PLSC 502 – Autumn 2022
Data: Structure, Measurement, and Management

September 1, 2022

Measurement

Measurement

The quantification of characteristics of a unit, for purposes of comparison.

Importance of:

1. Theory
2. Context
3. Precision

In general:

Conceptualization → *Operationalization* → *Measurement*

Measures: Desiderata

Validity

- Construct Validity
- Content Validity
- Criterion Validity
- Face Validity

Reliability

- Test-Retest Reliability ("time")
- Interrater Reliability ("space")
- Internal Consistency ("tools")
- Parallel Forms (also "tools")

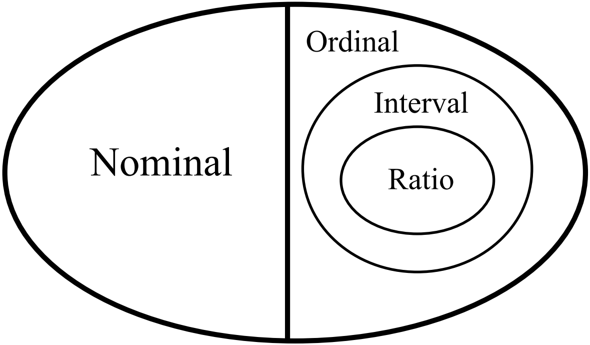
Levels of Measurement

- Nominal (classification)
- Ordinal (order)
- Interval (equal intervals)
- Ratio ("true zero")

In terms of information:

$$\textit{Ratio} \geq \textit{Interval} \geq \textit{Ordinal} \geq \textit{Nominal}$$

Levels of Measurement (continued)



Discrete vs. Continuous Indicators

Consider a variable $X \in [a, b]$...

For Continuous X

- X can take on *any* value within the range from a to b
- Number of possible values is (theoretically) infinite
- Formally, $\Pr(X = x) = 0 \ \forall \ x$...
- In general, X is defined over all values from a to b
- *In practice*, the number of possible values X can take on is limited by the precision of the measurement tool

For Discrete X

- X can take on a *finite* or *countably infinite* number of values S between a and b
- $\Pr(X = x) > 0 \ \forall \ x \in S$, or 0 otherwise
- That means that $\sum\limits_{x \in S} \Pr(X = x) = 1$

Examples of Measures

Examples of Measures, by Type and Level of Measurement

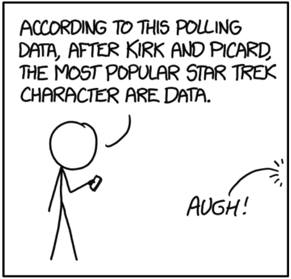
Level of Measurement	Discrete	Continuous
Nominal	{Heels, Boots, Sneakers}	n/a
Ordinal	Social Class (Upper, middle, lower)	(certain rankings)
Interval	Year	Temperature, degrees F
Ratio	Counts of things	Height, weight, distance, etc.

The Key Point About Measurement

"...measurement is always a theory about one's observations. In other words, measurement constitutes a proposition about the ways that numerical scores reflect substantively interesting properties of data... No measurement whatsoever is "natural," "pre-ordained," or exists prior to/apart from human interpretation."

– Jacoby (1999, 272-273)

Data


ACCORDING TO THIS POLLING DATA, AFTER KIRK AND PICARD, THE MOST POPULAR STAR TREK CHARACTER ARE DATA.
AUGH!

ANNOY GRAMMAR PEDANTS ON ALL SIDES BY MAKING "DATA" SINGULAR *EXCEPT* WHEN REFERRING TO THE ANDROID.

Rectangular Data

Organization:

i	X_1	X_2	...	X_K
1	X_{11}	X_{21}	...	X_{K1}
2	X_{12}	X_{22}	...	X_{K2}
3	X_{13}	X_{23}	...	X_{K3}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
N	X_{1N}	X_{2N}	...	X_{KN}

with indices:

$$i \in \{1, 2, 3, ...N\} \text{ (for units / rows)}$$

$$k \in \{1, 2, 3, ...K\} \text{ (for variables / columns)}$$

Dimensions of Variation

Data can vary...

- ... cross-sectionally:
  - Each line of data is an observation on a unique unit of observation
  - Data represent a single point in time (or unit of time)
  - Example: A single cross-sectional survey of public opinion
- ... temporally:
  - Each line of data is an observation on a unique unit of observation
  - Data represent a single point in time (or unit of time)
  - Example: Monthly / annual public mood data for the U.S.
- ... relationally:
  - Each line of data is a “connection” between two or more units of observation
  - Data represent characteristics of the relationship between those two or more units
- Any / all of the above simultaneously...

