



# Class 5 CS545

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Welcome to class 5



## Roadmap

- Log Book
- Design
- Evaluation
- Statistics
- The Project
- Readings this class: Stone et.al., Chapters 22 -26 (evaluation)

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Today we will focus some time on Tidwell's patterns, continue to discuss personas and give you some hints on questionnaire design. We will finish up with discussing the project.

**Log Entry Low Fi Proto**

<http://www.nngroup.com/articles/mozilla-paper-prototype/>

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The text below was from the cited web site:

Although there is no single answer to the question of flat vs deep hierarchies, our many years of usability research indicate that with too many choices, people easily get overwhelmed. When people click the right thing first, they are almost 3 times as likely to succeed at their task.

*The first version of the paper prototype for the Mozilla Support homepage: Users could start with a task (1), a product or service (2), or choose a hot topic (3).*

In the second panel the different Mozilla products were now hidden under a collapsed accordion – progressive disclosure, simplifying the interface

*A later-iteration design for the Support homepage: People could choose a task (2) or expand the software row (1) to choose a product or service first. When someone clicked the question in the middle, we showed them another piece of paper like this, but with the middle section expanded (compare with the previous screenshot).*



## The Process – part A

- Select your team
- Select an idea (ideate)
- Brainstorm ideas
- Research competitors
- Field Study – look
  - Web resources
- Questionnaire for cohort
- Story board
- Persona
- Story board based on persona

- User story
- The E
- Low Fi prototype
- Test friends and a few users
- Increase Fidelity
- Test friends and a few users
- The Prototype
- (reviews)
- User Testing
- Final Eval

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So this really takes us from low fidelity proto type to actual user testing with your code.



In class next time



## An Exercise

The screenshot shows a web browser window titled "Gregg Vesonder's Web Page". The page itself has a white background with a small graphic of three overlapping circles (blue, red, and yellow) at the top left. The main content area contains the following text:

Welcome to my new home! Still under construction and should be changing all summer.

The corrected version of the SMC 2011 paper can be found [here](#).

This web page discusses, [software engineering](#), [Human Computer Interaction \(HCI aka CHI\)](#), [rule based programming](#), MAC OS X, alife, [my current reading](#), [my past talks](#), including my October 2010 NABIC talk, and other stuff I like (and dislike). If you are interested in my blogs, the oldest for past and present students (and anyone else), [enter here](#) and the newest on gadgets, human computer interaction and the iphone [enter here](#). I also have a twitter feed SWUniverse.

**Software Universe Twitter Updates**

- UK advice on User Centred Design <http://t.co/0fErHVILP> 98 days ago
- Spacy Expressions <http://t.co/0cdoGK4a> 127 days ago
- Go FORTH <http://t.co/NZQw3LkZ> 203 days ago
- Got a fitbit for Christmas. I will log my experiences with it both here and in blog/website. <http://t.co/209> 209 days ago
- I just applied for the O'Reilly Blogger Review Program <http://t.co/0j1C0yk> via @oreillymedia. I will post on my experience, later! <http://t.co/222> 209 days ago

[follow me on Twitter](#)

**Course Work**

This site also supports courses I am teaching both at [Stevens Institute of Technology](#) and at the [University of Pennsylvania](#).

Notes are available when courses are in session. The current courses I teach at Penn are: EMTM 601, Introduction to Software Engineering, EMTM 604 Security and Privacy and EMTM 608 Human Computer Interaction. The current courses I teach at Stevens are SSW540, Quantitative Software Engineering and SSW565 Software Architecture and Design.

