Carnegie Mellon University

Effective User Survey Design and Data Analysis

Hanan Hibshi and Travis Breaux

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Tutorial Outline

- Effective User Survey Design
  - Session 1: Introduction to experimental research and user surveys
  - Session 2: Building user surveys
- Analyzing and Reporting User Survey Data
  - Session 3: Quantitative analysis of survey data
  - Session 4: Qualitative analysis of survey data

Session 3:

QUANTITATIVE ANALYSIS OF SURVEY DATA

Topics of Third Session

- Statistical significance
- Data preparation
- Statistical tests
- Role of assumptions in statistical tests
- Effect of study design on data analysis
- Effect of conditions (levels of a variable)
- Threats to validity
- Power analysis
- Reporting results and descriptive statistics

Identifying the Variables and Metrics

- We need to think of independent/dependent variables
  - **Independent variable:** that is being changed or controlled
  - **Dependent variable:** that is being tested
  - **Control variable:** holding a dependent variable constant (e.g. age)

Is developers' productivity affected by type of programming language?

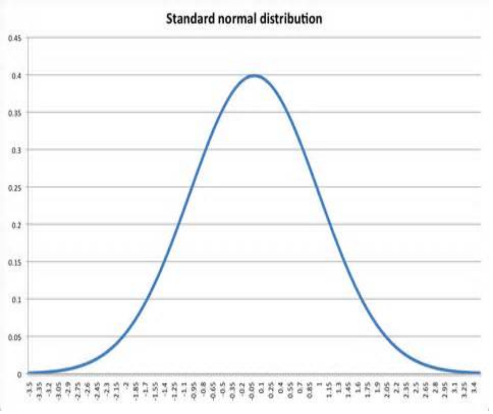
- How to measure productivity:
  - Time!
  - Number of lines
  - Number of hours
  - Number of tasks, submissions, commits, results etc.

Without Statistical Significance

- Mary scored 90% on PL assessment test, John scored 75%,
  - Mary is a better programmer then John
- The average score of three male students on PL test: 70%, the average of three female students is 90%
  - Females are better programmers then males
- Arguments:
  - Size of compared groups is very small
  - The individuals in the groups are not representative of all males and females
  - I can go and find another 6 students and prove the opposite!

Statistical Significance

- We cant collect data from every male and female
- The full population follow a normal distribution
- We can select a small sample that represent the population
- Significance tests can indicate if results from our sample can generalize



- Lazar, J., Feng, J.H. and Hochheiser, H., 2010. Research methods in human-computer interaction. John Wiley & Sons.

How Significance Testing Work

- **Null hypothesis: $\boldsymbol{H_0}$** (No difference between groups)
- **Alternative hypothesis: $\boldsymbol{H_1}$** (Group A is better then B
- The significance tests tell us to reject or accept H_0
- Example:
  - $\boldsymbol{H_0}$ There is no difference between the transaction time of an ATM with touch screens and ATM with buttons
  - $\boldsymbol{H_1}$ ATM with touch screen has a shorter transaction time than an ATM with buttons
- Significance testing is subject to Type I and Type II errors

- Lazar, J., Feng, J.H. and Hochheiser, H., 2010. Research methods in human-computer interaction. John Wiley & Sons.

Type I and Type II Errors

- Type I (false +ve) is worse than Type II (false –ve)
- α: Type 1 error rate or significance level
- β: Type 2 error rate. (1- β) is the power of the test

		Reality	
		H_0 is True	H_0 is False
Decision	Accept H_0	Accurate $(1-\alpha)$	Type II Error β
	Reject H_0	Type I Error α	Accurate $(1-\beta)$

Power: The probability of successfully rejecting a null hypothesis when its false and should be rejected [1]

[1] Cohen, J., 1988. Statistical power analysis for the behavioral sciences, 2nd Edition.

[2] Rosenthal, R. and Rosnow, R.L., 1991. Essentials of behavioral research: Methods and data analysis. McGraw-Hill Humanities Social.

