Making sense of data

It is crucial to identify the type of data under analysis. In this section, we are going to learn about different types of data that you can encounter during analysis. Different disciplines store different kinds of data for different purposes. For example, medical researchers store patients' data, universities store students' and teachers' data, and real estate industries storehouse and building datasets. A dataset contains many observations about a particular object. For instance, a dataset about patients in a hospital can contain many observations. A patient can be described by a *patient identifier (ID), name, address, weight, date of birth, address, email,* and *gender*. Each of these features that describes a patient is a variable. Each observation can have a specific value for each of these variables. For example, a patient can have the following:

```
PATIENT_ID = 1001
Name = Yoshmi Mukhiya
Address = Mannsverk 61, 5094, Bergen, Norway
Date of birth = 10th July 2018
Email = yoshmimukhiya@gmail.com
Weight = 10
Gender = Female
```

These datasets are stored in hospitals and are presented for analysis. Most of this data is stored in some sort of database management system in tables/schema. An example of a table for storing patient information is shown here:

PATIENT_ID	NAME	ADDRESS	DOB	EMAIL	Gender	WEIGHT
001	Suresh Kumar Mukhiya	Mannsverk, 61	30.12.1989	skmu@hvl.no	Male	68
002	Yoshmi Mukhiya	Mannsverk 61, 5094, Bergen	10.07.2018	yoshmimukhiya@gmail.com	Female	1
003	Anju Mukhiya	Mannsverk 61, 5094, Bergen	10.12.1997	anjumukhiya@gmail.com	Female	24
004	Asha Gaire	Butwal, Nepal	30.11.1990	aasha.gaire@gmail.com	Female	23
005	Ola Nordmann	Danmark, Sweden	12.12.1789	ola@gmail.com	Male	75

To summarize the preceding table, there are four observations (001, 002, 003, 004, 005). Each observation describes variables (`PatientID`, `name`, `address`, `dob`, `email`, `gender`, and `weight`). Most of the dataset broadly falls into two

groups—numerical data and categorical data.

Numerical data

This data has a sense of measurement involved in it; for example, a person's age, height, weight, blood pressure, heart rate, temperature, number of teeth, number of bones, and the number of family members. This data is often referred to as **quantitative data** in statistics. The numerical dataset can be either discrete or continuous types.

Discrete data

This is data that is countable and its values can be listed out. For example, if we flip a coin, the number of heads in 200 coin flips can take values from 0 to 200 (finite) cases. A variable that represents a discrete dataset is referred to as a discrete variable. The discrete variable takes a fixed number of distinct values. For example, the `Country` variable can have values such as Nepal, India, Norway, and Japan. It is fixed. The `Rank` variable of a student in a classroom can take values from 1, 2, 3, 4, 5, and so on.

Continuous data

A variable that can have an infinite number of numerical values within a specific range is classified as continuous data. A variable describing continuous data is a continuous variable. For example, what is the temperature of your city today? Can we be finite? Similarly, the `weight` variable in the previous section is a continuous variable. We are going to use a car dataset in `Chapter 5`, *Descriptive Statistics*, to perform EDA.

A section of the table is shown in the following table:

Model	Year	Engine Fuel Type	Engine HP	Engine Cylinders	Transmission Type	Driven_Wheels	Number of Doors	Market Category	Vehicle Size	Vehicle Style	highway MPG	city mpg	Popularity	MSRP
1 Series M	2011	premium unleaded (required)	335.0	6.0	MANUAL	rear wheel drive	2.0	Factory Tuner,Luxury,High-Performance	Compact	Coupe	26	19	3916	46135
1 Series	2011	premium unleaded (required)	300.0	6.0	MANUAL	rear wheel drive	2.0	Luxury,Performance	Compact	Convertible	28	19	3916	40650
1 Series	2011	premium unleaded (required)	300.0	6.0	MANUAL	rear wheel drive	2.0	Luxury,High-Performance	Compact	Coupe	28	20	3916	36350
1 Series	2011	premium unleaded (required)	230.0	6.0	MANUAL	rear wheel drive	2.0	Luxury,Performance	Compact	Coupe	28	18	3916	29450
1 Series	2011	premium unleaded (required)	230.0	6.0	MANUAL	rear wheel drive	2.0	Luxury	Compact	Convertible	28	18	3916	34500
1 Series	2012	premium unleaded (required)	230.0	6.0	MANUAL	rear wheel drive	2.0	Luxury,Performance	Compact	Coupe	28	18	3916	31200
1 Series	2012	premium unleaded (required)	300.0	6.0	MANUAL	rear wheel drive	2.0	Luxury,Performance	Compact	Convertible	26	17	3916	44100
1 Series	2012	premium unleaded (required)	300.0	6.0	MANUAL	rear wheel drive	2.0	Luxury,High-Performance	Compact	Coupe	28	20	3916	39300

