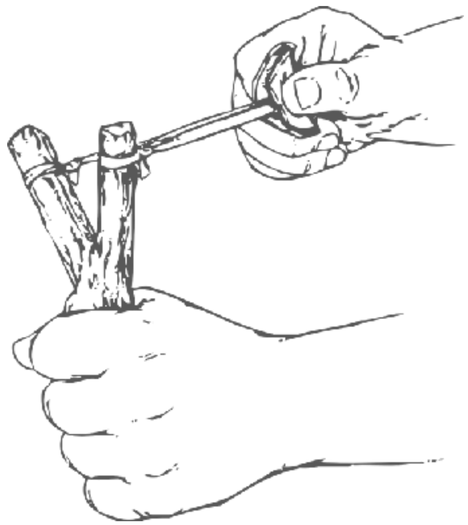
DATA ANALYSIS

WHAT'S DATA?

LEARNING GOALS



- appreciate the diversity of data
- distinguish different kinds of variables
  - dependent vs independent
  - nominal vs ordinal vs metric
- get familiar with basic aspects of experimental design
  - factorial designs, within- vs between subjects design
  - repeated measures, randomization, fillers and controls

WHAT DOES “DATA” MEAN?

1 **:** factual information (such as measurements or statistics) used as a basis for reasoning, discussion, or calculation

// the *data* is plentiful and easily available

— H. A. Gleason, Jr.

// comprehensive *data* on economic growth have been published

— N. H. Jacoby

2 **:** information in digital form that can be transmitted or processed

3 **:** information output by a sensing device or organ that includes both useful and irrelevant or redundant information and must be processed to be meaningful