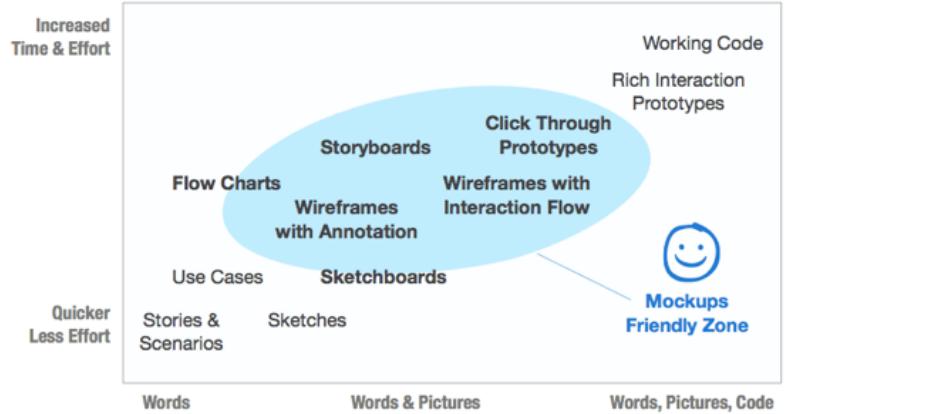
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My web site several years ago—boring!



BalsamIQ

## Techniques for Specifying Interaction with Mockups



What you will see on the next page is a wireframe – a moderate fidelity prototype of the site which, when encoded in one of the tools, has some clickable components



# My Wireframe

Gregg Vesonder's Web Page

Welcome to my new home! Still under construction and should be changing all summer.

Some text in my sidebar

Software Universe Twitter Updates

Item One  
Item Two  
Item Three

Course Work

Description of the section - like sidebar and classes

University of Pennsylvania

U of Penn  
[CS 250](#)

Stevens

Stevens Classes  
[CS 250](#)

Miscellaneous

Source, email Gregg

Penn CIS 700-920 Human Computer Interaction

UI of classes

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An example of a redesign of my site. It has since gone through more iterations and has become simpler



## Other Moderate Fidelity Tools

- Moqups
- POP
- Balsamiq
- and more: <http://despreneur.com/wireframing-tools/>

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There are many choices each with their own twist. Some are free and even the expensive ones provide 30 day trials which should be enough for your course. I have a copy of Balsamiq which I use. POP provides your first 2 apps free and you use hand drawings that are then converted to the interface. It is fairly popular



## High Fidelity

Is your code and  
mileage may differ  
depending on what  
you are comfortable  
using

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My expectation is the code you use for your actual prototype will be what you like to use and fits the task.



## Evaluation

- Have a **plan** considering: what stage is design, is it well defined or exploratory, expected user population (type and number), risk of interface (furby vs nuclear power plant), budget (time, cash, resources), experience of design and evaluation team
- Expectation is that there is ongoing evaluation throughout the lifecycle of the system/app/interface, things do change!
- **Remember your E!**

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So onto evaluation. The first thing to have, and this should have been done early in the project after you selected your E, is that you developed a plan to evaluate your design prototypes and product candidates. The first bullet suggests the dimensions that you should consider. Note you should evaluate continuously, even after the product is released to collect data for future improvements or for your next product. Happy users are loyal users.



## Don't be overwhelmed! Types of testing/eval

- A/B testing
- Think Aloud testing
- Group testing, single testing, user panel
- Mass testing with survey and data logging
- Expert reviews
- Inspections (standards, ...)
- Record or not record, notes are good too and less time consuming

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There are many testing choices. A/B testing is comparing one version of your project with another to see which the users would prefer. For example a monochrome versus an app in color. One thing I discourage is complete video testing of the user doing the task. First there are privacy issues and second it is extraordinarily expensive to extract expensive data from it.