Check the preceding table and determine which of the variables are discrete and which of the variables are continuous. Can you justify your claim? Continuous data can follow an interval measure of scale or ratio measure of scale. We will go into more detail in the *Measurement scales* section in this chapter.

Categorical data

This type of data represents the characteristics of an object; for example, gender, marital status, type of address, or categories of the movies. This data is often referred to as **qualitative datasets** in statistics. To understand clearly, here are some of the most common types of categorical data you can find in data:

- Gender (Male, Female, Other, or Unknown)
- Marital Status (Annulled, Divorced, Interlocutory, Legally Separated, Married, Polygamous, Never Married, Domestic Partner, Unmarried, Widowed, or Unknown)
- Movie genres (Action, Adventure, Comedy, Crime, Drama, Fantasy, Historical, Horror, Mystery, Philosophical, Political, Romance, Saga, Satire, Science Fiction, Social, Thriller, Urban, or Western)

- Blood type (A, B, AB, or O)
- Types of drugs (Stimulants, Depressants, Hallucinogens, Dissociatives, Opioids, Inhalants, or Cannabis)

A variable describing categorical data is referred to as a **categorical variable**. These types of variables can have one of a limited number of values. It is easier for computer science students to understand categorical values as enumerated types or enumerations of variables. There are different types of categorical variables:

- A binary categorical variable can take exactly two values and is also referred to as a **dichotomous variable**. For example, when you create an experiment, the result is either success or failure. Hence, results can be understood as a **binary categorical variable**.
- **Polytomous variables** are categorical variables that can take more than two possible values. For example, marital status can have several values, such as annulled, divorced, interlocutory, legally separated, married, polygamous, never married, domestic partners, unmarried,

widowed, domestic partner, and unknown. Since marital status can take more than two possible values, it is a **polytomous variable.**

Most of the categorical dataset follows either nominal or ordinal measurement scales. Let's understand what is a nominal or ordinal scale in the next section.

Measurement scales

There are four different types of measurement scales described in statistics: nominal, ordinal, interval, and ratio. These scales are used more in academic industries. Let's understand each of them with some examples.

Nominal

These are practiced for labeling variables without any quantitative value. The scales are generally referred to as **labels**. And these scales are mutually exclusive and do not carry any numerical importance. Let's see some examples:

- What is your gender?
- Male
- Female
- Third gender/Non-binary
- I prefer not to answer
- Other
- Other examples include the following:
- The languages that are spoken in a particular country
- Biological species
- Parts of speech in grammar (noun, pronoun, adjective, and so on)
- Taxonomic ranks in biology (Archea, Bacteria, and Eukarya)

Nominal scales are considered qualitative scales and the measurements that are taken using qualitative scales are considered **qualitative data**. However, the advancement in qualitative research has created confusion to be definitely considered as qualitative. If, for example, someone uses numbers as labels in the nominal measurement sense, they have no concrete numerical value or meaning. No form of arithmetic calculation can be made on nominal measures.

You might be thinking *why should you care about whether data is nominal or ordinal? Should we not just start loading the data and begin our analysis?* Well, we could. But think about this: you have a dataset, and you want to analyze it. How will you decide whether you can make a pie chart, bar chart, or histogram? Are you getting my point?