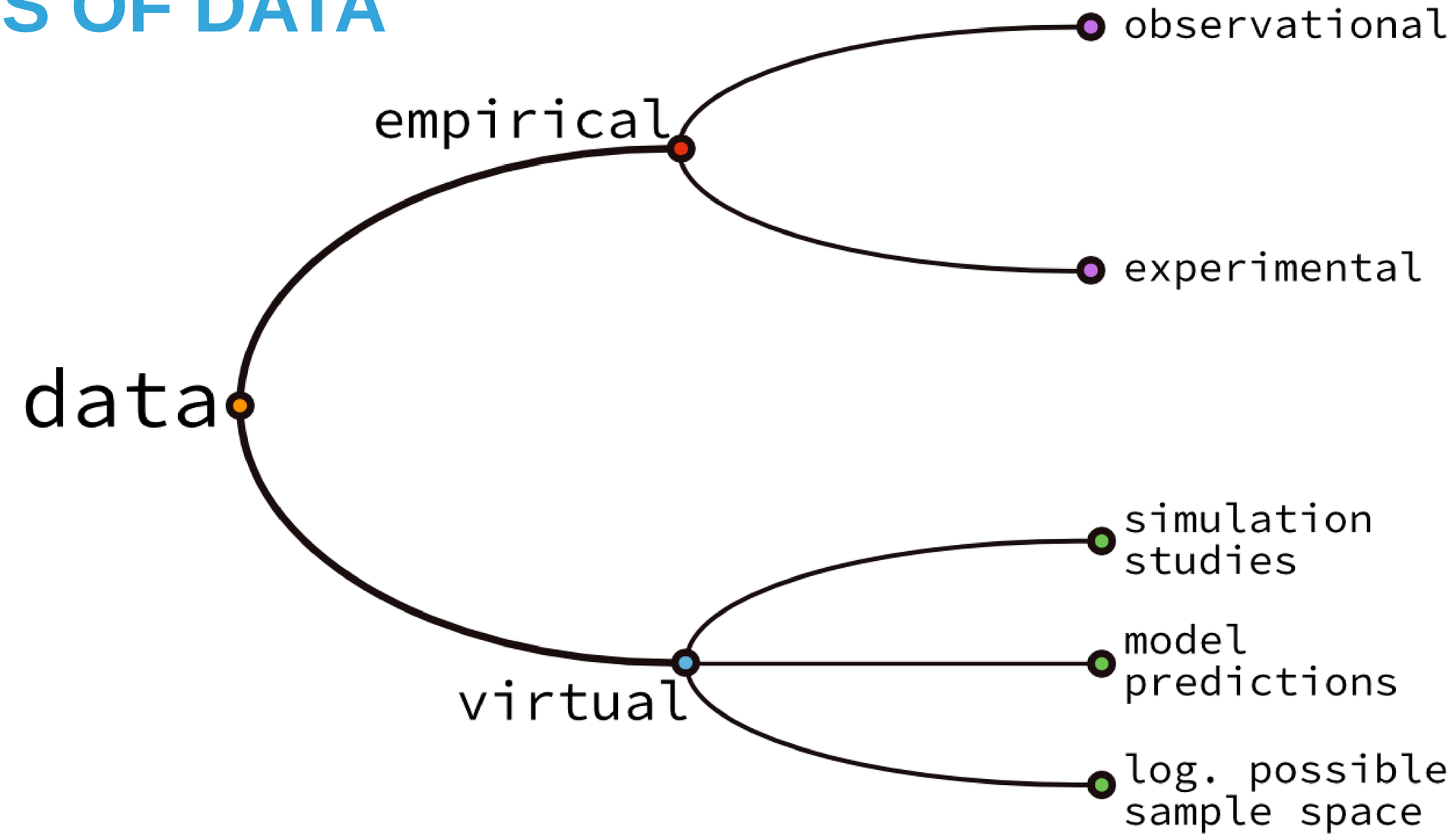
Merriam-Webster®

GOALS OF DATA ANALYSIS

- explanation: understand / find the true relation between variables of interest
  - e.g., causal mechanism or correlation

- prediction: accurately predict hitherto unobserved (e.g., future) data points
  - e.g., for medical image classification (tumor recognition)