## Wide Range of Choices

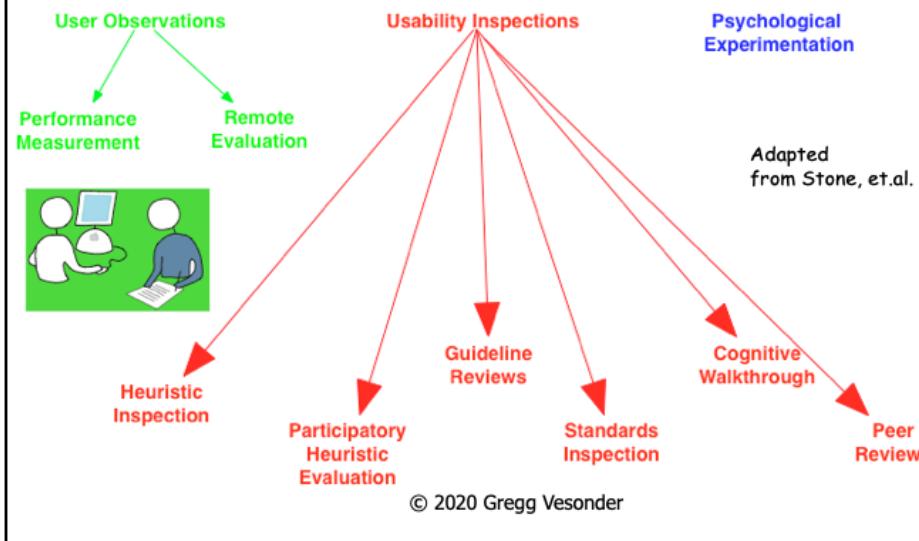
- Real life vs. simulation
- Actual users ..... User reps/experts
- Actual tasks ..... Task descriptions
- Real environment .. Controlled environment
- Users with domain knowledge ..... Users w/o domain knowledge
- Usability checkers: W3C to commercial
- ... the profile

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So there are many choices for how to conduct the evaluation. In selecting them you must consider the constraints of your project, two of which are staffing and times. Note that there are also usability checkers. For example you can test accessibility by using tools by the w3c - <http://www.w3.org/WAI/ER/tools/#General>. If you have a web application please do so. Either way please note that accessibility discussions in HCI refer to attending to folks with special needs. It is amazing how many folks do not grasp that concept initially.



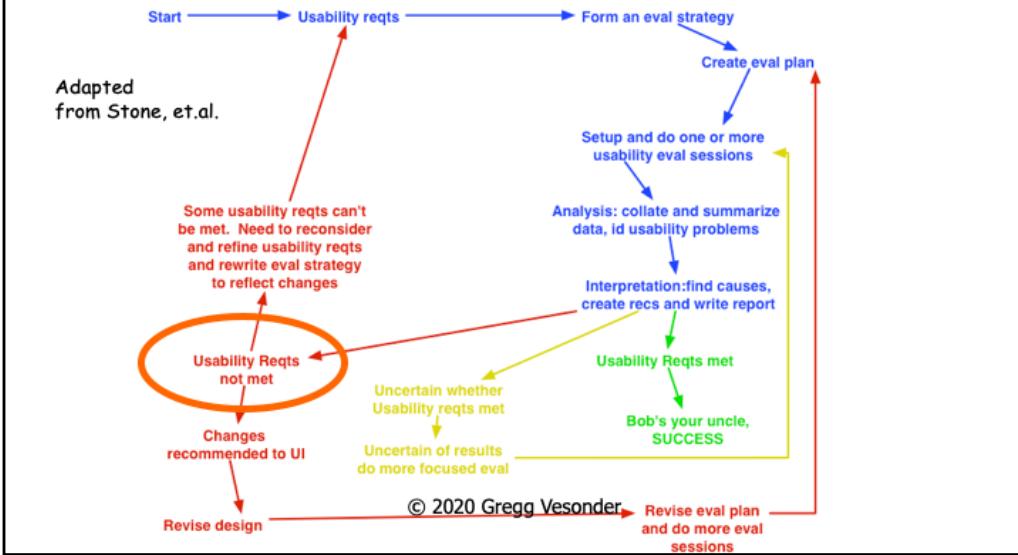
# Usability Evaluation Techniques



We will discuss these techniques a bit. Stone, covers it well. Note that there is a host of resources and industry effort on evaluation which demonstrates its importance to the industry.



## Usability Eval Process



Note you want to get to the green but that may entail several iterations, if ever. My one quibble is that there should be a pointer to the state that it is not practical at this time – some check to see if you still have available resources to continue when the evaluation finds that usability requirements are not met- orange circle.



## Success Criteria, 5E's (rational weighting)



Again pre selecting which Es are the most important are crucial both to focus your design and to measure in the evaluation.