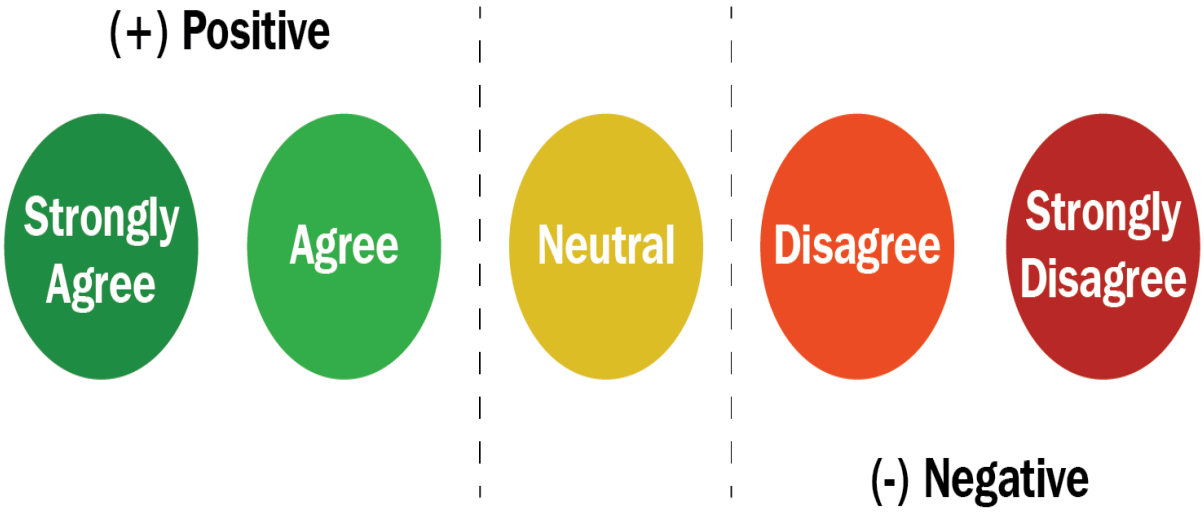
Well, for example, in the case of a nominal dataset, you can certainly know the following:

- **Frequency** is the rate at which a label occurs over a period of time within the dataset.
- **Proportion** can be calculated by dividing the frequency by the total number of events.
- Then, you could compute the **percentage** of each proportion.
- And to **visualize** the nominal dataset, you can use either a pie chart or a bar chart.

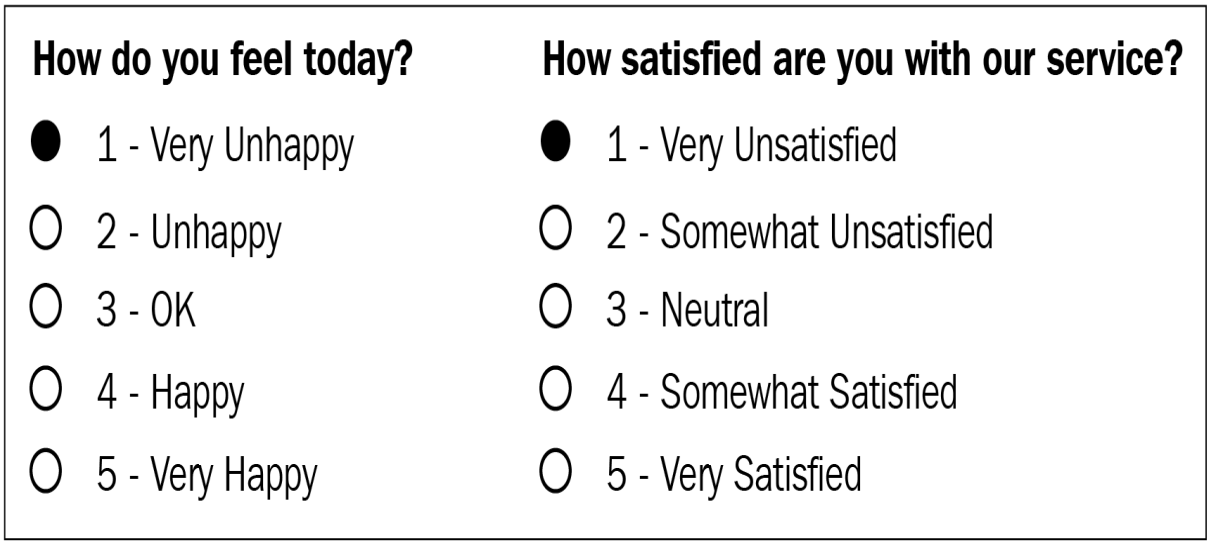
If you know your data follows nominal scales, you can use a pie chart or bar chart. That's one less thing to worry about, right? My point is, understanding the type of data is relevant in understanding what type of computation you can perform, what type of model you should fit on the dataset, and what type of visualization you can generate.

