Levels of Measurement

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Basic Math Review

- For statistics you need to know some basic math, including decimals, fractions and mixed numbers, percents, and signed numbers.
- Decimals
  - Rounding: look at the number to the right of the place to which you are rounding.
  - If the number is 5 or greater, round up.
  - If the number is less than 5, round down.

Basic Math Review

Fractions and Mixed Numbers

- The top number is the numerator, the bottom number is the denominator (4/5)
- Make sure fractions are reduced (find a number that can be divided evenly into both the numerator and denominator)
  - 6/12 can be reduced to 1/2
- A mixed number is when there is a whole number and a fraction:
  - $23/7 = 3\ 2/7$
- To add or subtract fractions you have to have the same denominator.

Basic Math Review

Percents

- Percents are ways to represent a part of something where the whole is 100%.
- To find what percent a part is of the whole, you divide the part by the whole and then transform that decimal (called the proportion) into a percent by multiplying by 100.
- Example: What percent of 40 is 4?
  - $4/40 = 0.10 * 100 = 10\%$.

Basic Math Review

- Signed Numbers
  - Numbers can be either positive or negative
- A positive number + a positive number = a positive number
  - 10 + 10 = 20
- A negative number + a negative number = a negative number
  - -10 + -10 = -20
- With a positive number + a negative number the result takes the sign of the larger number
  - 10 + -13 = -3

Basic Math Review

- A negative number - a positive number = a negative number
  - -5 - -10 = -15
- A positive number - a negative number = a positive number
  - 12 - -6 = 18
- When subtracting a negative number, it is the same a s adding a positive number
  - 10 - -5 = 15

R, GNU Emacs, and ESS

- R is a statistical programming language used to analyze data.
- GNU Emacs is the best way to interact with R.
- ESS stands for Emacs Speaks Statistics (it is what allows Emacs to talk to R)

Variables

- Characteristics that change from person to person or object to object in a population of interest
- Variables can take different values or levels
- They are called variables because they vary between cases

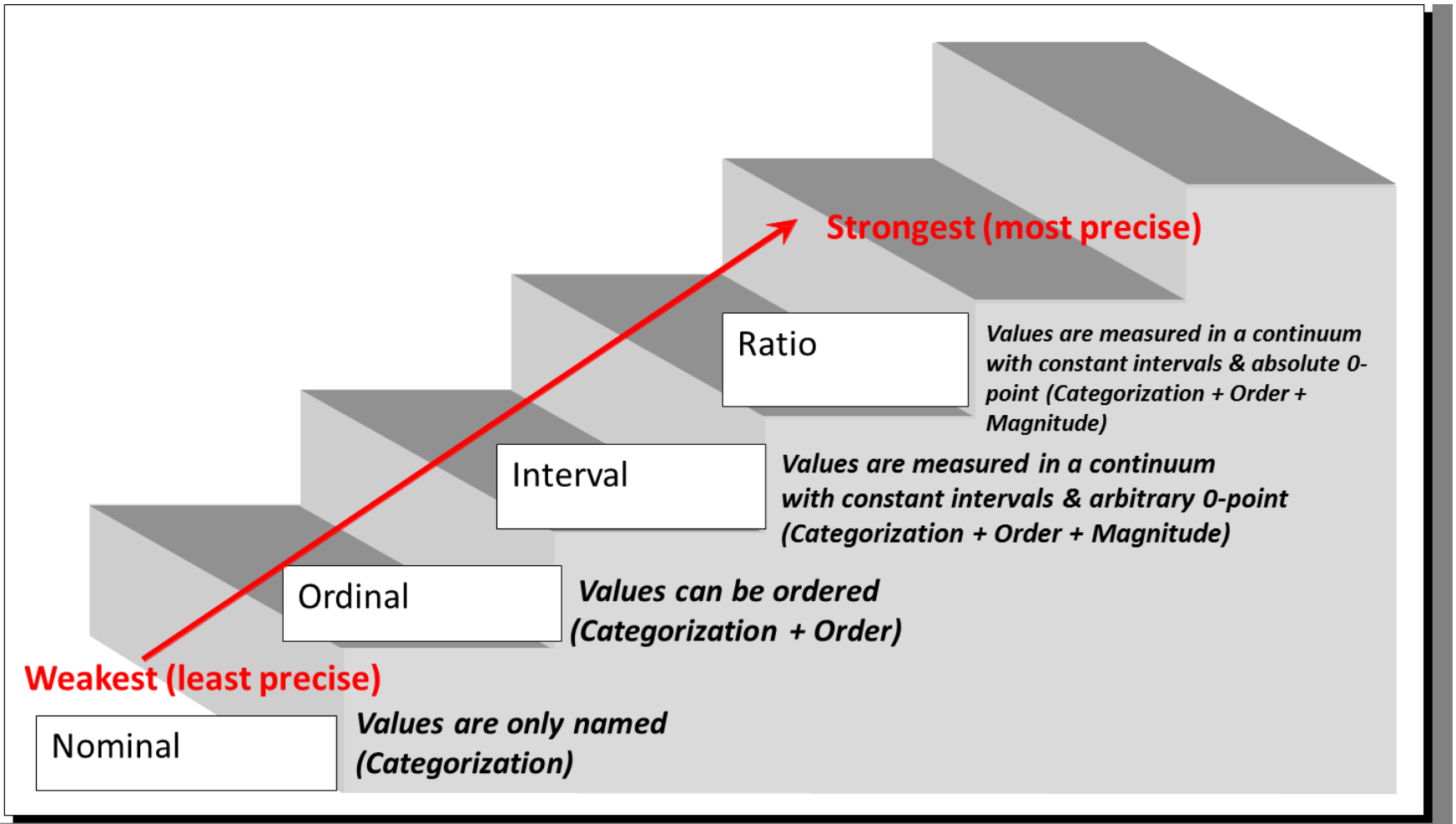
Variable	Levels/ Values
Gender	Male and Female
Race	White, Black, Asian, etc
Age	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10……etc.
Depression	Yes/ No OR 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10……etc.
I love statistics	1=Strongly Disagree; 2=Disagree; 3=Agree; 4=Strongly Agree

