CS-525V: Building Effective Virtual Worlds

Evaluation

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Measuring Effectiveness

- How do we know if our world/technique/ application/etc. is effective?
- Is this a binary thing?
- Why measure this?
- How can we measure?

Qualitative vs. Quantitative

- Qualitative
  - Look at the data, and draw conclusions
- Quantitative
  - Form a hypothesis, and try to prove it
- Both are effective, Quantitative is less time consuming to do

Objective vs. Subjective Measures

- Objective
  - Measure using performance metrics
  - Speed, accuracy, etc.
- Subjective
  - Measure using questionnaires, interviews, etc.
- These can either be gathered using quantitative or qualitative means

Descriptive Methods

- Frequency distributions
  - How many people were similar in the sense that according to the dependent variable, they ended up in the same bin
  - Table
  - histogram (vs. bar graph)
  - Frequency polygon
  - Pie chart

Descriptive Methods (cont.)

- Distributional shape
  - Normal distribution (bell curve)
  - Skewed distribution
    - Positively skewed (pointing high)
    - Negatively skewed (pointing low)
  - Multimodal (bimodal)
  - Rectangular
  - Kurtosis
    - High peak/thin tails (leptokurtic)
    - Low peak/thick tails (platykurtic)

Descriptive Methods (cont.)

- Central tendency
  - Mode
    - Most frequent score
  - Median
    - Divides the scores into two, equally sized parts
  - Mean
    - Sum of the scores divided by the number of scores
  - Normal distribution: mode ≈ median ≈ mean
  - Positive skew: mode < median < mean
  - Negative skew: mean < median < mode

Descriptive Methods (cont.)

- Measures of variability
  - Dispersion (level of *sameness*)
  - Range
    - max - min of all the scores
  - Interquartile range
    - max - min of the middle 50% of scores
  - Box-and-whisker plot
  - Standard deviation (*SD*, *s*, σ, or *sigma*)
    - Good estimate of range: *4 * SD*
  - Variance (s^2 or σ^2)

Descriptive Methods (cont.)

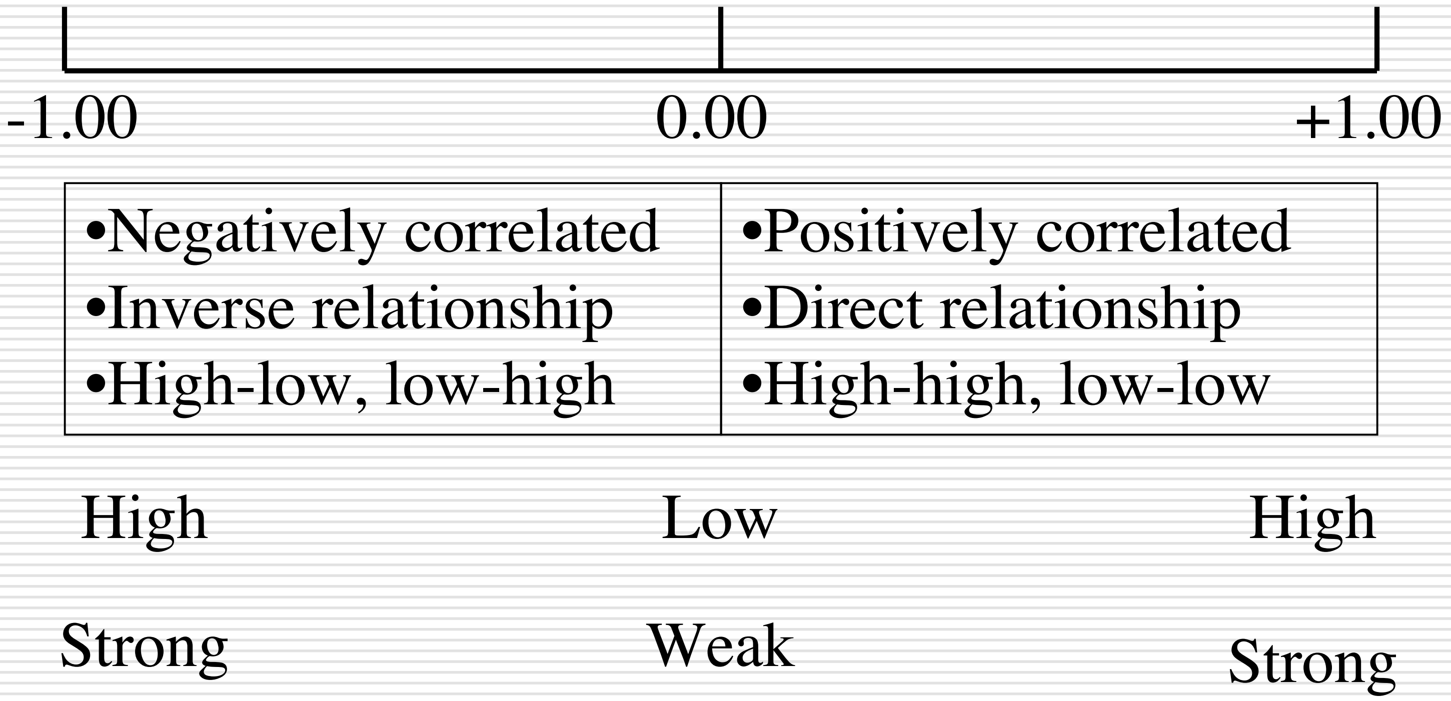
- Standard scores
  - How many SDs a score is from the mean
  - *z*-score: mean = 0, each SD = +/-1
    - *z*-score of +2.0 means the score is 2 SDs above the mean
  - *T*-score: mean = 50, each SD = +/-10
    - *T*-score of 70 means the score is 2 SDs above the mean