Ordinal

The main difference in the ordinal and nominal scale is the order. In ordinal scales, the order of the values is a significant factor. An easy tip to remember the ordinal scale is that it sounds like an *order*. Have you heard about the **Likert scale**, which uses a variation of an ordinal scale? Let's check an example of ordinal scale using the Likert scale: *WordPress is making content managers' lives easier. How do you feel about this statement?* The following diagram shows the Likert scale:



As depicted in the preceding diagram, the answer to the question of *WordPress is making content managers' lives easier* is scaled down to five different ordinal values, **Strongly Agree**, **Agree**, **Neutral**, **Disagree**, and **Strongly Disagree**. Scales like these are referred to as the Likert scale. Similarly, the following diagram shows more examples of the Likert scale:



To make it easier, consider ordinal scales as an order of ranking (1st, 2nd, 3rd, 4th, and so on). The **median** item is allowed as the measure of central tendency; however, the **average** is not permitted.

Interval

In interval scales, both the order and exact differences between the values are significant. Interval scales are widely used in statistics, for example, in the *measure of central tendencies—mean, median, mode, and standard deviations.* Examples include location in Cartesian coordinates and direction measured in degrees from magnetic north. The mean, median, and mode are allowed on interval data.

Ratio

Ratio scales contain order, exact values, and absolute zero, which makes it possible to be used in descriptive and inferential statistics. These scales provide numerous possibilities for statistical analysis. Mathematical operations, the measure of central tendencies, and the **measure of dispersion** and **coefficient of variatio**n can also be computed from such scales.

Examples include a measure of energy, mass, length, duration, electrical energy, plan angle, and volume. The following table gives a summary of the data types and scale measures:

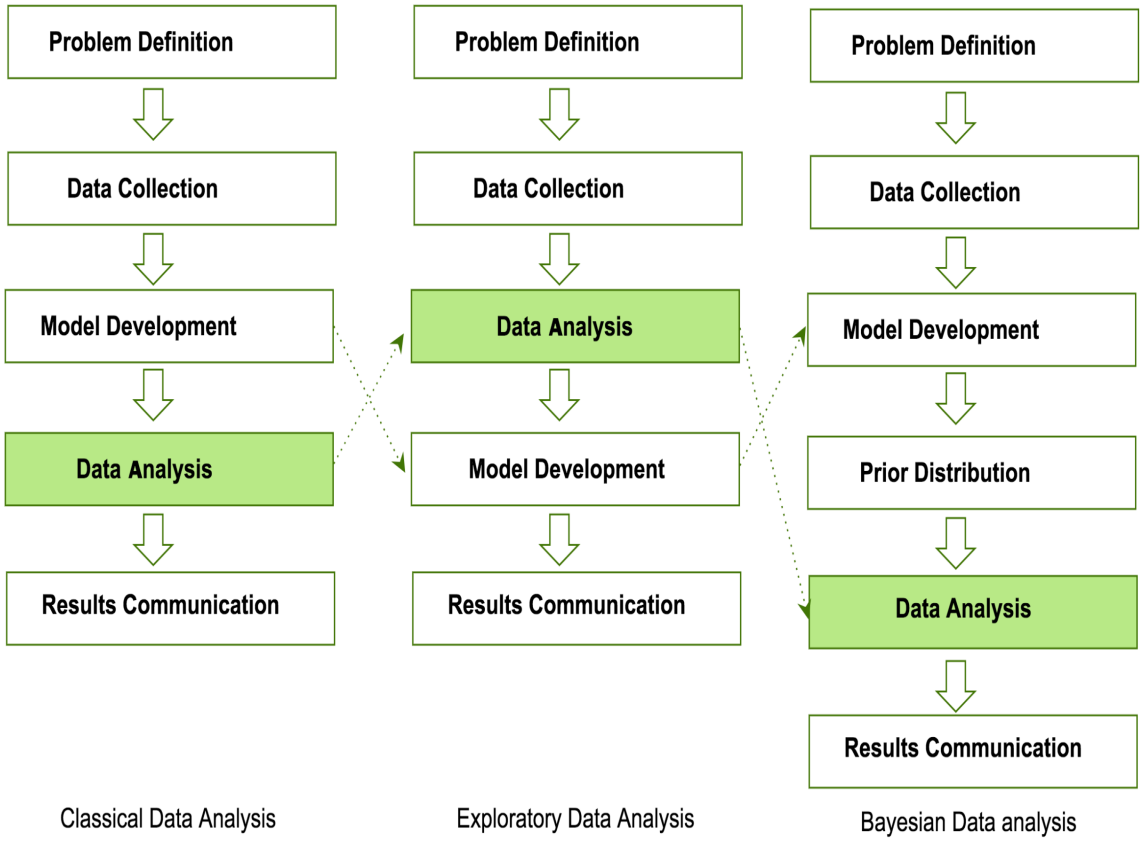
Provides:	Nominal	Ordinal	Interval	Ratio
The "order" of values is known		✓	✓	✓
"Counts," aka "Frequency of Distribution"	✓	✓	✓	✓
Mode	✓	✓	✓	✓
Median		✓	✓	✓
Mean			✓	✓
Can quantify the difference between each value			✓	✓
Can add or subtract values			✓	✓
Can multiple and divide values				✓
Has "true zero"				✓

