ID430B: Data Analytics for Designers 디자인 특강V <디자이너를 위한 데이터 분석>

Lecture 3

Descriptive Statistics, Types of Distribution, and Levels of Measurement

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Goals

1. **Descriptive Statistics**

   What is Descriptive Statistics? Why does it matter?

2. **Types of Distribution**

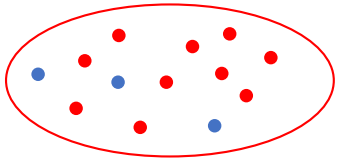
   Normal distribution, Exponential distribution, and Uniform distribution

3. **Levels of Measurement**

   Nominal, Ordinal, Interval, Ratio

Descriptive Statistics

What is Descriptive Statistics?

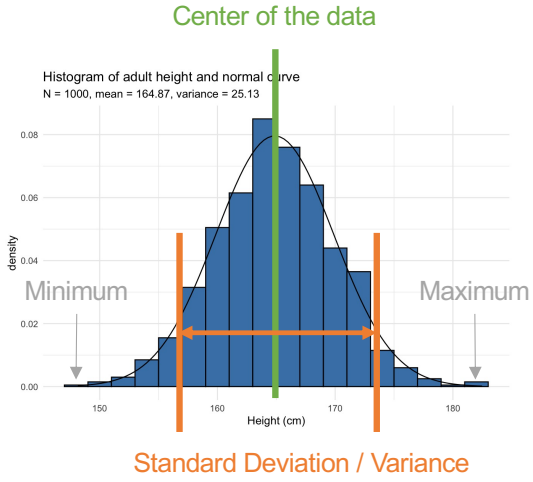


… quantitatively **summarizes** or **describes** the characteristics of a dataset (NOT the population)

E.g. Hundreds samples E.g. Millions of the entire users

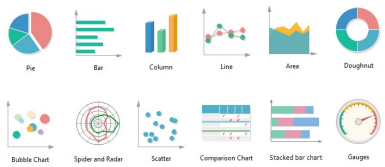
… consists of basic categories of measures shown below

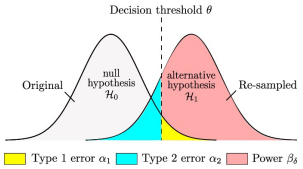
1. What is the **central tendency** of the data? (Mean, Median, Mode)
2. How **spread out** is the data? (Standard deviation, Variance)
3. What are the **extremes** of the data? (Minimum, maximum; Outliers)
4. What is the "**shape**" of the distribution? Is it symmetric or asymmetric? Are the values mostly clustered about the mean or spread at the tails?
5. How many (**unique** / **non-empty**) values are in the data?



Descriptive Statistics vs Inferential Statistics

Descriptive	Inferential
Describe, summarize, and present characteristics of the known data	Inferring about the population based on the random sample of it
Organize, analyze and present	Compares, test and predicts
Describe a situation	Explain the chance of occurrence of an event
Central tendency, Variability, Distribution	Estimation of parameters, Hypothesis test
Results shown with charts and tables	Results shown with probability or model
E.g. "The log data shows that users took average 64seconds to complete the task. However, a fraction of users spent over 200 seconds. Why?"	*E.g. "Based on the latest A/B test, the upgrade would significantly increase the efficiency of our system."*

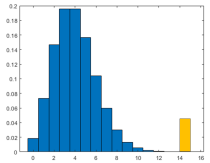




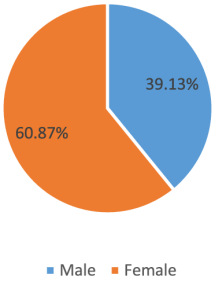
Why does Descriptive Statistics matter?

- **The first step** of understanding the dataset (i.e. the bottom layer of DIKW)

- **Sanity Check**: Use charts and descriptive statistics to spot data quality issues
  - (Completeness) *"Some students got negative scores from the exam. It might be a technical issue."*
  - (Accuracy) *"Some data points are much greater than the others (i.e. outliers). We must check our collection method."*
  - (Redundancy) "Lots of data points are identical. We must check duplicates in our dataset."
  - (Bias) "90% of our participants are men. Is our dataset biased?"