Cross-Sectional Data: 1997 Baseball Survey

```
> select<-c("respon","age","female","followbaseball","DH_appr")
> head(DH[select],8)

  respon age female followbaseball DH_appr
1      1  65 Female              0      NA
2      2  63   Male              1       1
3      3  56 Female              1      NA
4      4  24 Female              0      NA
5      5  47   Male              0      NA
6      6  81 Female              1      NA
7      7  28   Male              1       1
8      8  76   Male              1       0
```

Time Series Data: SCOTUS Clerks

```
> select<-c("Term","female","white","top5law","lcclerk")
> head(Clerks[select],15)

   Term female  white top5law lcclerk
1  1953  0.000 100.00   44.44  12.500
2  1954  0.000 100.00   64.71  44.444
3  1955  0.000 100.00   76.47  41.667
4  1956  0.000 100.00   55.56  20.000
5  1957  0.000 100.00   58.82  30.000
6  1958  0.000 100.00   57.89  27.273
7  1959  0.000 100.00   61.11  44.444
8  1960  0.000 100.00   66.67   7.143
9  1961  0.000 100.00   55.56  21.429
10 1962  0.000 100.00   71.43  21.429
11 1963  0.000 100.00   78.95  25.000
12 1964  0.000 100.00   62.50   8.333
13 1965  0.000 100.00   70.00  43.750
14 1966  5.882 100.00   52.94  33.333
15 1967  0.000  95.24   66.67  44.444
```

Panel/TSCS Data

Organization:

$$X_{it} \in X = \begin{pmatrix} X_{11} \\ X_{12} \\ \vdots \\ X_{1T} \\ X_{21} \\ X_{22} \\ \vdots \\ X_{NT-1} \\ X_{NT} \end{pmatrix}$$

... with $i \in \{1, 2, 3, ...N\}$ indexing units and $t \in \{1, 2, 3, ...T\}$ indexing time points.

Panel/TSCS Data: Countries, 1946-2000

```
> select<-c("country","ccode","year","gdppc","polity","region","coldwar")
> Panel<-Panel[order(Panel$ccode,Panel$year),] # sort
> Panel[1:200,select]
     country ccode year     gdppc polity region coldwar
9664      US     2 1946        NA     10      1       1
9665      US     2 1947        NA     10      1       1
9666      US     2 1948        NA     10      1       1
9667      US     2 1949        NA     10      1       1
9668      US     2 1950  1915.000     10      1       1
9669      US     2 1951  2196.000     10      1       1
9670      US     2 1952  2300.000     10      1       1
.
.
.
9706      US     2 1988 20848.000     10      1       1
9707      US     2 1989 22192.000     10      1       1
9708      US     2 1990 23218.000     10      1       0
9709      US     2 1991 23639.000     10      1       0
.
.
.
9715      US     2 1997 30468.000     10      1       0
9716      US     2 1998 31776.000     10      1       0
9717      US     2 1999        NA     10      1       0
2676             2 2000        NA     10      1       0
3886  CANADA    20 1946        NA     10      1       1
3887  CANADA    20 1947        NA     10      1       1
3888  CANADA    20 1948        NA     10      1       1
3889  CANADA    20 1949        NA     10      1       1
3890  CANADA    20 1950  1544.000     10      1       1
3891  CANADA    20 1951  1717.000     10      1       1
```

Relational Data

Organization is into pairs / “dyads”:

- Data are indexed as X_{ij}, where
- $i \in \{1, 2, 3, ...N\}$ indexes the “first” unit and
- $j \in \{1, 2, 3, ...N\}$ indexes the “second” unit in each “dyad.”