KINDS OF DATA



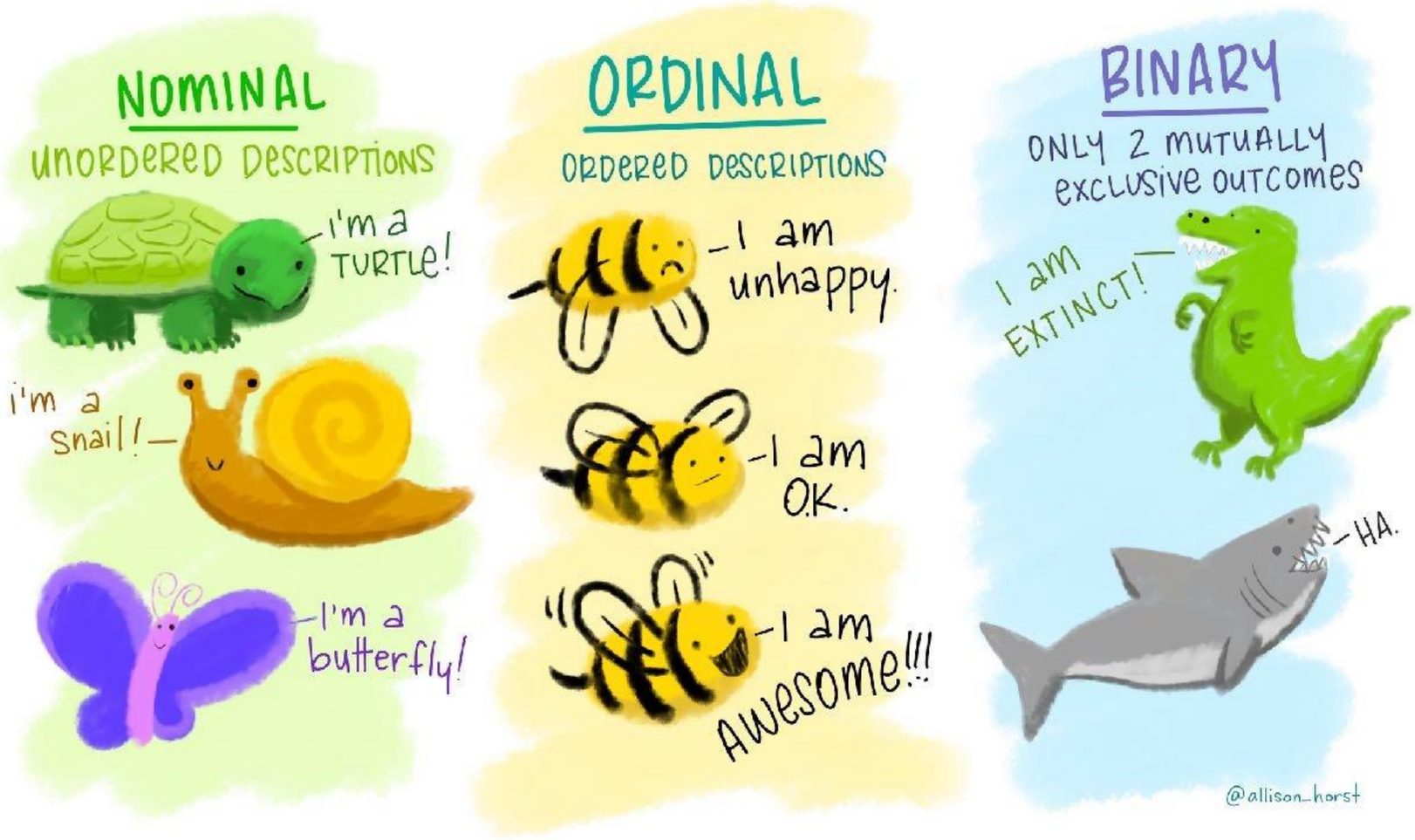
RECTANGULAR DATA

- columns represent variables
- rows are associated observations

```
# proportion of tutorials attended and exam pass/fail
exam_results <-
  tribble(
    ~student,   ~tutorial_proportion,   ~pass,
    "Jax",      0.0,                    TRUE,
    "Jason",    0.78,                   FALSE,
    "Jamie",    0.39,                   TRUE
  )
exam_results
```

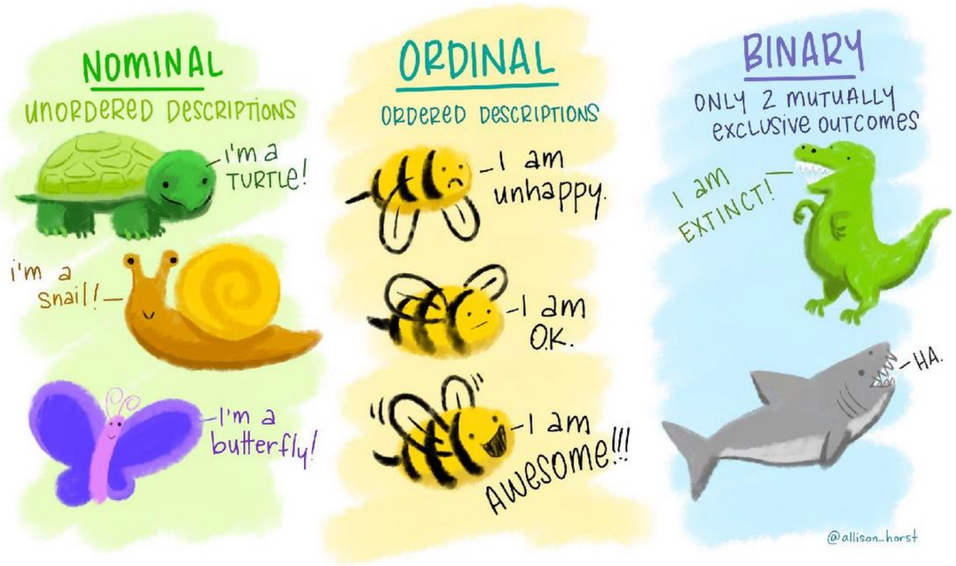
```
## # A tibble: 3 x 3
##   student tutorial_proportion pass
##   <chr>                 <dbl> <lgl>
## 1 Jax                     0    TRUE
## 2 Jason                   0.78 FALSE
## 3 Jamie                   0.39 TRUE
```