In the next section, we will compare EDA with classical and Bayesian analysis.

Comparing EDA with classical and Bayesian analysis

There are several approaches to data analysis. The most popular ones that are relevant to this book are the following:

- **Classical data analysis:** For the classical data analysis approach, the problem definition and data collection step are followed by model development, which is followed by analysis and result communication.
- **Exploratory data analysis approach**: For the EDA approach, it follows the same approach as classical data analysis except the model imposition and the data analysis steps are swapped. The main focus is on the data, its structure, outliers, models, and visualizations. Generally, in EDA, we do not impose any deterministic or probabilistic models on the data.
- **Bayesian data analysis approach:** The Bayesian approach incorporates prior probability distribution knowledge into the analysis steps as shown in the following diagram. Well, simply put, prior probability distribution of any quantity expresses the belief about that particular quantity before considering some evidence. Are you still lost with the term prior probability distribution? Andrew Gelman has a very descriptive paper about *prior probability distribution*. The following diagram shows three different approaches for data analysis illustrating the difference in their execution steps:



Data analysts and data scientists freely mix steps mentioned in the preceding approaches to get meaningful insights from the data. In addition to that, it is essentially difficult to judge or estimate which model is best for data analysis. All of them have their paradigms and are suitable for different types of data analysis.

Software tools available for EDA

There are several software tools that are available to facilitate EDA. Here, we are going to outline some of the open source tools:

- **Python**: This is an open source programming language widely used in data analysis, data mining, and data science (https://www.python.org/). For this book, we will be using Python.
- **R programming language**: R is an open source programming language that is widely utilized in statistical computation and graphical data analysis (https://www.r-project.org).
- **Weka**: This is an open source data mining package that involves several EDA tools and algorithms (https://www.cs.waikato.ac.nz/ml/weka/).
- **KNIME**: This is an open source tool for data analysis and is based on Eclipse (https://www.knime.com/).

Getting started with EDA

As mentioned earlier, we are going to use Python as the main tool for data analysis. Yay! Well, if you ask me why, Python has been consistently ranked among the top 10 programming languages and is widely adopted for data analysis and data mining by data science experts. In this book, we assume you have a working knowledge of Python. If you are not familiar with Python, it's probably too early to get started with data analysis. I assume you are familiar with the following Python tools and packages:

Python programming	Fundamental concepts of variables, string, and data types Conditionals and functions Sequences, collections, and iterations Working with files Object-oriented programming
NumPy	Create arrays with NumPy, copy arrays, and divide arrays Perform different operations on NumPy arrays Understand array selections, advanced indexing, and expanding Working with multi-dimensional arrays