Rigorous Evaluation

Analysis and Reporting

SWEN-444

Structure is from A Practical Guide to Usability Testing by J. Dumas, J. Redish

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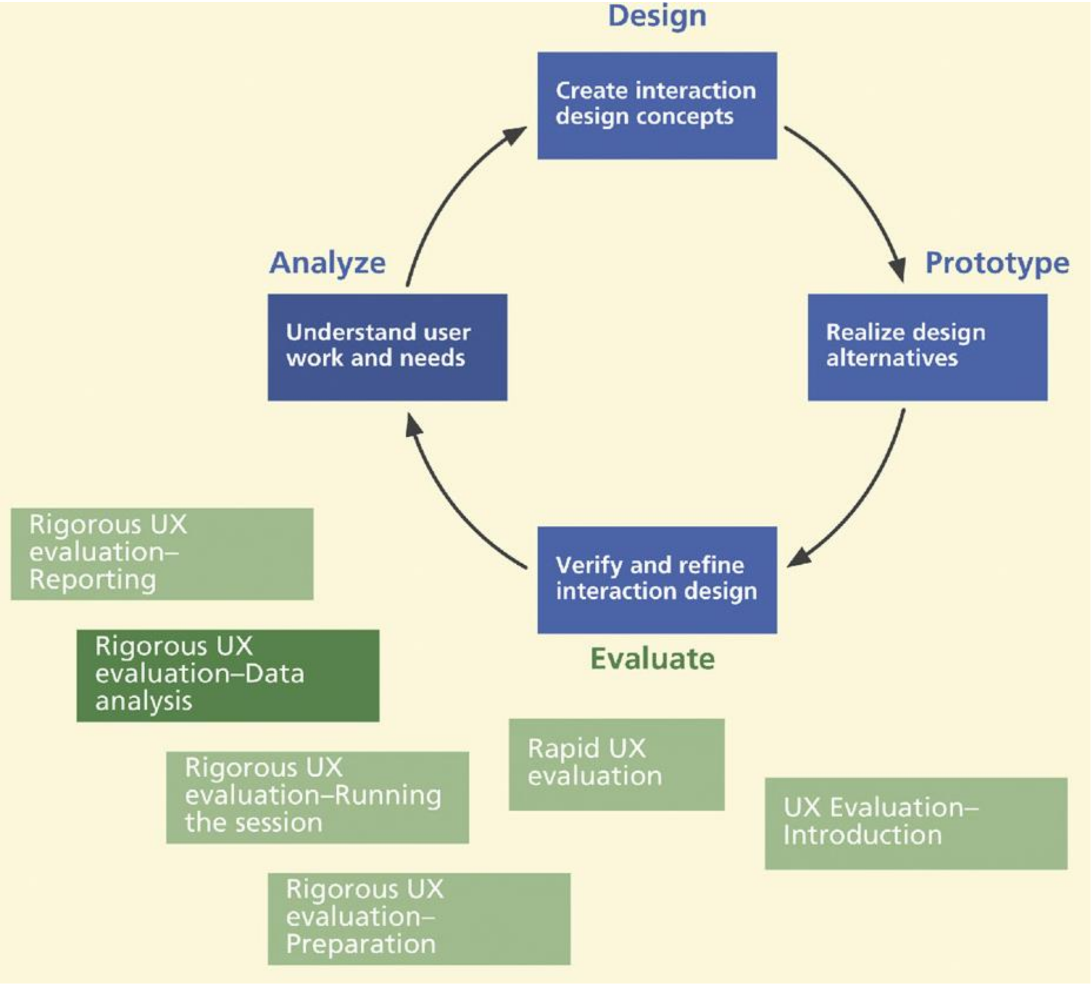
Design
Create interaction design concepts
Analyze
Understand user work and needs
Prototype
Realize design alternatives
Verify and refine interaction design
Evaluate
Rigorous UX evaluation–Reporting
Rigorous UX evaluation–Data analysis
Rigorous UX evaluation–Running the session
Rapid UX evaluation
UX Evaluation–Introduction
Rigorous UX evaluation–Preparation