"There exist outliers. We need to check whether this is an accuracy issue. "



"If 90% of our data points are male, the dataset is biased (significantly different from the real population shown left)."

Measures of Central Tendency

- **Mean (i.e. Average)** is found by adding all of the numbers together and dividing by the number of items in the set

  E.g. (20 + 10 + 70 + 40 + 10) / 5 = 30

- **Median** is found by ordering the set from lowest to highest and finding the exact middle. The median is just the middle number. If the dataset has even # values, use the average of the two median values

  E.g. Original:[20,10,70,40,10] → Sorted:[10,10,**20**,40,70] → Median: 20

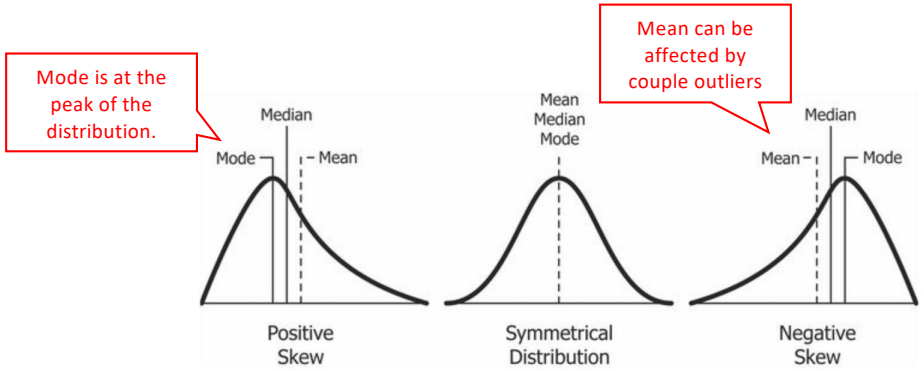
- **Mode** is the most frequently observed value

  E.g. Original:[20,**10**,70,40,**10**]

  → FreqByValue:{20:1, 10:2, 70:1, 40:1}

  → SortKeysByValue: [[10,2], [20,1], [70,1], [40,1]]

  → Mode: 10



Measures of Variation (or Dispersion)

- Standard Deviation (SD) is calculated as below

Dataset $2,\ 4,\ 4,\ 4,\ 5,\ 5,\ 7,\ 9.$

Mean $\mu = \dfrac{2+4+4+4+5+5+7+9}{8} = \dfrac{40}{8} = 5$

Mean

Squared Deviations

$(2-5)^2 = (-3)^2 = 9 \qquad (5-5)^2 = 0^2 = 0$

$(4-5)^2 = (-1)^2 = 1 \qquad (5-5)^2 = 0^2 = 0$

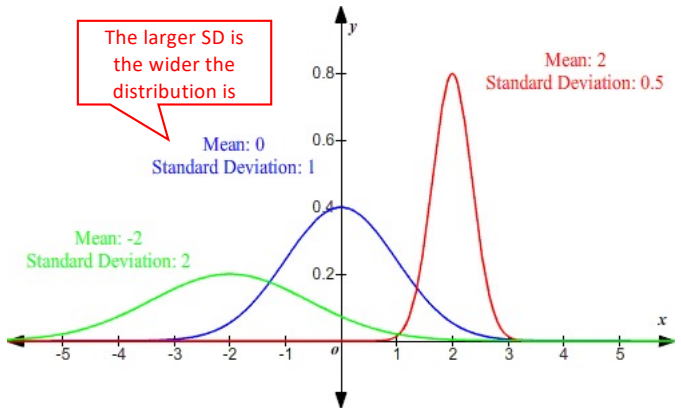
$(4-5)^2 = (-1)^2 = 1 \qquad (7-5)^2 = 2^2 = 4$

