Data Types and Scales of Measurement

by Sophia

WHAT'S COVERED

In this lesson, you will learn about classifying data as categorical or numerical and then by the measurement scale—nominal, ordinal, interval, or ratio. You will learn how to identify each of these data types and scales. Specifically, this lesson covers:

1. Classifying Data

The explanatory and response variables represent the quantities that are being changed or measured in an experiment. This lesson focuses on Steps 5 through 8 of the experimental method.

- **Step 5:** Analyze the test results to determine what the results tell you about the cause-and-effect relationship between the two variables.
- **Step 6:** Conclude whether or not the test showed that the prediction was correct or incorrect.
- **Step 7:** Revise your guess if the prediction was wrong and start from Step 2. -or- If the prediction looks plausible, start testing again from Step 4 to verify your results.
- **Step 8:** Once satisfied, report the findings so that others can review and possibly test them themselves.

One of the first steps in analyzing your findings is to classify the data type and measurement scale. Classification allows researchers to identify different types of information and apply the appropriate analytical and statistical tools.
Two common ways to classify data are by data type (qualitative or quantitative) and also by the scale of measurement (nominal, ordinal, interval, or ratio).

Data Types	Data Scales
Qualitative (Categorical) Data	Nominal Variables Ordinal Variables
Quantitative (Numerical) Data	Interval Variables Ratio Variables

2. Data Types

2a. Qualitative Data

Qualitative data is also often called **"categorical data"**. It is not numerical in the sense that we can do numerical operations with it, like adding numbers together or finding an average, but rather it fits in the category.

EXAMPLE Gender: male and female. That's a qualitative variable with two categories.
Letter grades AND zip codes feature numbers, but you wouldn't necessarily do mathematical equations with them. You wouldn't find an average zip code, for instance. The purpose of zip codes is to divide areas into categories. Hair color is another example of qualitative data because you can group those with black hair together and put those with blonde hair in another group.

HINT

Data represented by numbers can nevertheless be qualitative. Zip codes, student ID numbers, phone numbers, and customer numbers are all qualitative data represented with numbers.

TERM TO KNOW

Qualitative (Categorical) Data
Data that can be grouped into categories such as color, style, gender, or flavor.

2b. Quantitative Data

On the other hand, there is **quantitative data**. Quantitative data is expressed numerically. It makes sense to do numerical operations with it, like finding averages or adding them together.

Examples of quantitative data include:

- Weight
- Commute time to work

- Outdoor temperature

All of these are measured in numbers. It makes sense to find, for instance, averages of these; you can do numerical operations with them.
It's important to note that data is displayed differently for qualitative data than for quantitative data. Statistical operations depend on the type of data.

TERM TO KNOW

Quantitative (Numerical) Data

Data that can be measured or counted and used for numerical operations.

3. Data Scales of Measurement

The way your data is measured is called the data scale. It is important to identify your data scale because some scales of measurement allow for more robust statistical analysis that is not possible in others. The scales in the table below are listed in order from least versatile to most.

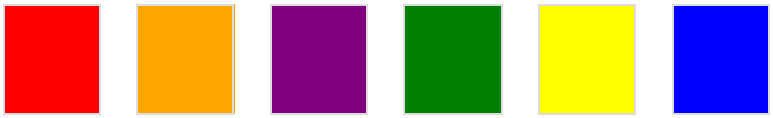
Nominal (least versatile)	Ordinal	Interval	Ratio (most versatile)

THINK ABOUT IT

As you become more familiar with each measurement scale, think about which aspects of the data make it more or less adaptable to different types of analyses and interpretations.

3a. Nominal Scale

EXAMPLE Consider, for instance, favorite color. The order of the listed categories makes no difference. It doesn't matter if you put the colors below in the order of the color spectrum or not.



