

How to Understand the Four Levels of Measurement: Nominal, Ordinal, Interval, and Ratio

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Levels of Measurement: Nominal, Ordinal, Interval and Ratio

Levels of Measurement

Nominal	Ordinal	Interval	Ratio
"Eye color"	"Level of satisfaction"	"Temperature"	"Height"
Named	Named	Named	Named
	Natural order	Natural order	Natural order
		Equal interval between variables	Equal interval between variables
			Has a "true zero" value, thus ratio between values can be calculated

Foundations of Data Measurement in Statistical Analysis

In the expansive field of **statistics**, the methodology used to collect and interpret information is dictated by the nature of the data itself. Not all **data** is created equal, and understanding the nuances between different types of information is fundamental to conducting rigorous **quantitative research**. To provide structure to this diversity, researchers utilize a framework known as the **levels of measurement**, or scales of measurement, which categorize variables based on their mathematical properties and the types of operations that can be performed upon them.

The concept of **measurement scales** was originally proposed by psychologist **Stanley Smith Stevens** in 1946. Stevens argued that all measurements in science are conducted using four different levels: **nominal**, **ordinal**, **interval**, and **ratio**. Each level builds upon the properties of the previous one, increasing in complexity and the amount of information provided. By identifying the specific level of a **variable**, a researcher can determine which **descriptive statistics** or inferential tests are appropriate for **data analysis**.

Choosing the correct **measurement scale** is a critical step in the research design process because it influences the precision of the findings and the **statistical significance** of the results. If a researcher applies a high-level statistical test to low-level data, the conclusions drawn may be invalid. Conversely, failing to utilize the full mathematical potential of high-level data can result in a

loss of valuable insight. This post provides an in-depth exploration of these four scales, offering clarity on how to distinguish them and apply them effectively in various professional and academic contexts.

The Nominal Level: Categorization and Qualitative Labeling

The **nominal scale** represents the most basic level of measurement, where numbers or labels are used solely to categorize or identify objects, individuals, or events. At this level, the data is strictly **qualitative**, meaning that the categories do not possess any inherent numerical value or ranking. The primary purpose of **nominal data** is to distinguish between different groups. For instance, assigning a "1" to represent "Male" and a "2" to represent "Female" does not imply that one is greater than the other; the numbers are simply shorthand for the group names.

Variables measured on a **nominal scale** are characterized by being **mutually exclusive** and collectively exhaustive. This means that every observation must fit into exactly one category, and all possible categories must be accounted for. Common examples of nominal variables include **blood type**, **religious affiliation**, and **political preference**. Because there is no logical order to these categories, the researcher cannot perform mathematical operations like addition or subtraction, nor can they calculate an average value for the dataset.

When analyzing **nominal scale** data, the statistical options are limited but nonetheless informative. The primary measure of **central tendency** for nominal data is the **mode**, which identifies the most frequently occurring category within the sample. Researchers often present this data using **frequency distributions** or percentage breakdowns to illustrate the composition of a population. For example, a survey might reveal that the **mode** for a neighborhood's preferred method of transportation is "Personal Vehicle," followed by "Public Transit" and "Cycling."

The Ordinal Level: Ranking and Relative Positioning

The **ordinal scale** introduces the concept of **order** to the measurement process. Unlike nominal data, ordinal variables allow researchers to rank observations based on a specific attribute. However, while the order is clear, the **intervals** between the ranks are not necessarily equal or quantifiable. In other words, we know that one value is "greater than" or "less than" another, but we do not know by exactly how much. This level of measurement is frequently used in **social sciences** and market research to gauge opinions and perceptions.

A classic example of **ordinal measurement** is the **Likert scale**, which is commonly found in customer satisfaction surveys. Responses such as "Very Dissatisfied," "Dissatisfied," "Neutral," "Satisfied," and "Very Satisfied" provide a clear hierarchy of sentiment. However, the psychological "distance" between "Satisfied" and "Very Satisfied" may be much larger for one respondent than the distance between "Neutral" and "Satisfied" is for another. Other examples include

socioeconomic status (low, middle, high) and competition rankings (first, second, third place).

From a statistical perspective, **ordinal data** offers more flexibility than nominal data. In addition to the **mode**, researchers can calculate the **median**, which represents the middle value in a ranked list. This is particularly useful for identifying the typical response in a set of ordered categories. While some researchers debate the use of **mean** calculations for ordinal scales, it is generally accepted that non-parametric tests, such as the **Spearman's rank correlation**, are the most appropriate tools for examining relationships between ordinal variables.