## Expert reviews

- Start with colleagues or customers
- Move on to experts (application and interface)
  - Both can be hired

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Always prototype and trial with friends and family. We usually offer chocolate bars to our colleagues to trial a concept. I suppose beers would work too but after, not before the trial!



## 8 Golden Rules - Redux

- Strive for consistency
- Cater to universal usability and design for change
- Offer informative feedback
- Design dialogue to yield closure (beginning, middle and end)
- Prevent errors
- Permit easy reversal of actions
- Support internal locus of control - user is in charge
- Reduce short term memory load

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Just a refresher of what you should be doing, the essential to a great interface, note that most of these points focus on the UI, which is only a component of the user experience.



## Expert Review Types

- Heuristic evaluation
- Guidelines review - organizational guidelines
- Consistency inspection
- Cognitive walkthrough -- walk through task, wizard of oz prototyping (regular users too)
- Formal usability inspection - courtroom like

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There are many way to use expert reviewers. They vary from a “let’s see how it works” and have the user experience consultant experience it. To a formal usability inspection that sifts through the interface/experience to unearth any flaw – no flaw is too trivial to be noted in such a process.



## Expert Review Goals

- Comprehensiveness (bird's eye view)
- No comment too small, minutiae should be included
- Live total experience, training courses, ...

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Just an expansion on the expert review. One of the few instances when hiring a consultant for two weeks with high UI knowledge but little domain knowledge may be appropriate. Of course if you can find user experience experts with domain expertise, that's even better.



## Heuristic Evaluation

- How does it work?
  - Evaluators use a checklist of basic usability heuristics
  - Evaluators go through an interface twice
    - 1<sup>st</sup> pass get a feel for the flow and general scope
    - 2<sup>nd</sup> pass refer to checklist of usability heuristics and focus on individual elements
  - The findings of evaluators are combined and assessed
- There is a formal evaluation too

From Kessel

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Meaning it is easy (can be taught in a half day seminar). The checklists help facilitate and guide the process. The first I am presenting is from Kessel (see reference at the end)



# Heuristic Evaluation

Usability Heuristics (original, unrevised list)

- Simple and natural dialogue
- Speak the users' language
- Minimize the users' memory load **PAR!**
- Consistency
- Feedback
- Clearly marked exits
- Shortcuts
- Precise and constructive error messages
- Prevent errors
- Help and documentation

From Kessel

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So the next few slides bombard you with the contents of some popular heuristic evaluation checklists. Each of these items should be fairly familiar to you.



## Nielsen-1

- **Visibility of system status** The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
- **Match between system and the real world** The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
- **User control and freedom** Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

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Nielsen is a bit more self explanatory and looks at the higher level relationships among elements of the user experience.



## Nielsen-2

- **Consistency and standards** Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
- **Error prevention** Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
- **Recognition rather than recall** Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate. **PAR!**

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In our bag of list design advice slides you have seen many of these items. You not only use the concepts in design but also in evaluating the design



## Nielsen-3

- **Flexibility and efficiency of use** Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
- **Aesthetic and minimalist design** Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility. **Skeumorphism!**
- **Help users recognize, diagnose, and recover from errors** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
- **Help and documentation** Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

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More and a little discussion of skeumorphism. A **skeuomorph** (*/skju:əmɔrf/*) is a derivative object that retains ornamental design cues from structures that were necessary in the original. Examples include pottery embellished with imitation rivets reminiscent of similar pots made of metal and a software calendar that imitates the appearance of binding on a paper desk calendar. (wikipedia) Apple's newest iOS design has rejected this concept and is now sporting a minimalist design. Which do you like better? I do appreciate the difference of the new iOS interface but I sometimes miss the ornamental design.



## Tog-1

- Anticipation
- Autonomy
- **Color Blindness**
- Consistency
- Defaults
  - Should be easy to over ride
- Efficiency of the User
  - Focus on user efficiency rather than computer efficiency
- Explorable Interfaces
  - Roads and landmarks
- **Fitt's Law**
  - Getting to target function of distance and size of the target
- Human-Interface Objects – not necessarily the same as software objects

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Tog's evaluation points evaluate the experience at a variety of levels. Note we have discussed Fitt's Law already and I am going to review it and present a slide on color blindness to make those points a bit more clear.