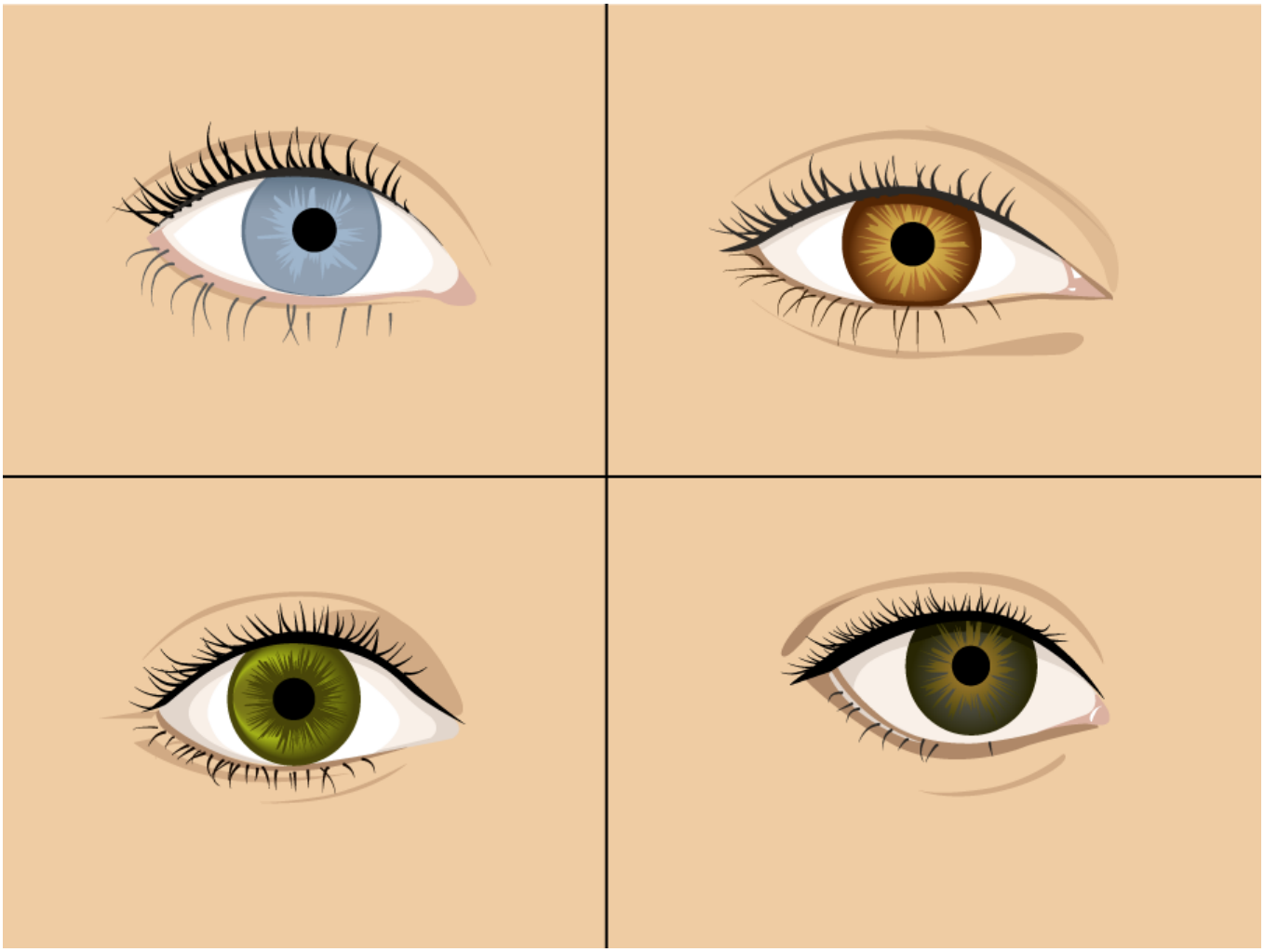
With **nominal data**, it only makes sense to reference which category has the largest frequency. In this case, let's say most people say that green is their favorite color. That is what you would report, and it doesn't matter that green is the fourth box from the left.

Nominal measurement scales do not show direction or magnitude. Direction means that data can be ordered, and magnitude means that one thing can be considered larger or smaller than another. When something does not have magnitude, then this comparison can't be made. When something does not have direction, then the order in which it's presented does not matter.

- Direction: Data can be ordered.

- Magnitude: Data can be less than or greater than other data.

Consider eye color. If you were at the Department of Motor Vehicles getting a new driver's license, you would have four choices for describing your eye color: blue, brown, green, and hazel.



These choices don't have magnitude because they can't be compared to one another. Blue eyes aren't necessarily bigger or better than brown eyes. Nor do the choices have a direction. The order in which they're presented doesn't matter, though they are likely to be in alphabetical order. Nominal variables can also have categories that are numbers.

> EXAMPLE Think of a telephone number; it's going to have an area code. This is an example of a nominal variable that consists of a number. All numbers within that area code would start with the same three digits. The area code varies from one region to the next.