$(4-5)^2 = (-1)^2 = 1 \qquad (9-5)^2 = 4^2 = 16$

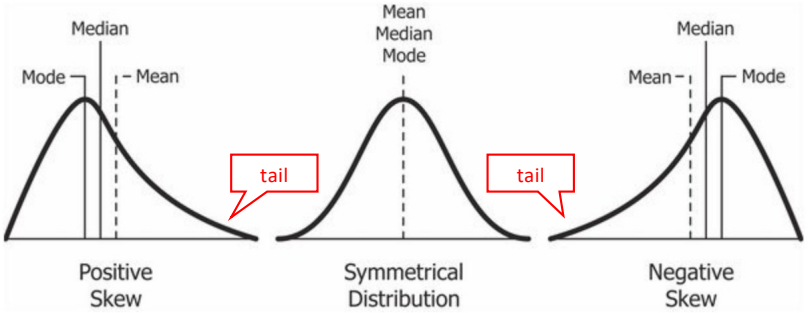
Variance $\sigma^2 = \dfrac{9+1+1+1+0+0+4+16}{8} = \dfrac{32}{8} = 4.$

values

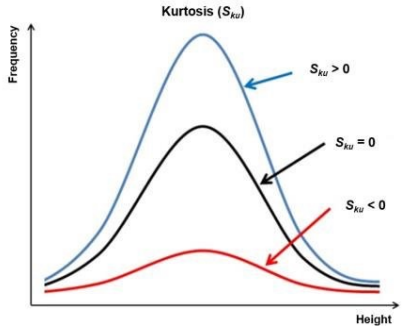
Standard Deviation $\sigma = \sqrt{4} = 2$



Skewness and Kurtosis



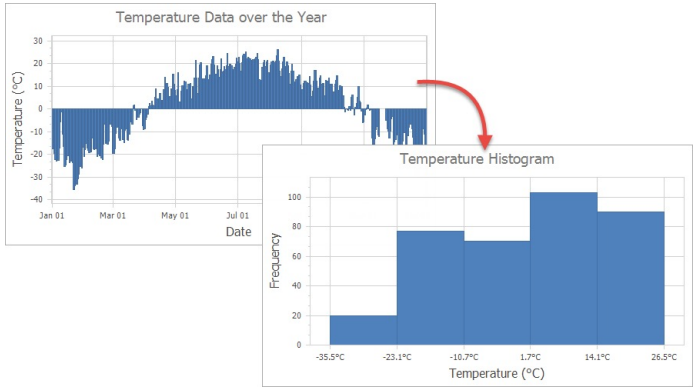
- **Skewness** is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. The skewness value can be positive, zero, negative, or undefined.
- No need to learn / memorize the formula



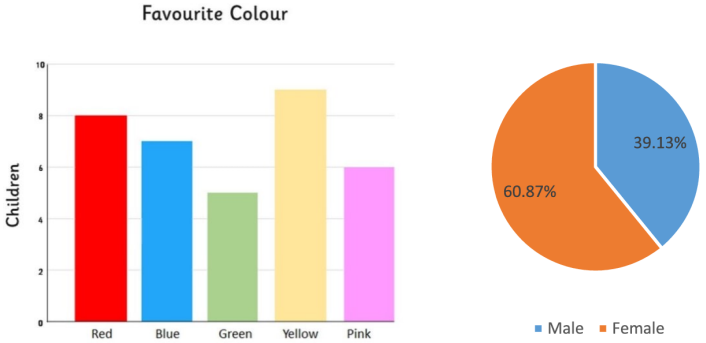
- **Kurtosis** is a measure the degree to which scores cluster in the tails or the peak of a frequency distribution.
- The smaller Kurtosis value is, the wider data points are spread out
- No need to learn / memorize the formula

Value Counting for numeric / non-numeric data

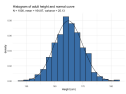
- How many values (i.e. rows) in the dataset
  - Do we have enough data for the analysis in mind?
- How many unique (i.e. distinct) values in the dataset
  - Do they have a consistent format? Do we need to ignore / remove / fix them?
- Draw value frequency with charts
  - Histogram (for numeric data)



  - Bar / Pie charts (for non-numeric data)