For N units, there are:

$$\frac{N(N-1)}{2} \text{ possible non-directed pairs (“dyads”)}$$

and

$$N(N-1) \text{ directed pairs (possible “directed dyads”)}$$

Note: “Unbalanced” relational data are also possible (with $i \in \{1, 2, ...N\}$ and $j \in \{1, 2, ...M\}$, $M \neq N$)

Relational Data (continued)

Organization (non-directed dyads):

$$X_{ij} \in X = \begin{pmatrix} X_{12} \\ X_{13} \\ \vdots \\ X_{1N} \\ X_{23} \\ X_{24} \\ \vdots \\ X_{2N} \\ X_{34} \\ X_{35} \\ \vdots \\ X_{N-2,N-1} \\ X_{N-2,N} \\ X_{N-1,N} \end{pmatrix}$$

Relational Data: Country “Dyads” (1968)

```
> select<-c("ccode1","ccode2","dyadid","dem1","dem2","allies","distance")
> Dyads[1:300,select]
    ccode1 ccode2 dyadid dem1 dem2 allies distance
1        2     20   2020   10   10      1        0
2        2     40   2040   10   -7      0     1135
3        2     41   2041   10   -9      1     1437
4        2     42   2042   10   -3      1     1477
5        2     51   2051   10   10      0     1446
6        2     52   2052   10    8      1     2176
.
.
.
126      2    840   2840   10    5      1     8570
127      2    850   2850   10   -7      0    10172
128      2    900   2900   10   10      1     9916
129      2    920   2920   10   10      1     8759
130     20     40  20040   10   -7      0     1586
131     20     41  20041   10   -9      0     1869
132     20     42  20042   10   -3      0     1893
133     20     51  20051   10   10      0     1897
134     20     52  20052   10    8      0     2547
135     20     53  20053   10   NA      0     2426
.
.
.
259     20    900  20900   10   10      0    10019
260     20    920  20920   10   10      0     9009
261     40     41  40041   -7   -9      0      722
262     40     42  40042   -7   -3      0      868
263     40     51  40051   -7   10      0      506
.
.
.
```

Other Data Formats: JSON

JSON (JavaScript Object Notation)

- Lightweight, simple, self-describing
- Fields can contain *strings*, *numbers*, *JSON objects*, *arrays*, *Booleans*, or be *null* (empty)
- Widely used in CS + IT; common format for (e.g.) data from APIs
- *In general*, should be converted to rectangular form for analysis

Tabular vs. JSON Formats

Tabular data:

```
> df

id        guitar  pickups
 1  Stratocaster        3
 2      Les Paul        2
 3    Telecaster        2
```

Same data, JSON format:

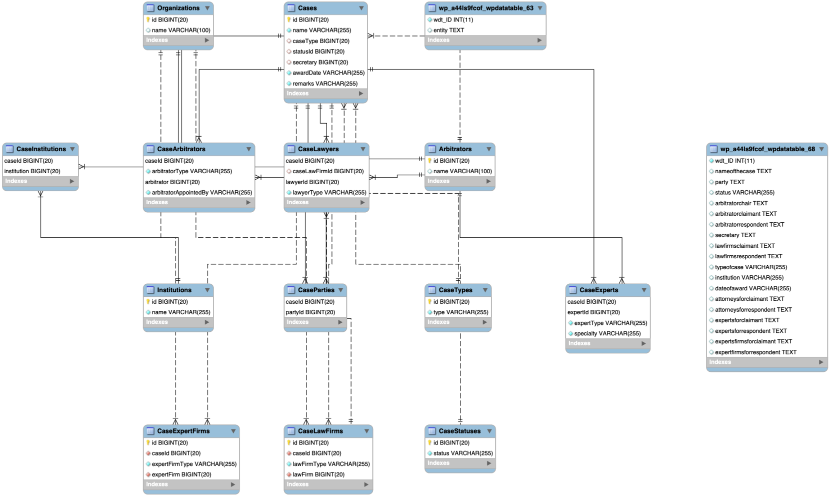
```
> df.JSON<-toJSON(df)
> df.JSON

[1] "{\"id\":[1,2,3],\"guitar\":[\"Stratocaster\",\"Les Paul\",\"Telecaster\"],\"pickups\":[3,2,2]}"
```

Other Data Formats: SQL

SQL (Structured Query Language)

- Pronounced *ess-kyew-ell* or sometimes *see-quill*
- Format for *(relational) databases*
- *De facto* standard database format in CS; applications include MySQL, SQL Server, Oracle, MS Access, PostgreSQL...
- Comprised of rectangular *tables* / arrays of data, that are *related* to each other via *indices* (identifiers)
- Generally one *extracts* tables from SQL databases to analyze them statistically using R...