## Tog-2

- Latency reduction
- Learnability
- Limit Tradeoffs
- Metaphors
- Protect the User's Work
- Readability
  - Presbyopia
- Track State
- Visible Interfaces

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I also will provide you more info on latency reduction – we all dislike waiting for a response! Presbyopia, the condition of hardened, less flexible lenses, coupled with reduced light transmission into the eye, affects most people over age 45. Again one should design for the broader population and always try to make your user experience reach the largest possible percentage of the population. State also is important, here is a list of questions you should explore regarding state and the user experience:

Whether this is the first time the user has been in the system

Where the user is

Where the user is going

Where the user has been during this session

Where the user was when they left off in the last session



## Color Blindness

- Red, blue and green cones in eye = color vision
  - ~10% males color blind
  - Protanopia, red ones not working
  - Deutanopia, green ones not working
  - Tritanopia – blue ones not working (rare) – can't depend on yellow blue differentiation
- Secondary cues can consist of anything from the subtlety of gray scale differentiation to having a different graphic or different text label associated with each color presented. What about traffic lights!

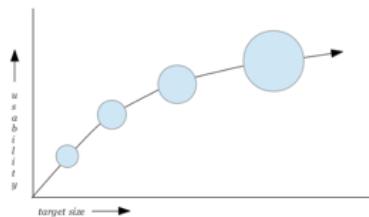
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I find this whole concept amazing. It is stunning that only one percent of the female population is color blind whereas about 10% of the male population is color blind!



## Fitt's Law

- Fitts Law, model of human hand movement - time for hand movement dependent on distance moved, D, and target size, W. Doubling distance is longer, but not twice as long and increasing the size of target makes pointing easier
  - $MT = a + b \log_2(D/W+1)$ , MT = movement time, a = start/stop time of device, b = device speed. There are variants



<http://sixrevisions.com/usabilityaccessibility/improving-usability-with-fitts-law/>

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You saw this last week but as Maeda states, repetition is good!



## Latency Reduction

- All button clicks provided visual/aural feedback w/in 50 msec
- **Animated Hourglass** for .5-2 sec
- Provide potential wait time for > 2 sec and provide progress indicator
  - Opportunity for tips
- >10 sec duration, when done visual and auditory indication
- Trap multiple clicks of a button

**Important slide a keeper**

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These are great heuristics to insure that you are providing a pleasant user experience. Note that if the user has to wait for more than 10 seconds they probably are attending to another task, so they needed to have a very explicit indicator when the task has been completed.



## Usability Laboratories

- Can rent them
- Most corporations should have them - test their own products and products they use (few do)
- Lab + observation room (think aloud technique)
- Mall based surveys
- Portable Labs

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Big corporations have usability laboratories that have two way mirrors and mock ups of common venues, e.g. a living room for the cable company. There also are labs you can hire and some focused have actually setup user survey folks in malls. Again, these exerts must be reviewed by a committee to insure you are respecting the participant and their privacy. AT&T once had a large usability lab next to Spaceship Earth at Disney World. They would ask families if they would like to participate in a study and participants would receive gifts and free dinners.



## Usability Tests

- Paper mockups
- Discount usability testing - Q&D, 3 to 6 folks, early in design
- Competitive usability testing - A vs B
- Universal usability testing - Microsoft beta
- Field tests and portable labs - key
- Remote usability testing send stuff - phone interviews and web surveys
- Can you break this-**managers**
- Issue: first time usage and limited coverage of features, should be supplemented by expert review

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Many of you are probably using these first few techniques. Paper mockups are great at the very early stages of design to provide a user with the interface concepts, while you simulate the flow by handing the user new pages. Likewise many of you may interview only a few folks each time – more is usually always better but you can get decent information, early on with a few, so long as those few are not members of the development group. The 3-6 should be drawn from the target population(s). Competitive testing is great when you have competing designs and you would like to see which is better. Field tests are key because you are testing it in the actual setting it will (hopefully) eventually be used. The rest we have covered previously and expert reviews are a nice supplement especially if you feel that any of the others were insufficient.