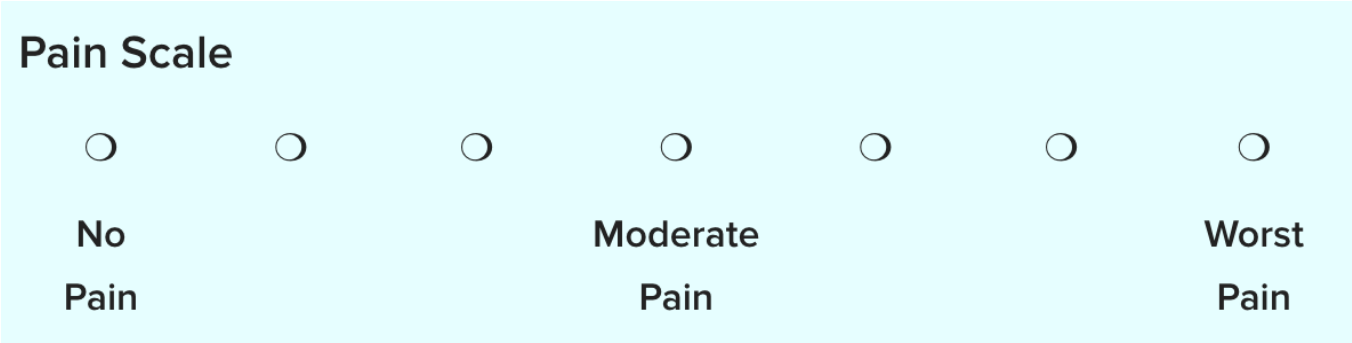
TERM TO KNOW

Nominal Scale

Qualitative measurement scale where the order in which the categories are presented does not matter.

3b. Ordinal Scale

EXAMPLE Consider the rating scale below. The order of the listed categories is very important because the order is associated with a type of value. You mustn't mix up the order here because the circle on the furthest left indicates you are feeling no pain.



With **ordinal data**, it's important to keep the order straight, or rather, *in order*, to express a spectrum ranging from lowest to highest, or worst to best.

A variable has an ordinal measurement scale if it provides categories, but only if the categories can be put in a meaningful order. What this means is that for each category, you can decide which is better or worse than others—or, put another way, which item comes before another. A variable like this is called an ordinal variable. While ordinal scales do show direction, they do not show magnitude, because direction refers to the position of categories or numbers.

EXAMPLE Take a look at the different classes that might exist in a high school or college. We have freshmen, sophomore, junior, and senior. Those are very common categories used to separate students based on how long they have attended the school.

- Freshman
- Sophomore
- Junior
- Senior

The class categories don't have magnitude, but they do have direction. Freshmen come first, sophomores come second, juniors third, and seniors fourth.

TERM TO KNOW

Ordinal Scale

Qualitative measurement scale where the order in which the categories are presented matters.

3c. Interval Scale

For quantitative data, it is often useful to consider the difference between variables on the scale. A variable has an **interval scale** if it provides numbers so that the difference between two values can be measured. The difference between any two values can always be determined the same way.

Consider SAT scores. The difference between a 1500 score and a 1700 score has the same meaning as the difference between a 1250 score and a 1450 score. This type of variable is called an interval variable.

With an interval variable, the number 0 does not mean that something does not exist. If somebody took the SAT and got a 0, that doesn't mean that person didn't take the exam; it means he or she failed to answer any questions correctly.

The Fahrenheit and Celsius temperature scales are also examples of interval scales. An important aspect of interval scales is that they do not have an absolute zero. In these temperature scales, zero is not the coldest possible temperature.

TERM TO KNOW

Interval Scale

A scale that provides numbers; the difference between two numbers is a measure of the magnitude of their difference.

3d. Ratio Scale

The fourth, and most versatile, measurement scale is the **ratio scale**. A ratio scale variable is similar to an interval variable but with the added feature of a true zero point. This means that a value of 0 on a ratio scale represents the absence of the variable being measured, or the lowest possible value. Examples include physical measurements like length, width, and mass. Variables that provide a count, such as the number of apps on your phone, are also ratio variables.

DID YOU KNOW

Scientists use the Kelvin temperature scale because, unlike Celcius or Fahrenheit, it is a ratio variable. This means that 0° K really is the coldest possible temperature! Absolute zero, 0° K, is equal to -273.15°C.