KINDS OF VARIABLES



KINDS OF VARIABLES

variable type	representation in R
nominal / binary	unordered factor
Boolean	logical vector
ordinal	ordered factor
metric	numeric vector



- Nominal data are those items which are distinguished by a simple naming system. They are data with **no numeric value**, such as profession. The nominal data just name a thing without applying it to an order related to other numbered items.
- Ordinal data is data which is **placed into some kind of order by their position on the scale**.
- Binary data is **a type of categorical data** in which **there are only two categories**.

- More info: https://www.intellspot.com/nominal-vs-ordinal-data/

DEPENDENT VS INDEPENDENT VARIABLES

- dependent variables represent data we want to explain / predict
  - ◊ dep. variable ≠ what's measured
- independent variables represent data we want to use as explanans/conditional information based on which to make predictions
- distinction is entirely purpose-driven

```
# A tibble: 3 x 3
  maker  price consumption
  <chr>  <dbl>       <dbl>
1 Audi   43900         7.2
2 Volvo  61350         6.8
3 Toyota 34290         5.3
```

It's not possible to say which of these variables has to be (for logical reasons) a dependent or independent variable. That depends on the goal of explanation/prediction.

More info:
https://nces.ed.gov/nceskids/help/user_guide/graph/variables.asp

EXPERIMENTAL DATA

- experimental data typically has:
  - at least one dependent variable
  - at least one independent variable
  - some association of observations between variables

```
tribble(
  ~subj_id,     ~group,        ~systolic,
  1,            "treatment",   118,
  2,            "control",     132,
  3,            "control",     116,
  4,            "treatment",   127,
  5,            "treatment",   122
)
```

```
## # A tibble: 5 x 3
##   subj_id group     systolic
##     <dbl> <chr>        <dbl>
## 1       1 treatment      118
## 2       2 control        132
## 3       3 control        116
## 4       4 treatment      127
## 5       5 treatment      122
```

EXPERIMENTAL DATA

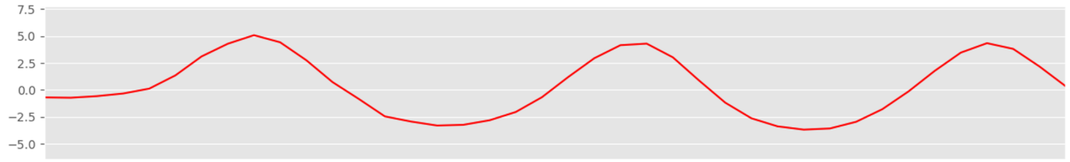
In experimental data, we also distinguish the **dependent variable(s)** from the **independent variable(s)**. The dependent variables are the variables that we do not control or manipulate in the experiment, but the ones that we are curious to record (e.g., whether a patient recovered from an illness within a week). Dependent variables are also called **to-be-explained variables**. The independent variables are the variables in the experiment that we manipulate (e.g., which drug to administer), usually with the intention of seeing a particular effect on the dependent variables. Independent variables are also called **explanatory variables**.

```
tribble(
  ~subj_id,     ~group,        ~systolic,
  1,            "treatment",   118,
  2,            "control",     132,
  3,            "control",     116,
  4,            "treatment",   127,
  5,            "treatment",   122
)
```

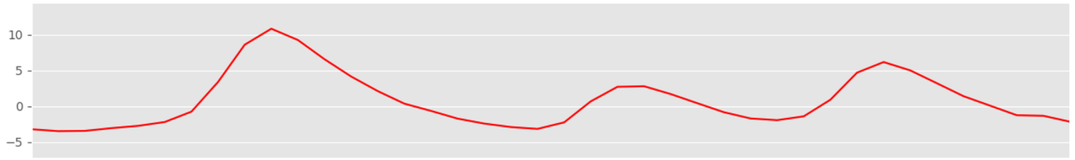
```
## # A tibble: 5 x 3
##   subj_id group     systolic
##     <dbl> <chr>        <dbl>
## 1       1 treatment      118
## 2       2 control        132
## 3       3 control        116
## 4       4 treatment      127
## 5       5 treatment      122
```

WHAT TO ANALYZE?