## Usability Tests

- Who? (peers early, “real” users, alone, pairs, teams)
  - 5+1(spare)
  - Incentives
  - Screening (profile)
- How?
  - Pre approval, ethics, legal details (non-disclosure, ...)
  - Scripted - read to participant (minimize exogenous variables)
  - Schedule (time between)
  - Task cards
  - Roles (greeter, observer, facilitator(flight attendant), note taker, equipment operator, recruiter)
  - Post questionnaire/sessions
  - Evaluate quickly -- may forget details

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Just a list of things to consider when setting up the usability tests, especially in a corporate setting.



## Rosenthal Effect

- You can influence results, the act of observing, is a change of the normal situation
- Randomly selected children told teachers they did well in IQ test, sure enough, the next year ...
- Milgram experiment -- effect of authority
- University of Iowa lab

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Be careful that you do not influence users, questions such as isn't this great are inappropriate. The second bullet refers to a study where teachers at a grade school were told that several students did well in an IQ test, when actually they were selected randomly. At the end of the year the teacher's grades and comments, for those students showed a much more dramatic improvement than the other students when compared to the previous year. We have already covered the Milgram Experiment. One last story relates to my interviewing for graduate schools. I was offered a position at the University of Iowa. The professor in charge insisted that all of his graduate research students cut their hair and wear white coats to provide a uniform impression to the participants. He did not want hair or clothes to influence the results of the experiments for reasons we already discussed. I rejected that offer and went to the University of Pittsburgh instead ☺.



## Cognitive Walkthroughs

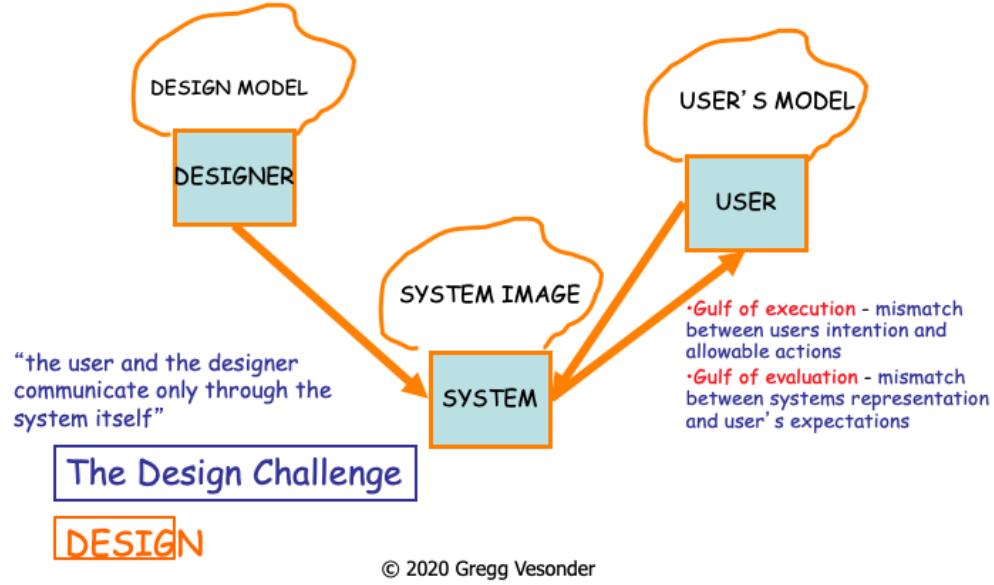
How does the user know what to do next? Is correct action evident/recognized or does it have to be recalled?	Is there anything that tells you what to do next?
Will the user connect description of correct action with what she/he is trying to do?	Is a choice available that matches what you want to do? Which is it?
Does the systems response indicate whether user made wrong or right choice?	Now that you tried it, did it do what you expected?

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These are really great questions, note it is very much in the Gulf of execution and evaluation spirit



## Knowledge in the World and in the Head



So what devices do we use to convey information from the system to the user and then permit the user to interact with the system.