Bivariate Correlation

- □ Discover whether a *relationship* exists
- □ Determine the *strength* of the relationship
- □ Types of relationship
  - High-high, low-low
  - High-low, low-high
  - Little systematic tendency

Bivariate Correlation (cont.)

- Scatter plot
- Correlation coefficient: *r*



-1.00 0.00 +1.00

•Negatively correlated •Inverse relationship •High-low, low-high	•Positively correlated •Direct relationship •High-high, low-low

High Low High

Strong Weak Strong

Bivariate Correlation (cont.)

- Quantitative variables
  - Measurable aspects that vary in terms of intensity
    - **Rank**; **Ordinal scale**: Each subject can be put into a single bin among a set of ordered bins
    - **Raw score**: Actual value for a given subject. Could be a composite score from several measured variables
- Qualitative variables
  - Which categorical group does one belong to?
    - E.g., I prefer the Grand Canyon over Mount Rushmore
    - **Nominal**: Unordered bins
    - **Dichotomy**: Two groups (e.g., infielders vs. outfielders)

Reliability and Validity

- Reliability
  - To what extent can we say that the data are consistent?
- Validity
  - A measuring instrument is valid to the extent that it measures what it purports to measure.

Inferential Statistics

- Definition: To make statements beyond description
  - Generalize
- A ***sample*** is extracted from a ***population***
- Measurement is done on this sample
- Analysis is done
- An educated guess is made about how the results apply to the population as a whole

Motivation

- Actual testing of the whole population is too costly (time/money)
  - "Tangible population"
- Population extends into the future
  - "Abstract population"
- Four questions
  - What is/are the relevant populations?
  - How will the sample be extracted?
  - What characteristic of those sampled will serve as the measurement target?
  - What will be the study's statistical focus?

Statistical Focus

- What statistical tools should be used?
  - Even if we want the "average," which measure of average should we use?

Estimation

- Sampling error
  - The amount a sample value differs from the population value
  - This ***does not*** mean there was an error in the method of sampling, but is rather part of the natural behavior of samples
    - They seldom turn out to *exactly* mirror the population
  - Sampling distribution
    - The distribution of results of several samplings of the population
  - Standard error
    - SD of the sampling distribution

Analyses of Variance (ANOVAs)

- □ Determine whether the means of two (or more) samples are different
  - ■ *If we've been careful*, we can say that the treatment is the source of the differences
  - ■ Need to make sure we have controlled everything else!
    - □ Treatment order
    - □ Sample creation
    - □ Normal distribution of the sample
    - □ Equal variance of the groups

Types of ANOVAs

- Simple (one-way) ANOVA
  - One independent variable
  - One dependent variable
  - Between-subjects design
- Two-way ANOVA
  - Two independent variables, and/or
  - Two dependent variables
  - Between-subjects design

Types of ANOVAs (cont.)

- One-way **repeated-measures** ANOVA
  - One independent variable
  - One dependent variable
  - Within-subjects design
- Two-way **repeated-measures** ANOVA
  - Two independent variables, and/or
  - Two dependent variables
  - Within-subjects design

Types of ANOVAs (cont.)

- Main effects vs. interaction effect
  - Main effects present in conjunction with other effects
- Post-hoc tests
  - Tukey's HSD test
    - Equal sample sizes
  - Scheffé test
    - Unequal sample sizes

Types of ANOVAs (cont.)

- Mixed ANOVA
- 2 x 3
  - Time of day
  - Real Walking / Walking in-place / Joystick

References

- Schuyler W. Huck *Reading Statistics and Research*, Fourth Edition, Pearson Education Inc., 2004.