SQL Example



Organizations
id BIGINT(20)
name VARCHAR(100)
Indexes

Cases
id BIGINT(20)
name VARCHAR(255)
caseType BIGINT(20)
statusId BIGINT(20)
secretary BIGINT(20)
awardDate VARCHAR(255)
remarks VARCHAR(255)
Indexes

wp_a44ls9fcof_wpdatatable_63
wdt_ID INT(11)
entity TEXT
Indexes

CaseInstitutions
caseId BIGINT(20)
institution BIGINT(20)
Indexes

CaseArbitrators
caseId BIGINT(20)
arbitratorType VARCHAR(255)
arbitrator BIGINT(20)
arbitratorAppointedBy VARCHAR(255)
Indexes

CaseLawyers
caseId BIGINT(20)
caseLawFirmId BIGINT(20)
lawyerId BIGINT(20)
lawyerType VARCHAR(255)
Indexes

Arbitrators
id BIGINT(20)
name VARCHAR(100)
Indexes

wp_a44ls9fcof_wpdatatable_68
wdt_ID INT(11)
nameofthecase TEXT
party TEXT
status VARCHAR(255)
arbitratorchair TEXT
arbitratorclaimant TEXT
arbitratorrespondent TEXT
secretary TEXT
lawfirmsclaimant TEXT
lawfirmsrespondent TEXT
typeofcase VARCHAR(255)
institution VARCHAR(255)
dateofaward VARCHAR(255)
attorneysforclaimant TEXT
attorneysforrespondent TEXT
expertsforclaimant TEXT
expertsforrespondent TEXT
expertsfirmsforclaimant TEXT
expertfirmsforrespondent TEXT
Indexes

Institutions
id BIGINT(20)
name VARCHAR(255)
Indexes

CaseParties
caseId BIGINT(20)
partyId BIGINT(20)
Indexes

CaseTypes
id BIGINT(20)
type VARCHAR(255)
Indexes

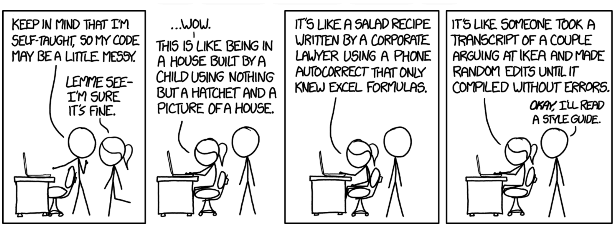
CaseExperts
caseId BIGINT(20)
expertId BIGINT(20)
expertType VARCHAR(255)
specialty VARCHAR(255)
Indexes

CaseExpertFirms
id BIGINT(20)
caseId BIGINT(20)
expertFirmType VARCHAR(255)
expertFirm BIGINT(20)
Indexes

CaseLawFirms
id BIGINT(20)
caseId BIGINT(20)
lawFirmType VARCHAR(255)
lawFirm BIGINT(20)
Indexes

CaseStatuses
id BIGINT(20)
status VARCHAR(255)
Indexes

Data Management


KEEP IN MIND THAT I'M SELF-TAUGHT, SO MY CODE MAY BE A LITTLE MESSY.
LEMME SEE– I'M SURE IT'S FINE.
...WOW.
THIS IS LIKE BEING IN A HOUSE BUILT BY A CHILD USING NOTHING BUT A HATCHET AND A PICTURE OF A HOUSE.
IT'S LIKE A SALAD RECIPE WRITTEN BY A CORPORATE LAWYER USING A PHONE AUTOCORRECT THAT ONLY KNEW EXCEL FORMULAS.
IT'S LIKE SOMEONE TOOK A TRANSCRIPT OF A COUPLE ARGUING AT IKEA AND MADE RANDOM EDITS UNTIL IT COMPILED WITHOUT ERRORS.
OKAY, I'LL READ A STYLE GUIDE.

Where Do Data Come From?

Sources:

- Researcher-collected (i.e., *you*...)
- Governments / sovereigns...
- Non-profit organizations (including universities...)
- Business and the private sector:
  - Free / online / etc.
  - Data vendors
  - Disclosed data
- Private individuals
- *Aggregations* of multiple sources...
- "Data exhaust"

Getting Data: The R Version

Options:

1. You can enter data into R/RStudio *by hand* (but you'd rather not).

2. You can read data from a *local file*. For example, in standard `.csv` format:
    - values in each row separated by commas,
    - rows separated by line breaks, and
    - a single row with comma-separated variable names at the top