Results from Usability Tests

- Quantitative data:
  - Performance data - times, error rates, etc.
  - Subjective ratings, from post test surveys
- Qualitative data:
  - Participant comments from notes, surveys, etc.
  - Test team observations, notes, logs
  - Background data from user profiles, pretest surveys and questionnaires

Work Role: User Class	UX Goal	UX Measure	Measuring Instrument	UX Metric	Baseline Level	Target Level	Observed Results	Meet Target?
Ticket buyer: Casual new user, for occasional personal use	Walk-up ease of use	Initial user performance	BT1: Buy special event ticket	Average time on task	3 min as measured at the kiosk	2.5 min	3.5 min	No
Ticket buyer: Casual new user, for occasional personal use	Walk-up ease of use for new user	Initial user performance	BT2: Buy movie ticket	Average number of errors	<1	<1	2	No
Ticket buyer: Casual new user, for occasional personal use	Initial customer satisfaction	First impression	Questions Q1–Q10 in questionnaire XYZ	Average rating across users and across questions	7.5/10	8/10	7.5	No

Summarize and Analyze Test Data

- Quantitative data …
  - Tabulate
  - Use statistics for analysis when appropriate
- Qualitative data …
  - For survey multiple choice questions, count responses or average (if large groups)
  - For survey open-questions/comments, interviews, and observations …
    - Identify critical comments
    - Group into meaningful categories (+ or – for a particular task/screen)

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Look for Data Trends/ Surprises

- Examine the quantitative data …
  - **Trends** or **patterns** in task completion, error rates, anomalies, etc.
- **Identify outliers** - what can they tell us, ignore at your peril
  - Non-usability anomaly such as technical problem?
  - Difficulties unique to one participant?
  - Unexpected usage patterns?
- **Correlate quantitative** data with **qualitative** data such as written comments
- If appropriate compare old versus new program versions, different user groups

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Examining the Data for Problems

- *Have you* ***achieved*** *the* ***usability goals*** *– learnable, memorable, efficient, understandable, satisfying?*
- **Unanticipated** usability **problems**?
  - Usability concerns that are not addressed in the design
- Have the quantitative criteria that you have set been met or exceeded?
- Was the expected emotional impact observed?

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Task and User Error Analysis

- What tasks did users have the most problems with (usability goals not met)?
- Conduct error analysis
  - Categorize errors/task by type
    - Requirement or design defect (or bug)
  - % of participants performing successfully within the benchmark time
  - % of participants performing successfully regardless of time (with or without assistance)
    - If low then BIG problems

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Errors in Testing Process?

- Sample size too small
- Biased sample
  - Not representative of the larger data set
  - You have failed to notice and compensate for other factors that can bias the results; e.g., cultural differences
- Sloppy data measurement
- Outliers were left in when they should have been removed
  - Is an outlier a fluke or a sign of something more serious

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Prioritize Problems

- Criticality = Severity + Probability
- **Severity**
    - 4: Unusable – not able/want to use that part of product due to design/implementation
    - 3: Severe – severely limited in ability to use product (hard to workaround)
    - 2: Moderate – can use product in most cases, with moderate workaround
    - 1: Irritant – intermittent issue with easy workaround; cosmetic
- **Factor in scope**– local to a task (e.g., on screen) versus global to the application (e.g., main menu)

- Rubin, Jeffrey, and Chisnell, Dana. Handbook of Usability Testing : How to Plan, Design, and Conduct Effective Tests (2). Hoboken, US: Wiley, 2008. ProQuest ebrary.

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Prioritize Problems (cont.)

- Probability of occurrence = frequency * scale

Frequency ranking	Estimated frequency of occurrence
4	Will occur ≥90% of the time the product is used
3	Will occur 51–89% of the time
2	Will occur 11–50% of the time
1	Will occur ≤10% of the time

Scale - % of target population

- When done – sort by Criticality (priority)

- Rubin, Jeffrey, and Chisnell, Dana. Handbook of Usability Testing : How to Plan, Design, and Conduct Effective Tests (2). Hoboken, US: Wiley, 2008.