The Interval Level: Quantifiable Differences Without a True Zero

The **interval scale** represents a significant leap in mathematical sophistication because it features **equal intervals** between consecutive points on the scale. This means that the difference between 70 and 80 degrees is exactly the same as the difference between 80 and 90 degrees. Because these distances are standardized, researchers can perform addition and subtraction on **interval data**, allowing for a much deeper level of **statistical analysis** than is possible with nominal or ordinal scales.

Despite its precision, the **interval scale** lacks a **true zero point**. In this context, "zero" does not represent a total absence of the property being measured; rather, it is an arbitrary point on the scale. The most common example is temperature measured in **Celsius** or **Fahrenheit**. Zero degrees does not mean there is "no temperature," and because the zero point is arbitrary, we cannot say that 100 degrees is "twice as hot" as 50 degrees. Other examples include **IQ scores** and standardized test scores like the **SAT**, where a score of zero is either impossible or does not indicate zero intelligence.

The ability to measure the exact distance between values allows for the calculation of the **mean**, **standard deviation**, and **variance**. These metrics provide a comprehensive view of the data's distribution and spread. Interval data is compatible with a wide range of advanced **parametric tests**, such as **t-tests** and **ANOVA**, which are used to compare means across different groups and identify significant trends within the **population**.

The Ratio Level: The Pinnacle of Quantitative Precision

The **ratio scale** is the most informative level of measurement, possessing all the characteristics of the interval scale--order and equal intervals--with the critical addition of a **true zero point**. At this level, a value of zero indicates a complete absence of the variable. This absolute reference point enables researchers to calculate **ratios** and fractions, making statements like "Object A is three times as heavy as Object B" mathematically valid. Most physical measurements in the natural sciences fall into this category.

Common variables measured on a **ratio scale** include **mass**, **length**, **time duration**, and **Kelvin temperature**. In a business context, financial metrics such as **revenue**, **profit**, and **price** are all ratio-level data. Because there is a non-arbitrary zero (e.g., zero dollars means no money), the mathematical relationships between values are perfectly preserved, allowing for the most complex forms of **mathematical modeling** and forecasting.

Statistical analysis of **ratio data** is virtually unlimited. Researchers can utilize the **geometric mean** and **coefficient of variation**, in addition to all the descriptive and inferential statistics available for interval data. The **ratio scale** provides the highest level of **statistical precision**, making it the preferred choice for experiments where subtle differences and exact proportions are essential for drawing accurate **scientific conclusions**.

Statistical Implications and the Hierarchy of Measurement

Understanding the hierarchy of **measurement scales** is vital because it dictates the "power" of the statistical tests you can perform. As you move from nominal to ratio, the mathematical complexity increases. **Nominal** and **ordinal** scales are generally classified as **categorical data** (or qualitative), while **interval** and **ratio** scales are classified as **continuous data** (or quantitative). This distinction is the first thing a statistician looks at when determining how to process a new **dataset**.

A concept known as "data degradation" occurs when a researcher collects high-level data (like ratio) but analyzes it as low-level data (like ordinal). For example, if you record the exact ages of participants (ratio) but then group them into categories like "Young," "Middle-aged," and "Senior" (ordinal) for your analysis, you lose the precision of the original measurement. While this is sometimes necessary for simplified reporting, it generally reduces the **statistical power** of the study, making it harder to detect real effects or relationships.

Conversely, you cannot "upgrade" data from a lower scale to a higher one. If you only collected data on whether people "passed" or "failed" a test (nominal), you cannot later determine their exact scores (ratio) or even their relative ranking (ordinal) unless that information was recorded at the time of measurement. Therefore, expert **data collection** strategies prioritize gathering data at the highest level of measurement possible to ensure maximum flexibility during the **data mining** and analysis phases.

Summary of Scale Properties and Applications

The following table provides a comprehensive summary of the attributes associated with each of the four measurement scales, serving as a quick reference guide for researchers and students alike:

Property	Nominal	Ordinal	Interval	Ratio
Has a natural "order"	NO	YES	YES	YES
Mode can be calculated	YES	YES	YES	YES
Median can be calculated	NO	YES	YES	YES
Mean can be calculated	NO	NO	YES	YES
Exact difference between values	NO	NO	YES	YES
Has a "true zero" value	NO	NO	NO	YES

In conclusion, the **levels of measurement** provide a standardized language for describing the nature of **empirical evidence**. By accurately identifying whether a variable is **nominal**, **ordinal**, **interval**, or **ratio**, practitioners can select the most appropriate tools for **data visualization** and statistical testing. This foundational knowledge ensures that the insights derived from data are both mathematically sound and practically meaningful, regardless of the field of study.