of category labels and rigorous pre-testing can mitigate these issues, MSI remains susceptible to these anchoring and context effects. Researchers must constantly evaluate whether the derived interval scale truly reflects equal

psychological distances or if the results are artifacts of the chosen categorical definitions.

## Applications in Psychophysics and Social Sciences

The Method of Successive Intervals enjoys broad application across diverse domains of psychological and social scientific inquiry, wherever the quantification of subjective experience is required. In **psychophysics**, MSI is extensively used for **sensory scaling**--determining the relationship between the physical magnitude of a stimulus and its perceived psychological intensity. This includes measuring the perceived loudness of sounds, the sweetness of solutions, the brightness of lights, or the intensity of tactile stimulation. By scaling these perceptions, researchers can establish reliable psychophysical functions that describe how human sensory systems transduce physical energy into subjective experience, contributing directly to fields like ergonomics and consumer product development.

In the social sciences, particularly in survey research and attitude measurement, MSI provides a rigorous foundation for developing valid measurement instruments. Researchers use MSI principles to scale the intensity of attitudes toward political candidates, social issues, or brands. By presenting a series of statements (stimuli) and asking respondents to categorize them based on their favorability or intensity, the scale values derived from MSI ensure that the resulting attitude scores possess interval properties, making them suitable for inferential statistics such as regression and ANOVA. This application is crucial for moving beyond simple ordinal ranking of opinions toward a metric understanding of attitudinal differences within a population.

Beyond traditional research, the principles of successive intervals are applied in specialized areas such as **clinical assessment** and consumer research. In clinical settings, MSI-based scaling can be used to quantify subjective symptoms, such as the perceived severity of depression or the intensity of chronic pain, providing standardized metrics for tracking treatment efficacy. In consumer research, MSI helps determine the perceived quality, desirability, or intensity of product characteristics (e.g., the perceived richness of a chocolate bar or the user-friendliness of a software interface). Across all these applications, MSI serves as a versatile tool for translating the inherent variability and subjectivity of human judgment into reliable, quantitative scale metrics.

## Comparison with Related Scaling Methods

To fully appreciate the utility of the Method of Successive Intervals, it is beneficial to contrast it with other scaling techniques, particularly those also derived from Thurstone's scaling framework. The **Method of Paired Comparisons** (MPC) is perhaps the most fundamental and robust method, requiring judges to compare every possible pair of stimuli and state which one possesses more of the attribute in question. MPC provides highly granular and statistically strong data, as it minimizes the reliance on subjective interval definitions. However, MPC suffers dramatically from practical

limitations: scaling  $N$  stimuli requires  $N(N-1)/2$  judgments, making it impractical for large stimulus sets (e.g., 50 stimuli require 1,225 comparisons). MSI solves this efficiency problem by reducing the judgment task to categorization, offering a significant administrative advantage at the cost of requiring the potentially restrictive assumptions of Case V.

Another related method is the older **Method of Equal-Appearing Intervals** (MEAI), sometimes used interchangeably with MSI in historical contexts, though modern psychometrics often distinguishes between them. In MEAI, the primary goal is often the direct construction of the scale by the judges themselves, who are explicitly instructed to sort stimuli (like attitude statements) into categories such that the categories appear equally spaced. The key difference in contemporary usage is often in the mathematical analysis: MSI almost invariably employs the rigorous, probability-based z-score transformation derived from Thurstone's model to empirically calculate the scale values and category boundary locations. Conversely, MEAI can sometimes rely on simpler calculations, such as the median or mean category assignment, which do not fully leverage the variability information inherent in the full distribution of judgments, potentially leading to less precise interval scales compared to the mathematically intensive MSI approach.

Ultimately, MSI represents a pragmatic and powerful compromise in psychometric scaling. It retains the theoretical rigor of the Thurstone scaling tradition, allowing the derivation of true interval scales that account for judgmental variability, while simultaneously offering the administrative efficiency of a categorization task. Its success depends entirely on the researcher's ability to create clearly defined **verbal anchors** or **samples** that guide the judge toward establishing subjectively equal intervals, ensuring that the collected frequency data accurately reflects the underlying structure of the psychological continuum.