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Statistical Analysis

- Summarize quantitative data to help discover patterns of performance and preference, and detect usability problems
- **Descriptive** and inferential techniques

Descriptive Statistics

- Describe the properties of a **specific data set**
- Measures of **central tendency** (single variable)
  - Frequency distribution (e.g., of errors)
  - Mean (average), median (middle value), mode (most frequent value in a set)
- Measures of **spread** (single variable)
  - Amount of variance from the mean, standard deviation
- **Relationships** between **pairs** of variables
  - Correlation
  - Scatterplot
- Sufficient to make meaningful recommendations for most tests

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Using Descriptive Statistics to Summarize Performance Data E.g., Task Completion Times

- **Mean** time to complete – rough estimate of group as a whole
  - Compare with original benchmark: is it skewed above/below?
- **Median** time to complete – use if data very skewed
- **Range** (largest value – smallest value) spread of data
  - If small spread then mean is representative of the group
  - A good measure
- **Interquartile range** (IQR) – divide data into four equal parts
- **Standard Deviation** (SD) – how much data dispersion from the mean; a better measure

Summarizing Performance Data (Cont.)

- Interquartile range (IQR) – another measure of statistical spread
  - Find the three data points (quartiles) that divide the data set into four equal parts, where each part has one quarter of the data
  - Difference between the upper (Q_3) and lower (Q_1) quartile points is the IQR
  - IQR = Q3 - Q1 (“middle fifty”)
  - Find outliers - below Q_1 - 1.5(IQR) or above Q_3 + 1.5(IQR)

i	x[i]	Quartile
1	102	
2	104	
3	105	Q_1
4	107	
5	108	
6	109	Q_2 (median)
7	110	
8	112	
9	115	Q_3
10	116	
11	118	

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Summarizing Performance Data (Cont’d)

- **Standard Deviation** (SD) is the square root of the variance
  - How much variation or "dispersion" is there from the average (mean or expected value) in a normal distribution

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

Sample SD
"Bessel's Correction"

  - E.g., Standard deviation of completion times
    - If small, then performance is similar
    - If large, then more analysis is needed
    - Influence by outliers possible, so rerun without them as well

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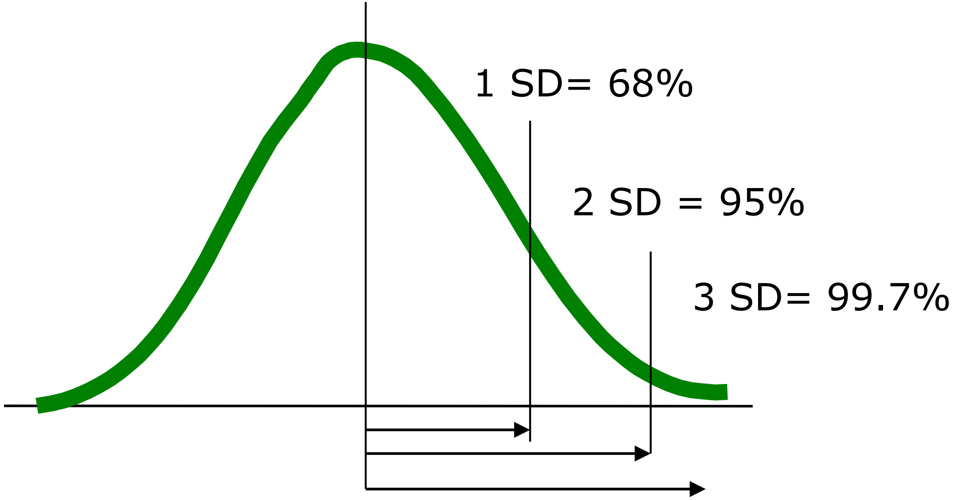
Normal Curve and Standard Deviation



- The smaller the value of SD, the sharper the curve (narrow peak and steep sides)
  - Results grouped around the mean
- The larger the value of SD, the broader the curve
  - And the larger the difference that values have from the mean