## Analysis

- (observe, compare, listen, measure)
- Data collection must be very systematic
  - Automatic collection of timings
  - Systematic: form based coding by observer, sampling, time slices (activity during)
- Coding scheme
  - Pre established rules (use prototypes)
- Verbal scoring scheme inter-rater reliability
- Statistical tests - descriptive, inferential
- Conclusions based on success criteria and analysis plan
- So much more ...

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We will be going through some of this in our statistics session, which covers descriptive statistics. I do not expect that you will compute inferential statistics, but if you are familiar with them – go for it! If you are observing participants, be certain that you have a predetermined coding scheme for what constitutes a behavior. For example a person must stay n seconds on a web page to be marked as visited. If you score what folks say you must have a scoring scheme that multiple scorers can use with high inter rater agreement. Of course your E factors heavily in this.



## Acceptance Tests

- Go/No Go, need measurable criteria:
  - Time to learn specific functions
  - Speed of task performance
  - Error rate
  - User retention of commands over X interval
  - Subjective user satisfaction
  - Reliability
- Often adversarial

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Of course even after significant testing, there still should be an acceptance phase, final beta, first application whatever the local term is to ascertain that the interface meets the needs of the users (and also satisfies the requirements).



## Lifecycle Evaluation

- Focus groups
- Logs
  - Usage frequency
  - Errors
  - Privacy
- If help desk, then logs and emerging problems
- Suggestion boxes of all types
- Discussion groups and news groups
- Periodic, explicit evaluation

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Your job as user experience designer should not end when you deliver the product. Logs are essential, as is meeting with and observing users. Of course you can also elicit user input in a variety of ways.



## Psychological Research

- Deal with practical problem w/in theoretical framework
- State a lucid, testable hypothesis
- Identify independent variables to be manipulated
- Identify dependent variables to be measured
- Judiciously select participants and carefully or randomly assign participants to groups
- Control for biasing factors - or at least note them
- Apply statistical methods for data analysis (should have a plan)
- Resolve the problem (hopefully), refine theory and method, give advice on future work

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These are the steps to do psychological research and this technique is best used to address larger questions, such as discovering whether a mouse or a trackball is best for certain classes of tasks.



Well-planned evaluations are driven by  
*goals* which aim to seek answers to clear  
*questions* ...

## DECIDE

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The key to evaluation is understanding the goals of the user experience and asking questions related to the goals. I want to reduce errors and does my menu configuration accomplish that when contrasted with the current menu system? So one uses evaluation to DECIDE ...



Determine the goals  
Explore the questions  
Choose the evaluation approach and methods  
Identify the practical issues  
Decide how to deal with the ethical issues  
Evaluate, analyze, interpret and present **ALL** the data

Onto gaining acceptance for your work

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Just a convenient memory trick to use when evaluating your evaluation. So in some ways this “ends” the HCI process, although you should be constantly in touch with your user base. Now that you know the process, how do you convince your peers and your management to focus on user experience?



## Simple Statistics

- Mean, median & mode – central tendency
- Standard deviation – dispersion
- Correlation

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At one time when teaching the course, I used to list these topics and suggest that folks review these if they have forgotten them. Then I included a few questions concerning these concepts on a test and folks did poorly. After that I decided to do a more extensive review of these concepts. Why? Because they are core skills you need to present any data and, in your projects, you should strive to use as much data as possible and gain insight about what you are measuring.



## Measures of Central Tendency

- **Measures of central tendency are a summary of a whole distribution of events or measurements.**
  - Mean (aka average) just add and divide by number of scores:  $8, 5, 5, 4, 3, 2, 2, 1 = 31/8 = 3.75$
  - Median is the middle value when scores are sorted in order
    - What happens if you have an odd number of scores, even number of scores?
    - Answer to above is 3.5
  - Mode is the number that occurs most frequently - what is the mode for the series above?