Levels of Measurement

- Each variable has a level of measurement.
- The level of measurement is important because it determines the type of analysis.
- There are four levels of measurement
  1. Nominal
  2. Ordinal
  3. Interval
  4. Ratio
- Nominal and Ordinal are categorical
- Interval and Ratio are scale
- The differences among the levels of measurement are the amount of information that they contain.

Hierarchy of Measurement Levels

A higher level of measurement has all the characteristics of the lower level(s) and more.



Nominal Variables

- The word nominal means “names”.
  - A nominal variable ONLY describes something
  - The only function is to label and categorize
  - NO INHERENT NUMERIC QUANTITY, NO Ranking of levels or ordering scheme
- Numbers can be nominal level if there is no quantity associated with them.
- Categories should be distinct, mutually exclusive, and completely exhaustive

Nominal Variables

Examples:

- Sex (Male or Female)
- Ethnicity (Asian, Black, White, Hispanic)
- Religious Affiliation (Lutheran, Baptist, Jewish, Catholic)
- Political Affiliation (Liberal, Republican, Democrat)
- Phone Number
- Social Security Number
- Police Precinct Number

Ordinal Variables

- Ordinal variables have the characteristics of a nominal variable PLUS
  - a series of rank: one level is ranked above or below another (ordered)
  - It has a set of levels that are organized in an ordered sequence
  - The "Ord" in ordinal level of measurement stands for order
- The exact amount of difference between levels is unknown
  - We only know that one level is greater than another, not by how much

Ordinal Variables

Examples

- What is your rating for the customer service in a restaurant? (Variable)
  - 1=Very Unsatisfied 2=Unsatisfied 3=Satisfied 4=Very Satisfied (Levels) or
  - 1=Poor 2=Fair 3=Good 4=Excellent (Levels)
- Letter grade (Variable)
  - 1=A 2=B 3=C 4=D 5=F (Levels)
- Status at Job (Variable)
  - 1=Manager 2=Director of Operations 3=CEO 4=President (Levels)
- Class Year at John Jay (Variable)
  - 1=Freshman 2=Sophomore 3=Junior 4=Senior (Levels)
- Age (Variable)
  - 1=29 or younger 2=30-39 3=40-49 4=50 or over (Levels)

Interval Variables

Interval Variables have the characteristics of an Ordinal Level PLUS exact inherently numeric values.