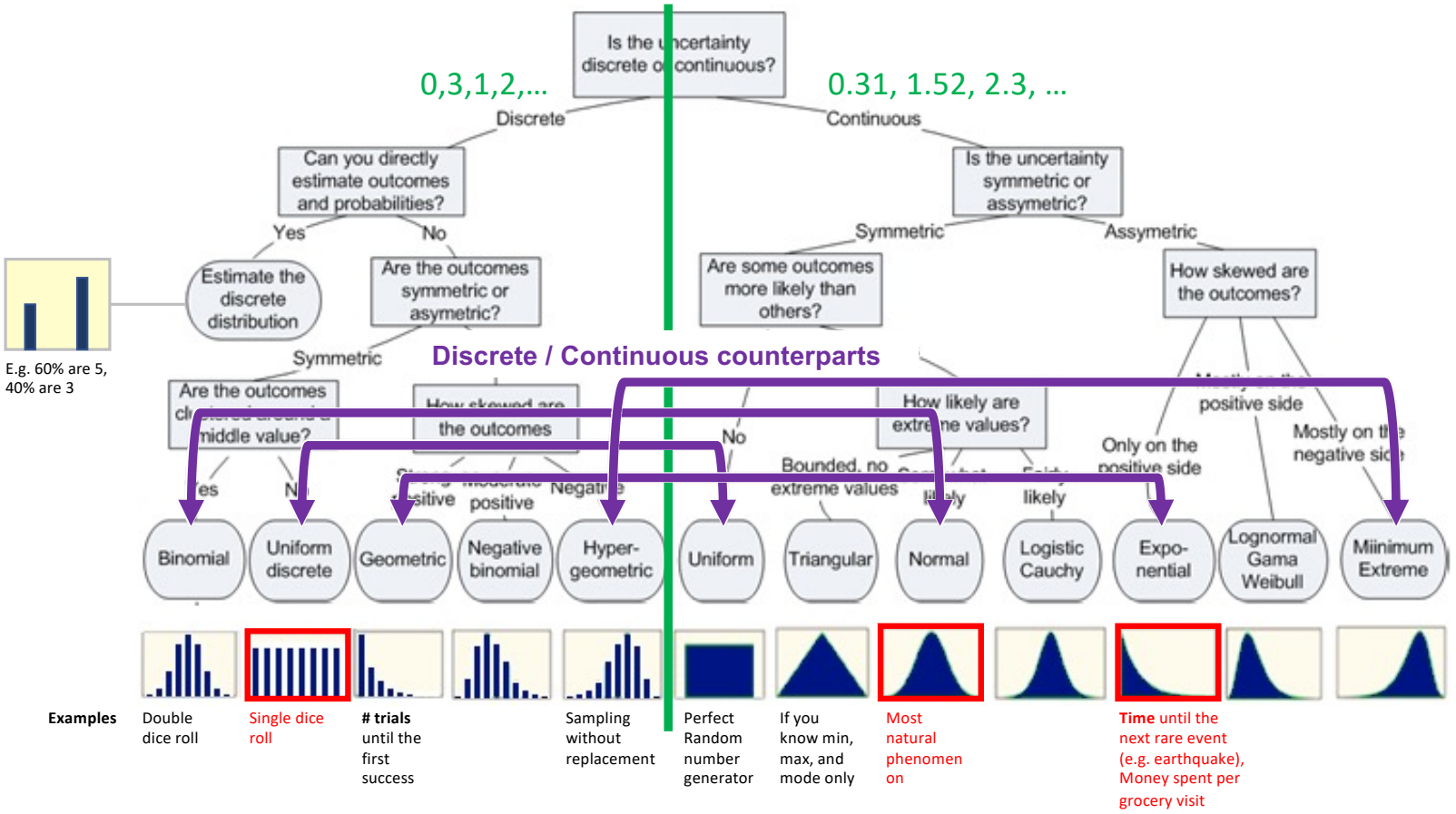


Types of Distribution

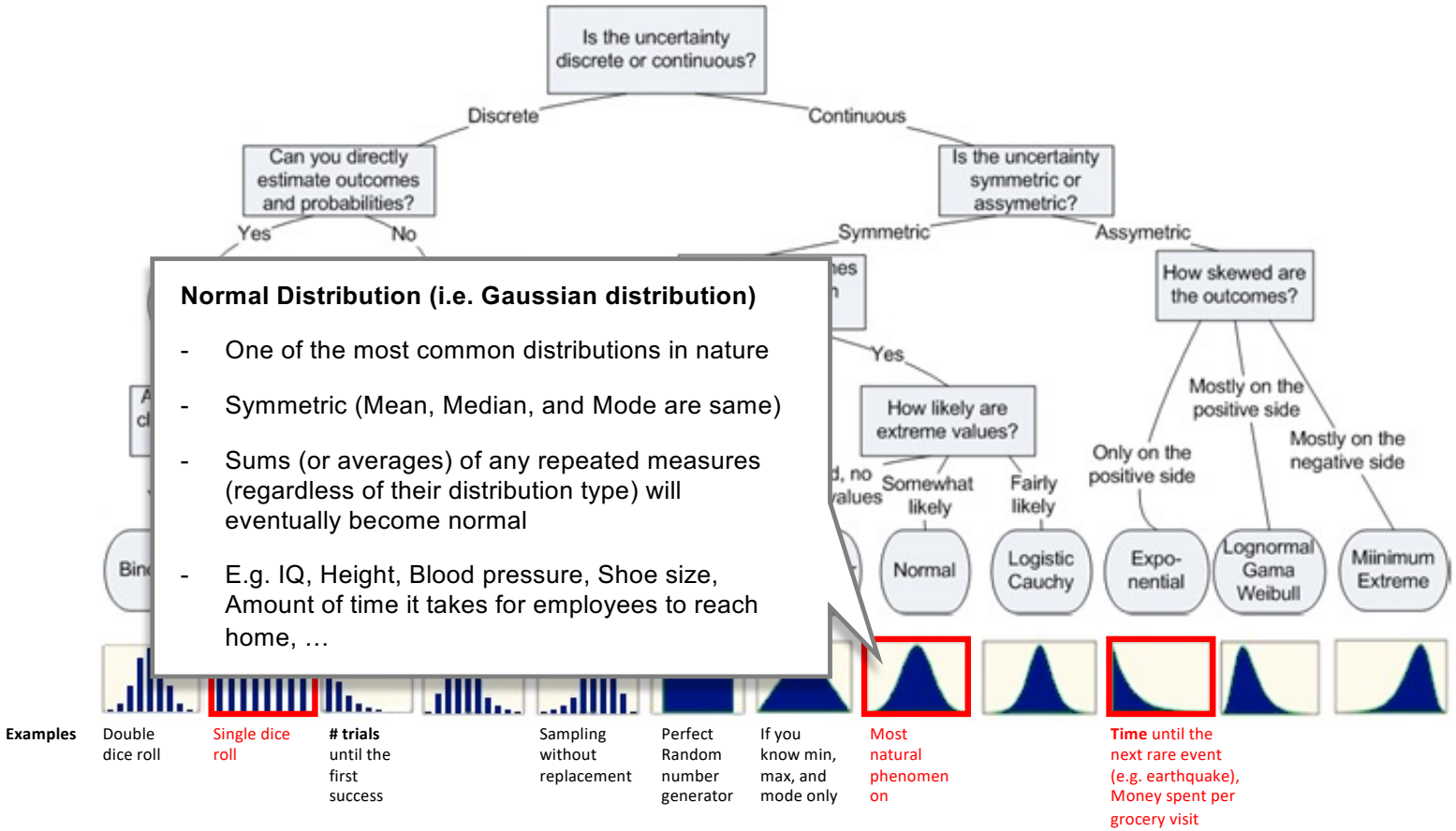


Types of Distributions

- Is it always bell-shaped? **No, there are many other types of distribution.**