P-value and Degrees of Freedom

- P-value
  - The probability of obtaining a result equal to or "more extreme" than what was actually observed, when the null hypothesis is true
  - We want this to be as small as possible
  - $p< \alpha$
  - If the P is higher it does not imply that the null hypothesis is true! It means we CANNOT REJECT the null hypothesis given the level α
  - Refers to one null hypotheses
- Degrees of Freedom
  - The degree of freedom is the number of values in a calculation that we can vary
  - $(20 + 10 + x + y)/4 = 25$

Data Preparation

- Data need to be organized, cleaned-up, and coded

Pno	Age	Gender	Degree
P0001	31	Male	College
P0002	20	Female	Graduate
P0003	27	Female	High School

Pno	Age	Gender	Degree
P0001	31	1	2
P0002	20	0	3
P0003	27	0	1

Likert-scale Coding Example

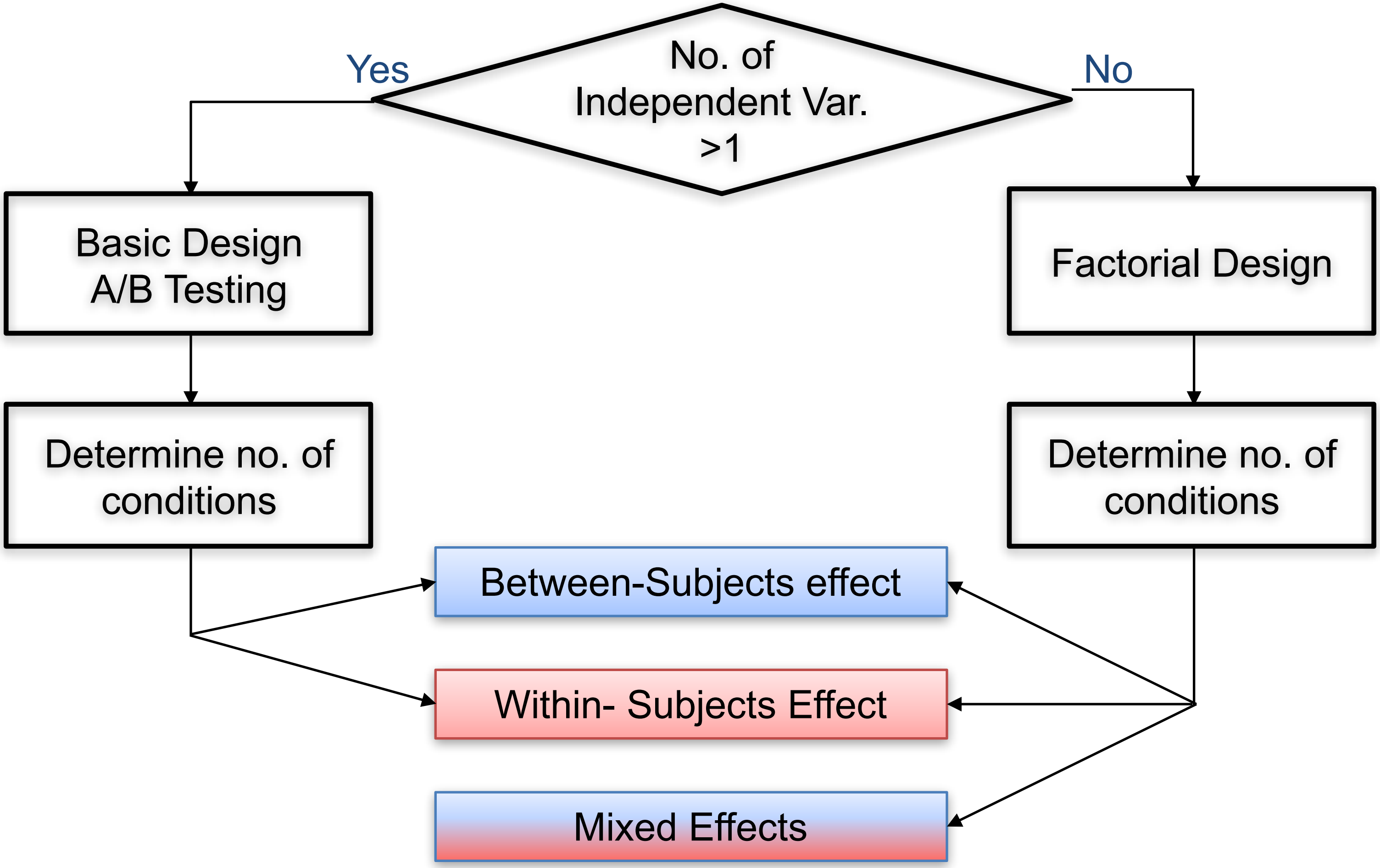
- Very unlikely = 1
- Unlikely = 2
- Natural = 3
- Likely = 4
- Very likely =5