- It is NOW possible to determine the size and not just the direction of the difference between two measurements or observations in the variables.
- We can talk about **how much more or less** one value is than another value
- **Example:**
  - A measurement of 80 degrees Fahrenheit is exactly 20 degrees higher than a measure of 60 degrees.
  - It is possible to determine not only that one is higher or lower, but by exactly how much.

Interval Variables

- Interval variables consist of a series of ordered values with equal intervals between the values.
- There is the same amount of difference between any two consecutive values.
- Interval variables are scale
- With interval variables, we can determine the direction and size of the difference between two observations.

Interval Variables

Interval variables have an arbitrary zero (0).

- This means that the value of zero (0) has no inherent meaning.
- Zero is just used as a reference on the scale.
- Example: In temperature, a value of Zero does not mean there is no temperature; it is simply a value on the scale of temperature.
- The value of the interval variable could be negative.

Ratio Variables

- Ratio variables are the same as interval variables, except they have a true Zero (0) point.
- The value of Zero in the variable has meaning
- There can be no negative values for ratio level variables
- Example: Number of Children one has
- With ratio level variables one can tell direction, size of the difference between two observations, and also a true zero point.

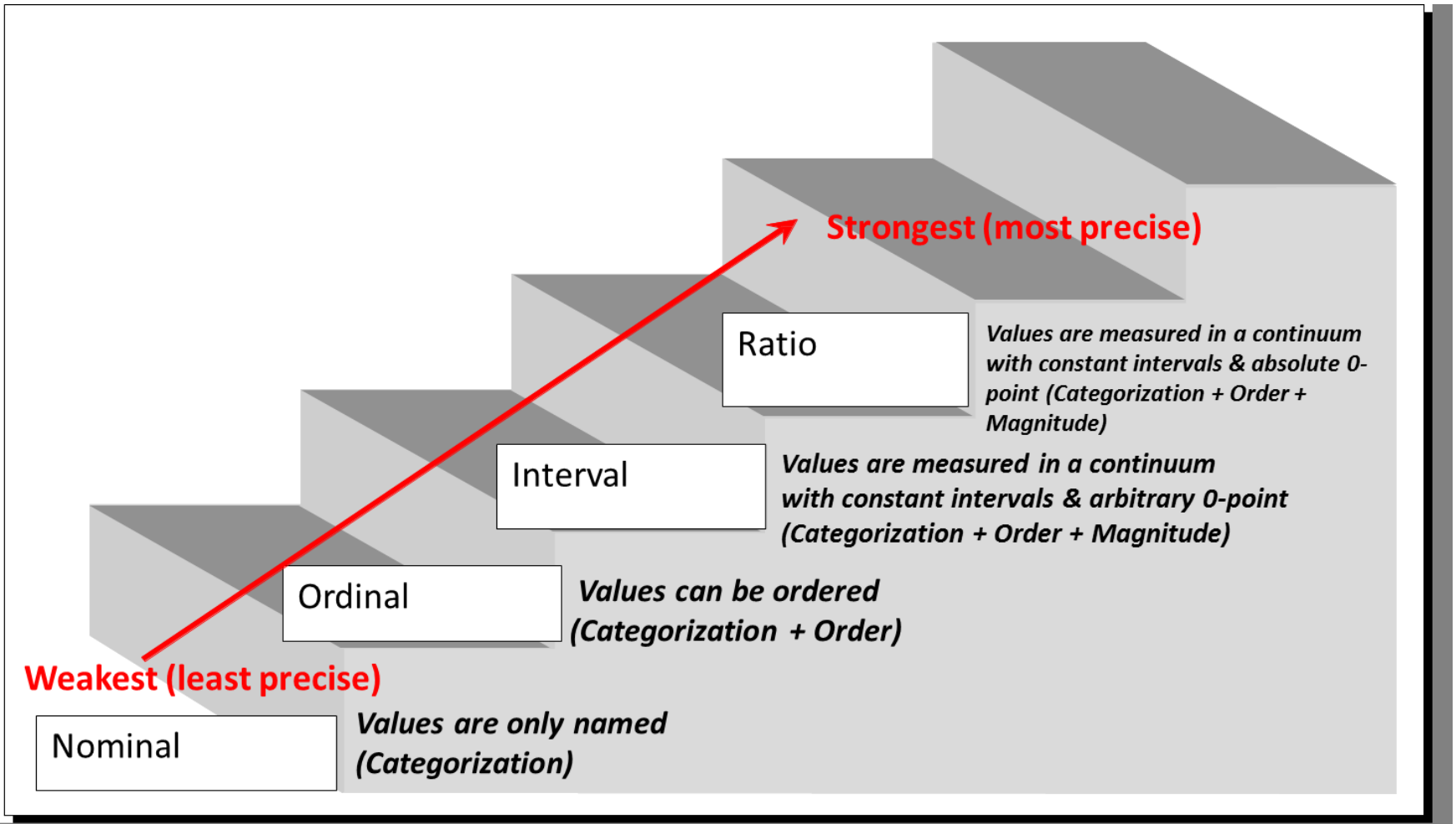
Interval & Ratio Variables

Examples:

- Age: Values would be respondent's exact age.
- Income: Value would be the person's exact income.
- Number of prior arrests: Values would be the number of times the respondent was arrested before.
- Commute time: Values would be the respondent's exact commute time to John Jay.

Hierarchy of Measurement Levels

A higher level of measurement has all the characteristics of the lower level(s) plus more information



Determining the Level of Measurement

Properly identifying a variable's level of measurement is a vital part of the research process.

1. **Determine if data can be ordered**
   - If no, Nominal
   - If yes, next question
2. **Determine if there are equal intervals**
   - If no, Ordinal
   - If yes, next question
3. **Determine if there is a true zero**
   - If no, Interval
   - If yes, Ratio

Scale of Measurement

- In addition to having levels, variables also have a scale
- Scales can be (1) Continuous or (2) Discrete
  - **Continuous scales:** have an infinite number of fractions between them
  - Example: your income this year
  - **Discrete scales:** are limited to whole numbers; there are no fractions or decimals