BIG IDEA

Knowing the scale of measurement for your data is important because each scale has different properties and limitations. For example, nominal data can only be categorized, while ratio data can be categorized, ranked, and has a true zero point. Understanding the scale of measurement can also help in selecting appropriate visualizations for the data, such as bar charts for nominal data and scatter plots for showing the relationship between ratio scale data.

This table summarizes just a few of the statistics we can, or cannot, use with the four scales of measurement. Notice that nominal data has the fewest options, whereas ratio data has the most options.

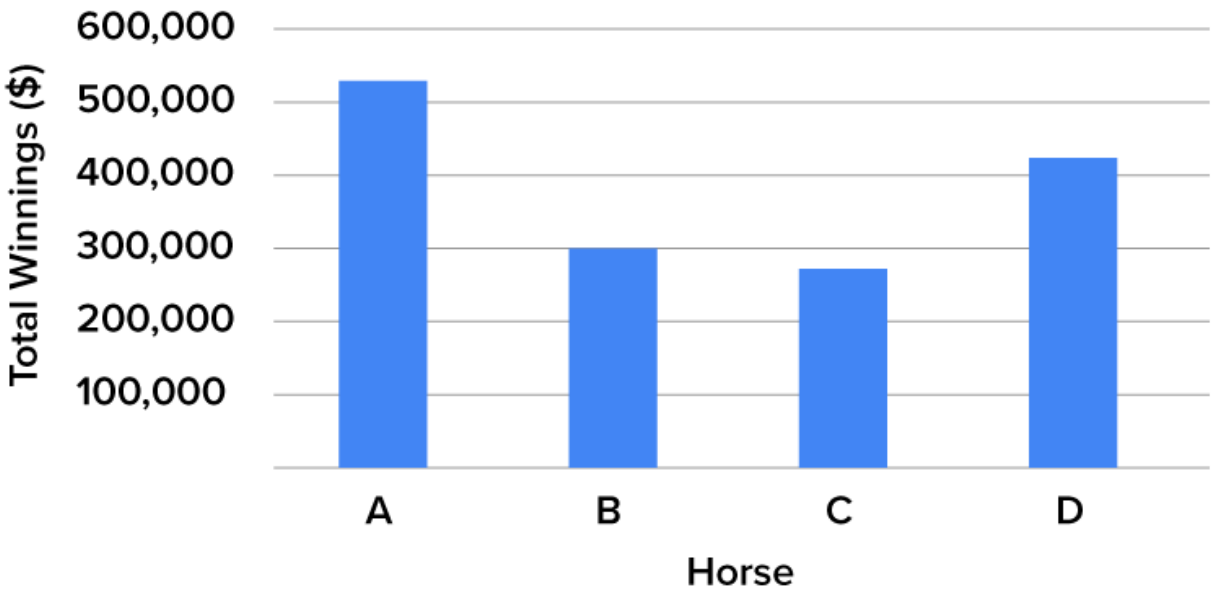
	Nominal	Ordinal	Interval	Ratio
Mode	yes	yes	yes	yes
Median	no	yes	yes	yes
Mean	no	no	yes	yes
Standard Deviation	no	no	yes	yes
Analysis of Variation (ANOVA)	no	no	yes	yes
Regression Analysis	no	no	no	yes

TERM TO KNOW

Ratio Scale

An interval scale; additionally, the number zero means the absence of a given quantity.

4. Classifying Data in Graphs



The bar graph above represents four hypothetical horses. For the sake of simplicity, they are called Horse A, Horse B, Horse C, and Horse D. You can see the different types of data here. That's important because it allows you to visually compare the horses' winnings, and it's relatively easy to tell which horse won more money than the others.

TRY IT

Even a simple scenario such as a horse race provides a variety of measurements. Let's identify the data types and scale in this graph.