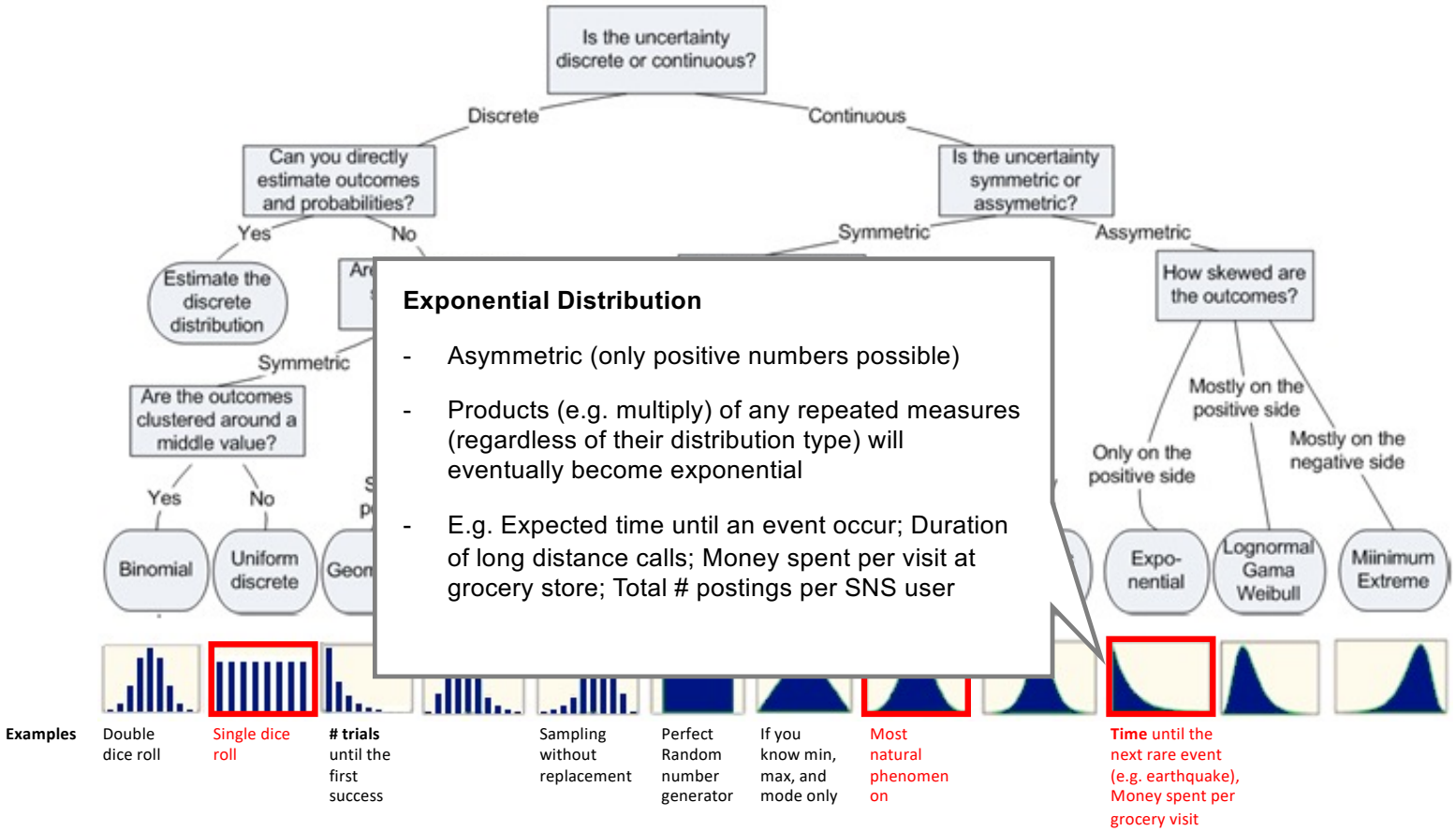
Types of Distributions



Normal Distribution (i.e. Gaussian distribution)

- One of the most common distributions in nature
- Symmetric (Mean, Median, and Mode are same)
- Sums (or averages) of any repeated measures (regardless of their distribution type) will eventually become normal
- E.g. IQ, Height, Blood pressure, Shoe size, Amount of time it takes for employees to reach home, …