  - Example: the number of siblings that you have.

Types of Variables

- Almost all studies have two types of variables:
  1. Independent Variable(s) (X)
  2. Dependent variable (Y)
- DO NOT CONFUSE LEVEL OF MEASUREMENT OR SCALE OF A VARIABLE WITH THE INDEPENDENT OR DEPENDENT VARIABLE CONCEPT.
- THEY ARE SEPARATE CONCEPTS
- Variables will have:
  1. A Level of Measurement
  2. A Scale
  3. Be used as an Independent or Dependent Variable

Independent Variables

- The independent variable (X) is presumed to "cause" the change in another variable (the dependent (Y) variable).
  - This does not actually mean "causation".
  - There are three criteria to determine causation.
    1. Temporal Proximity
    2. Co-variation
    3. Non-spuriousness
  - Most analyses just determine that there is a relationship.
- Another name for the X variable is the explanatory variable
  - Variable that is used to explain the change of the dependent variable based on theory

Dependent Variables

- The dependent variable (Y) is also called the outcome variable
- It is the variable in which researchers are most interested
- The dependent variable is observed so that we can assess if any change has occurred due to the influence of the independent variable
- The change of the dependent variable is assumed to depend on or be "caused" by the independent variable

Independent and Dependent Variables

- Any given variable can be treated as an independent variable in one part of the analysis and a dependent variable in another part of the analysis or study
- If we find that religiosity is affected by a person's sex: perhaps women are more religious than men
  - Sex would be the IV (X) and Religiosity would be the DV (Y)
- However, in another study, Religiosity can be treated as an independent variable (X) in explaining the dependent variable (Y) crime rates.
  - Perhaps crime rates are affected by religiosity. Those who are religious tend to commit less crime.
  - Religiosity is the IV (X) and Crime rate is the DV (Y)

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    - IV: Number of prior arrests
    - DV: Sentence Length

Validity and Reliability

- Validity: Addresses the question of whether the variable used actually reflects the concept or theory you seek to examine.
- Reliability: Addresses the question of whether a measure is stable and consistent.
  - Stability is if a measure is reliable over time with the same group.
  - Consistency is if a measure is reliable across different groups.

Summary

- Variables are important because they are the object of examination.
- Measurement and levels of measurement play a key role in statistical analysis
- Level of measurement determines type of analysis
- Different roles of variables determine how they will be examined.