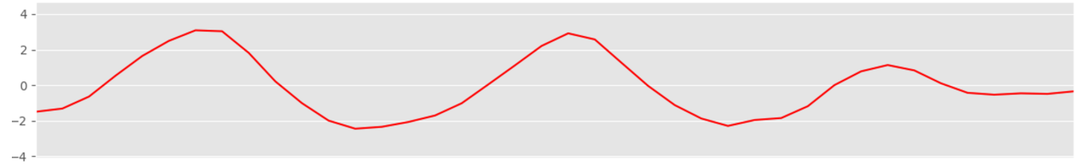
- Dependent variables
  - The dependent variable is (usually) what we plot, analyze and discuss, but very often, we measure much more or something else.



Breath rate of Neutral state



Breath rate of Stress state



Breath rate of Amuse state

FACTORIAL DESIGN

- if all independent variables are at most ordinal in nature, we have a factorial design
- a 2x3 factorial design has:
  - two factors
  - one with two levels
  - another one with three levels
- a 2x3 factorial design has 6=2*3 experimental conditions (= design cells)

```
tribble(
  ~subj_id,     ~group,        ~systolic,
  1,            "treatment",   118,
  2,            "control",     132,
  3,            "control",     116,
  4,            "treatment",   127,
  5,            "treatment",   122
)
```

```
## # A tibble: 5 x 3
##   subj_id group     systolic
##     <dbl> <chr>        <dbl>
## 1       1 treatment      118
## 2       2 control        132
## 3       3 control        116
## 4       4 treatment      127
## 5       5 treatment      122
```

WITHIN-& BETWEEN-SUBJECTS DESIGNS

- within-subjects design: every participant contributes at least one observation to each experimental condition

- between-subjects design: not every participant contributes data to each experimental condition

```
tribble(
  ~subj_id,     ~group,        ~systolic,
  1,            "treatment",   118,
  2,            "control",     132,
  3,            "control",     116,
  4,            "treatment",   127,
  5,            "treatment",   122
)
```

```
## # A tibble: 5 x 3
##   subj_id group     systolic
##     <dbl> <chr>        <dbl>
## 1       1 treatment      118
## 2       2 control        132
## 3       3 control        116
## 4       4 treatment      127
## 5       5 treatment      122
```

WITHIN-& BETWEEN-SUBJECTS DESIGNS

- within-subjects design: every participant contributes at least one observation to each experimental condition

- between-subjects design: not every participant contributes data to each experimental condition

```
tribble(
  ~subj_id,     ~group,        ~systolic,
  1,            "treatment",   118,
  2,            "control",     132,
  3,            "control",     116,
  4,            "treatment",   127,
  5,            "treatment",   122
)
```

Example of a between-subject design.

Different designs have different pro's and cons's

between-subjects	within-subjects
no confound between conditions	possible cross-contamination between conditions
more participants needed	fewer participants needed
less associated information for analysis	more associated data for analysis

REPEATED MEASURES

- single-shot experiment: every participant contributes exactly one data point to exactly one experimental condition
- repeated measures: every participants contributes more than one observation to at least one experimental condition
  - repetition can lead to data contamination
  - calls for fillers, randomization and item variability

```
tribble(
  ~subj_id,     ~group,         ~systolic,
  1,            "treatment",    118,
  2,            "control",      132,
  3,            "control",      116,
  4,            "treatment",    127,
  5,            "treatment",    122
)
```

This is a single-shot experiment.

TYPES OF TRIALS

- critical: belongs to an experimental condition.
- filler: used to introduce variance, disguise experimental purpose, avoid repetition etc.
- control: used to check whether participants paid attention, understood the task, etc.

SAMPLE SIZE

- how many observations does a study need for each experimental condition?

- answer depends on goals of statistical analysis
  - power-calculation, error control, etc.