What is the data type and scale for the x-axis? +

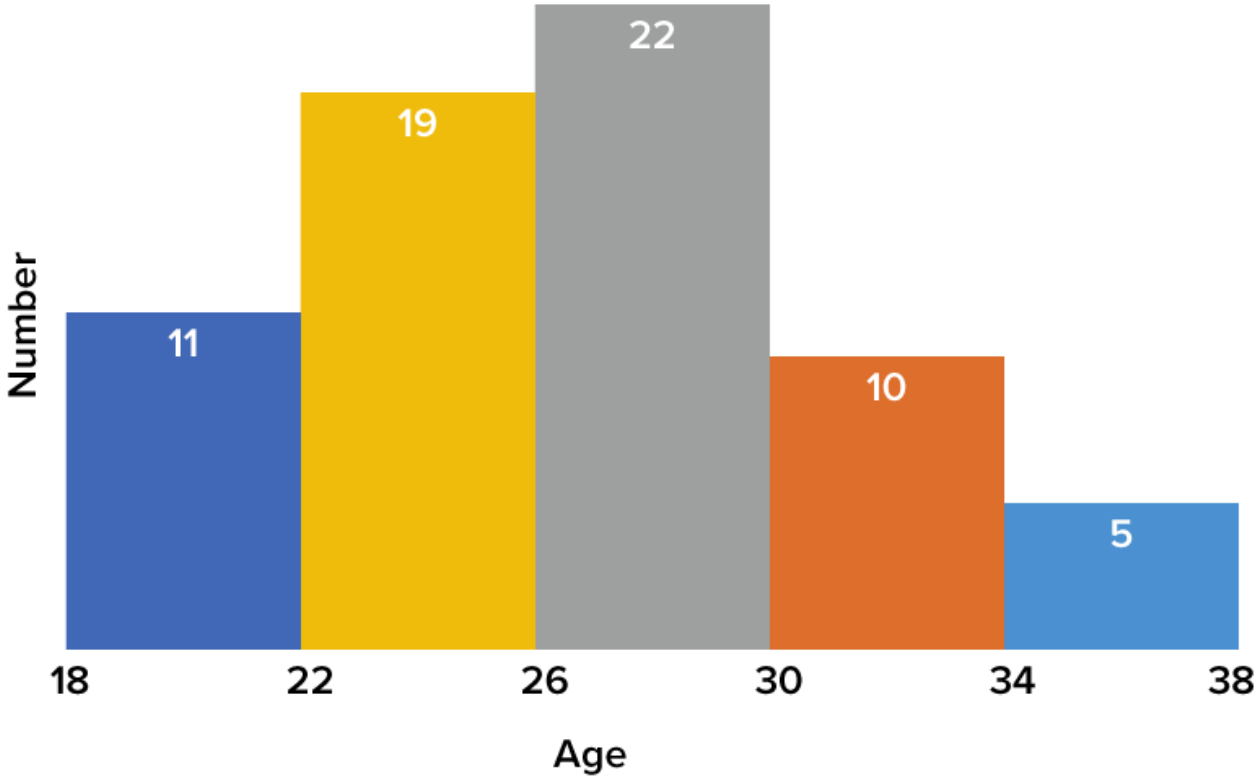
This is qualitative data with a nominal scale. The letters used to name the horses do not indicate a particular order or rank.

What is the data type and scale for the y-axis? +

Race winnings are quantitative data on a ratio scale. The number of dollars won has a numerical

meaning, and a horse could have a true zero, which would represent no winnings.

Let's look at a histogram, which is a different type of data visualization.



In this instance, you're looking at the age ranges of the jockeys who rode the horses. At the low end, you have 18. The histogram tells us there are 11 jockeys between the ages of 18 and 22. In the next range, there are 19 between the ages of 22 and 26. This goes up to five jockeys over the age of 34.

TRY IT

Identify the data types and scales in this graph.

What is the data type and scale for the x-axis? +

Age is a quantitative measurement. This is a unique case where we have created age ranges, so it is no longer possible to perform many numerical operations, yet the categories fall into a natural order. The x-axis is ordinal scale data.

What is the data type and scale for the y-axis? +

The number of jockeys is quantitative, and the numbers used have a true zero, making this the most versatile data scale, ratio.

SUMMARY

In this lesson, you learned that **classifying data** allows researchers to identify types of information. There are two main types of data, **quantitative** and **qualitative**, and four scales of measurement. The **nominal scale** provides categories. The **ordinal scale** provides categories that can be put in a meaningful order. On an **interval scale**, the difference between two values can be measured, but there is not a true zero. The **ratio scale** is an interval scale where the number zero means that something does not exist. Finally, you looked at some examples of **classifying data using graphs and scenarios**.

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TERMS TO KNOW

Interval Scale
A scale that provides numbers; the difference between two numbers is a measure of the magnitude of their difference.

Nominal Scale
Qualitative measurement scale where the order in which the categories are presented does not matter.

Ordinal Scale
Qualitative measurement scale where the order in which the categories are presented matters.

Qualitative (Categorical) Data
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An interval scale; additionally, the number zero means the absence of a given quantity.