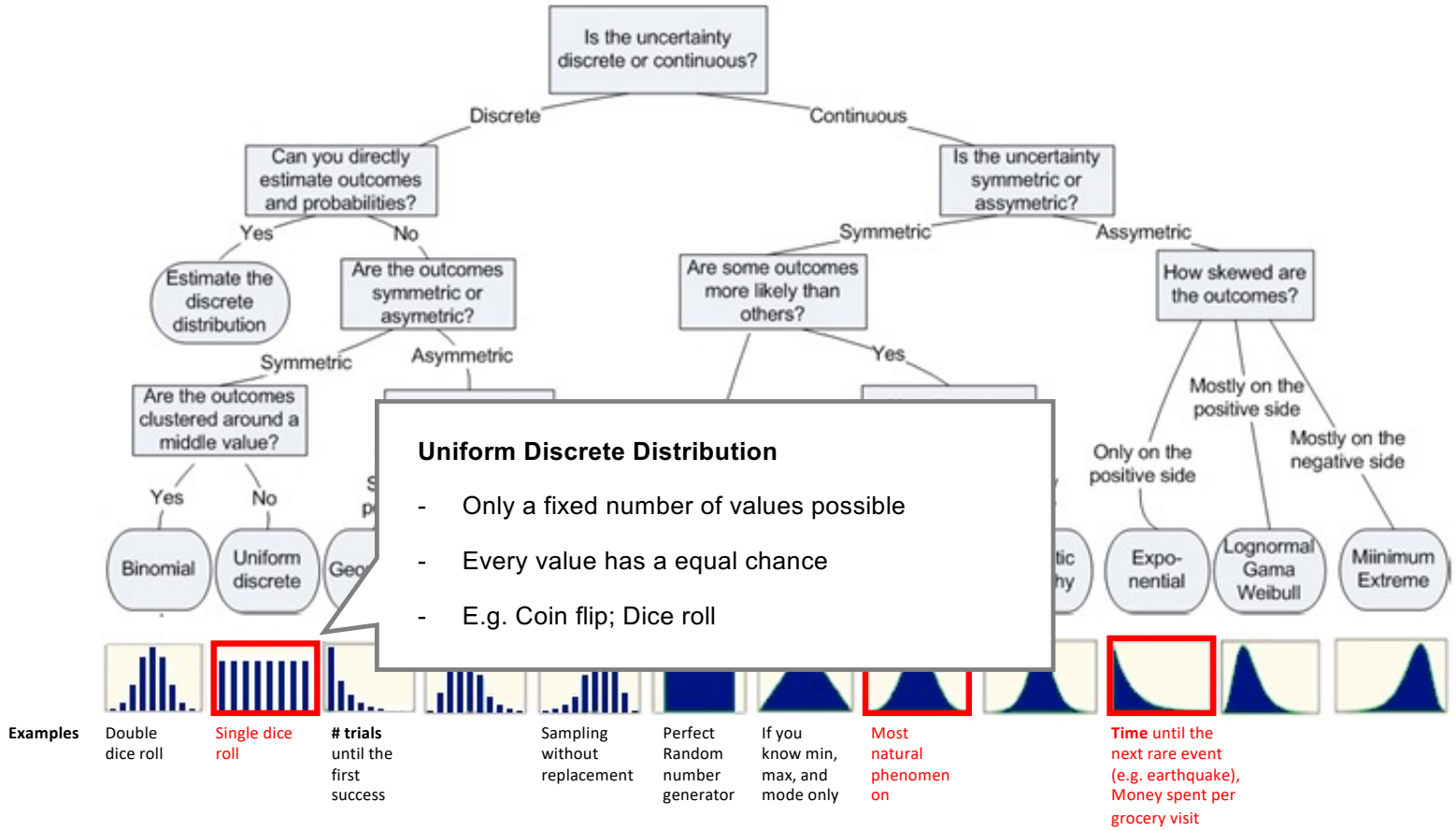
Types of Distributions



Exponential Distribution

- Asymmetric (only positive numbers possible)
- Products (e.g. multiply) of any repeated measures (regardless of their distribution type) will eventually become exponential
- E.g. Expected time until an event occur; Duration of long distance calls; Money spent per visit at grocery store; Total # postings per SNS user