Pno	Q1	Q2	Q3
P0001	3	1	1
P0002	2	1	0
P0003	5	3	1

Types of Variables

- Categorical, discrete
  - Ordinal
  - Nominal
- Continuous

Experiment Design: Structure



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Common Statistical Tests for Experiments

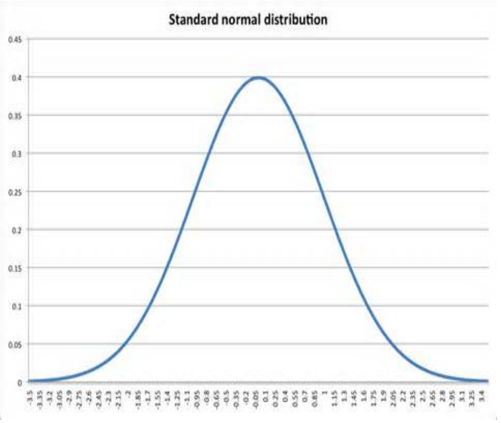
- Parametric tests
  - T-test
  - ANOVA (Analysis of Variance)
- Linear regression
- Non-parametric tests
  - Chi-square: significance of Frequency (contingency tables)
  - Fisher’s
  - Wilcoxon signed ranks test
  - Man-Whitney U test

T-Test

- One IV, two groups/conditions
- Independent sample T-test
  - Between Subjects design
  - Assumption: observations are independent
- Paired Sample T-Test
  - Within-Subjects design
- Example:
  - There was a significant difference in the scores for [C1] (M=4.2, SD=1.3) and no [C2] (M=2.2, SD=0.84) conditions; t (8)=2.89, p = 0.020

T-Test Assumptions

- DV scores are normally distributed
    - Violated: use non-parametric test
- Homogeneity of variance
    - Violated: use transformation (e.g. logs)
- Independent errors



ANOVA

- Analyses of Variance
- F statistic
- Between subjects
  - One Way ANOVA: One IV, 3 or more groups
  - Factorial ANOVA: 2 or more IV, 2 or more groups
- Within subjects
  - Repeated Measures
- Mixed design
  - Split-plot ANOVA

Linear Regression

- You can have a number of IV
- Purposes:
  - Model construction
    - Find the mathematical relationship (find the equation)
  - Predication
    - Predict the DV based on known factors
- Enter variables one at a time vs. all together
- Multi-level regression
  - Good for mixed methods
  - Can analyze hierarchal data

Power

- β: Type 2 error rate, (1- β) is the power of the test
- $Power = P(reject\ H_0|H_1\ is\ true)$
- Power analysis: calculate the minimum sample size required so that one can be reasonably likely to detect an effect of a given size
  - Specify your effect size
  - Your α, β
  - G power is a popular tool
  - Priori or post-hoc

Threats to Validity

- External validity
  - The degree to which results can be generalized
  - Example threat: convenience sampling
- Internal validity
  - the extent to which a causal conclusion based on a study is warranted, which is determined by the degree to which a study minimizes systematic error or 'bias‘
  - Example Threats: learning effect, fatigue, confounding variables…
  - Randomization, reduction of fatigue, attention checks
- Construct validity
  - Are we measuring what is claimed to be measured
  - Example threats: Errors in measuring instrument, lower control over measurement