   E.g.:

```
> DF <- read_csv("Data/SCOTUS-votes.csv")
```

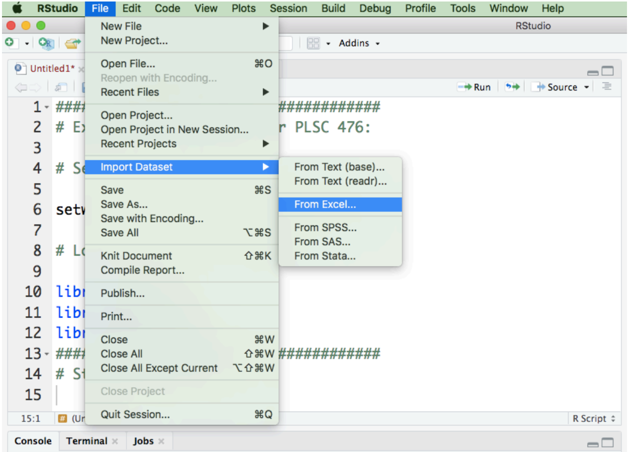
Getting Data (continued)

3. You can read a `.csv` (or, for that matter, a `.xls`, or other format file) directly from the web, via the file's URL, using routines in the `readr` package:

```
> install.packages("readr")
> library(readr)
> MQScores <- read_csv("http://mqscores.lsa.umich.edu/media/2020/justices.csv")
```

Getting Data (continued)

4. In RStudio, you can read data interactively, via “File → Import Dataset”



Getting Data (continued)

5. You can import data dynamically via RESTful (and other) APIs...
    - Simplest via the `httr` and `jsonlite` packages
    - Usually requires knowledge of JSON-formatted data
    - A basic tutorial is here.

Summary:

Data Formats and Packages

Format	Useful Command(s) / Package(s)
Plain text (`.txt`, etc.)	`read.table`, `readr`
Comma-separated (`.csv`)	`read_csv`, `read.csv`
Excel (`.xls`, etc.)	`readxl`, `xlsx`
SPSS (`.sav`, etc.)	`haven`, `foreign`
Stata (`.dta`)	`haven`, `foreign`
SAS (`.ssd`, etc.)	`haven`, `foreign`
JSON (`.json`)	`jsonlite`
Databases (`.adb`, `.sql`, etc.)	`DBI`, `odbc`

Missing Data

Why?

- Observation doesn't exist
- Data don't exist for that observation
- Data exist, but are *impossible* to measure
- Data exist, but were not measured

Three types:

- Missing completely at random ("MCAR") – easy to deal with
- Missing at random ("MAR") – harder to deal with
- Informatively (or "non-ignorably") missing – *very* hard to deal with

Missing Data: What To Do?

- Listwise deletion / “complete cases analysis”
- Interpolation / replacement values
- *Imputation*-based approaches

Things We Do With Data[1]

Inter alia:

- *Sort* data (by values in one or more columns)
- *Add* rows / columns
- *Remove* / *subset* rows / columns
- *Combine* rows / columns (*aggregation*)
- *Separate* rows / columns (*disaggregation*)
- *Transform* rows / columns (including recoding, handling missingness, etc.)
- *Reshaping* data ("wide" vs. "long" formats)
- *Merging* (a/k/a "joining": 1-to-1, 1-to-many, many-to-1, many-to-many, "inner," "outer," "left" / "right," etc.)

[1] That Aren't Statistics Or Graphics

General Data Tips

- **Use descriptive variable names**.
  - Spell it out.
  - Use "directional" names.
- **Be consistent in naming variables**.
- **Label everything**.
- **Never overwrite anything you can't recreate**.
- **Make everything recreateable**.
- **Annotate your code**.
- **Write reproducible code**.

Reproducible Code

3 Rs: Readable, reusable, robust.

What does that mean?

- Pull data directly from the source whenever possible.
- Query for packages, and install as necessary.
- Use `set.seed()` when conducting simulations (and use a consistent seed).
- Annotate code to clarify purpose and content.
- Use line breaks and whitespace strategically for clarity.
- Strongly consider consulting a *style guide*.

For more, see (e.g.) here.

Reproducible Code: Example

From PLSC502-DayTwo-2022.R:

```
>#-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=
># PLSC 502 -- Fall 2022
.
.
.
> library(readr)
>
> # DH data:
>
> DH<-as.data.frame(read_csv("https://raw.githubusercontent.com/PrisonRodeo/
>                             PLSC502-2022-git/master/Data/DH.csv"))
>
> select<-c("respon","age","female","followbaseball","DH_appr") # select variables
> head(DH[select],8)  # prints the first 8 lines + 5 variables of DH
.
.
.
```