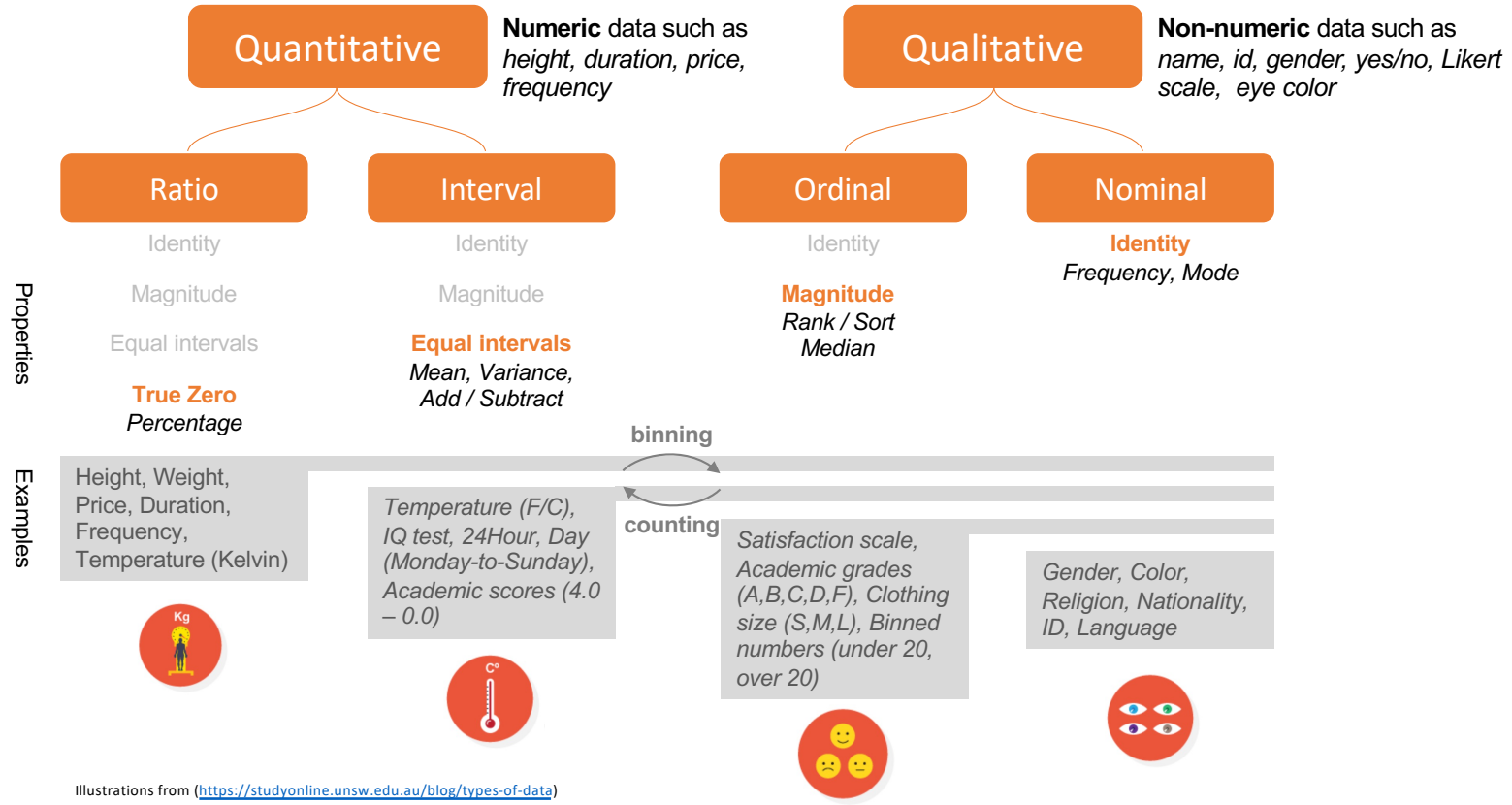
Types of Distributions



Levels of Measurement

Four Levels of Measurement

Whether a value is numeric or non-numeric is decided by its semantic meaning (not character itself). For instance, "5" is numeric (quantitative) if it means "5 pieces of cake"; or non-numeric (qualitative) if it means "5 out of 10 satisfaction scale on survey data"



Illustrations from (https://studyonline.unsw.edu.au/blog/types-of-data)

E.g. Academic Grading is … weird

(1)

40% Assignments
30% Final exam
30% Midterm exam
Total: 100%

Total score earned throughout the course **is ratio.**
If a student didn't submit anything he/she may get true zero point.

(2)

A: 90% - 100%
B: 80% - 90%
C: 70% - 80%
D: 60% - 70%
F: - 60%

Letter grade is ordinal because they can be ranked (i.e. A is better than B). Differences are not precisely meaningful, for example, if one student scores an A and another a B on an assignment, we cannot say precisely the difference in their scores, only that an A is larger than a B.

Note.
Letter grade also qualifies as nominal values since we can check the equality (e.g. *two students got the same grade A*)

(3)

4.0
3.0
2.0
1.0
0.0

GPA is interval because they are added to calculate the total GPA. However GPA is not ratio since A is not twice of C by any means. Also F does not mean true zero.

(4)

Total GPA: 420
 # classes = 120
Average GPA:
420/120 = 3.5

Average GPA is ratio again.