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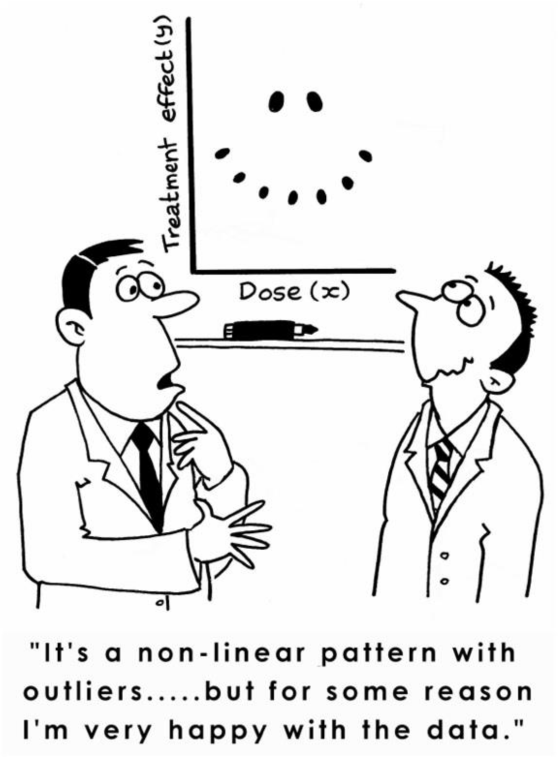
Sample Data

Tasks	% of Participants Performing within Benchmark	Mean Time	SD
Set Temp and Pressure	83	3.21	0.67
Set flows	33	12.08	10.15
Load the sample tray	100	.46	.17
Set oven temperature program	66	6.54	2.56

Correlation

- Allows exploration of the strength of the **linear relationship** between **two** continuous **variables**
- You get two pieces of information; **direction** and **strength** of the relationship
  - Direction
    - +, as one variable increases so does the other
    - -, as one variable increases, the other variable decreases
  - Strength
    - Small: .01 to .29 -.01 to -.29
    - Medium: .3 to .49 -.3 to -.49
    - Large: .5 to 1 -.5 to -1
  - Pearson's correlation coefficient (r) is most often used to measure correlation



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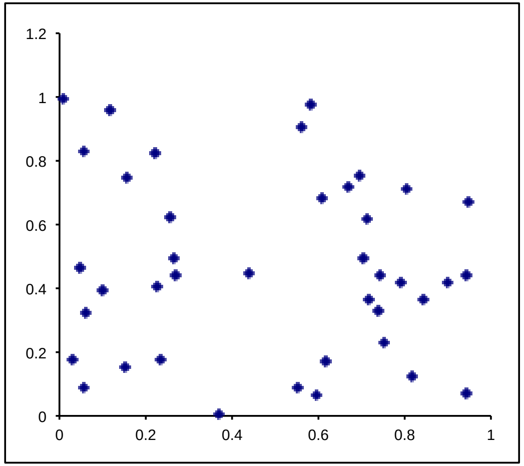
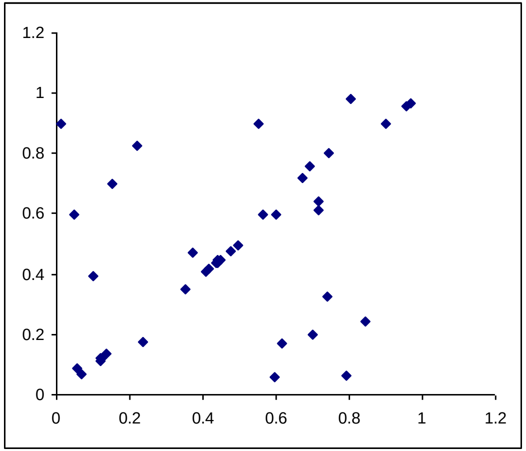
Scatterplots

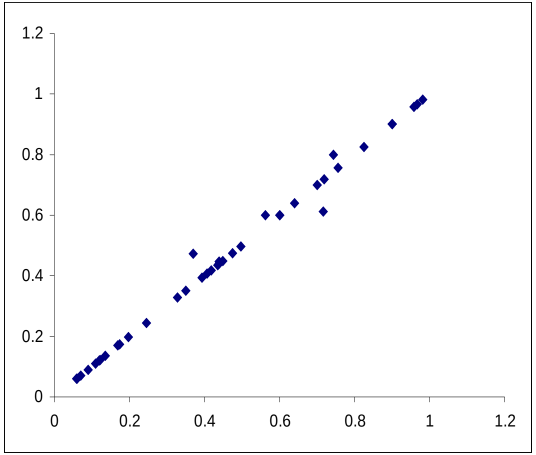
- Need to visually examine the data points
- Scatterplot – plot (X,Y) data point coordinates on a Cartesian diagram



r = .00



r = .40



r = .99

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Data Analysis Activity

- See the Excel spreadsheet “Sample Usability Data File” under “Assignments and In-Class Activities” in myCourses
- Follow the directions
- Submit to the Activity dropbox “Quantitative Data Analysis”

Supplemental Information
Inferential Statistics

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Inferential Statistics

- Infer some property or general pattern about a larger data set by studying a *statistically significant sample (*large enough to obtain repeatable results*)*
  - In expectation the results will generalize to the larger group
  - Analyze data subject to random variation as a sample from a larger data set
- Techniques:
  - Estimation of descriptive parameters
  - Testing of statistical hypotheses
- Can be complex to use, controversial
  - Keep Inferential Statistics Simple (KISS 2.0)

Statistical Hypothesis Testing

- A method for making decisions about statistical validity of observable results as applied to the broader population
- Based on data samples from experiments or observations
- Statistical hypothesis – (1) a statement about the value of a population parameter (e.g., mean) or (2) a statement about the kind of probability distribution that a certain variable obeys

Establish a Null Hypothesis (H_0)

- The **null hypothesis H_0** is a simple hypothesis in **contradiction** to what you would like to prove about a data population
- The **alternative hypothesis H_1** is the **opposite**
  - what you would like to prove
- For example: I believe the mean age of this class is greater than or equal to 20.7
  - H_0 - the mean age is < 20.7
  - H_1 – the mean age is ≥ 20.7

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Does the Statistical Hypothesis Match Reality?

	STATE OF NATURE	
DECISION	H_0 is true	H_0 is false
Accept H_0:	satisfactory	Type II error
Reject H_0:	Type I error	satisfactory

- Two types of errors in deciding whether a hypothesis is true or false
  - Note: a **decision** about what you **believe** to be true or false about the hypothesis, **not a proof**
- **Type I error** is considered **more serious**

Null Hypothesis

- Null hypothesis (H_0) – hypothesis stated in such a way that a **Type I error occurs** if you believe the **hypothesis is false and it is true**
- **In any test of H_0** based on **sample observations** open to **random variation**, there is a **probability of a Type I error**
  - **P(Type I Error) = α**
  - Called the "significance level"
- Essential idea - limit, to the small value of α, the likelihood of incorrectly reaching the decision to reject H_0 when it is true
  - As a result of experimental error or randomness

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How It Works

- Establish H_0 (and H_1)
- Establish a relevant test statistic and distribution for the sample (e.g., mean, normal distribution)
- Establish the maximum acceptable probability of a Type I error - the significance level α (0.05)
- Describe an experiment in terms of …
  - Set of possible values for the test statistic
  - Distribute the test statistic into values for which H_0 is rejected (critical region) or not
  - Threshold probability of the critical region is α
- Run the experiment to collect data and compute the test statistic **p**
- If **p** > α reject H_0

Simple Example

- I believe the mean age of this class is ≥ 20.7
- Establish H_0
  - The mean age in this class is less than 20.7 years
- Establish a relevant test statistic and distribution for the sample
  - Mean, assume normal distribution from 17 to 26 of all undergraduate SE students
- Establish the significance level α
  - 0.05 by convention
- Distribute the test statistic into values for which H_0 is rejected (critical region)
  - Let's say 19 and above
  - Run the test with a sample size of 10, compute the mean μ and the probability p of that mean value occurring from a sample size of 10 in the general population
- If $p > \alpha$, reject H_0

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