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The most common statistic one usually uses and sees is the average. The average is just one measure of “representative” performance or what statisticians would call, measures of central tendency. The median is the middle value when all the data is sorted. When you have an odd number of data items you simply take the middlemost item. When you have an even number of data items you average the two data items on either side of the mid point. Finally the mode is the data item value that occurs most frequently. What is the mode for the series on the slide? Answer on next page.

The mode is best used on categorical (aka nominal) data where values of the scale have no numeric meaning - for example the most frequently occurring number on the jerseys of baseball players, the distribution of gender in a university, marital status in a population, ...

The median is best used on ordinal data where the data can be ordered but there is not a uniform difference between the nth and nth+1 positions. For example star product ratings on amazon.com. Do we really know that the interval between two stars and three stars is the same as between three stars and four stars?

The median can also be used for interval data where there is a uniform difference between the nth and nth+1 positions. For example temperature in degrees Fahrenheit. You can also use a mean if the data is symmetrical.

Finally rational data is best characterized by a mean if symmetrical and a median if not. In ratios there is a rational zero point for the scale and the ratio of 2 to 1 is the same as 8 to 4 (twice as much). Length or distance is an example.

Actually there are many more measures of central tendency: geometric mean, harmonic mean, weighted average.



## Why 3 Measures of Central Tendency?

- Mean is the most common
- But if there are outliers – one, or a relative few, very high or very low numbers they will influence the mean and the median is a better choice
- For categorical data (non numeric), e.g., colors, the mode, most frequent color, is the obvious choice, but also can be instructive on numerical data – bi-modal

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The answer to the mode question is 5 & 2!

A bit more information on when you would use these techniques.



## Measures of Dispersion

- Range - difference of largest and smallest, 8, 5, 5, 4, 3, 2, 2, 1: range =  $8-1 = 7$ , but it is best to also show the range 1-8
- Mean deviation - calculate mean get absolute difference of each number from mean (3.75) and divide by number of scores:  $(4.25+1.25+1.25+.25+.75+1.75+1.75+2.75)/8 = 1.75$
- Standard deviation is square root of the variance, variance =  $\Sigma(x-\mu)^2/n-1$  , std dev = 2.252
  - If I added more variability in the data 12, 5, 4, 3, 2, 2, 1, 1, even though mean is same, standard deviation is 3.6154 and mean deviation is  $(8.25 + 1.25 + .25 + .75 + 1.75 + 1.75 + 2.75 + 2.75)/8 = 2.438$

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Measures of dispersion indicate how variable your data is. It provides yet another indication of how representative your measure of central tendency is. Note the red - 1 in the calculation of standard deviation, this adds uncertainty (variability) to the measure, indicating that it is a sample and not the complete population. It is good practice to report BOTH measures of central tendency and measures of dispersion in your data reports.



## Correlation

- Correlation coefficient, 
$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{n})(\sum Y^2 - \frac{(\sum Y)^2}{n})}}$$
- Data set 1: (1, 8) (2, 15) (3, 20) (4, 25)  
 $r=.996$
- Data set 2: (10, 5) (20, 3) (30, 2) (40, 1)  $r=-.982$
- "inferring causality from simple correlations is an extremely dangerous pastime!"- Underwood

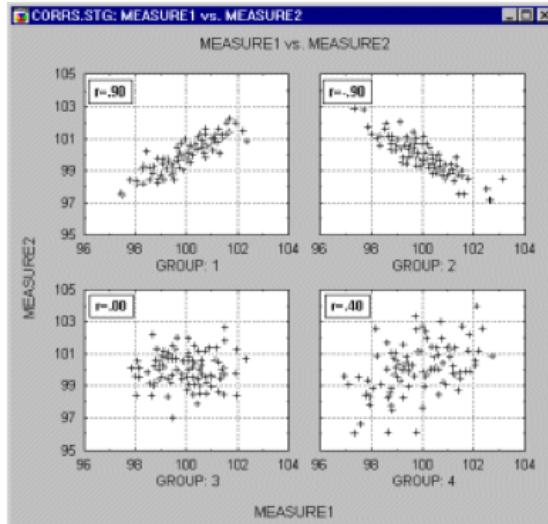
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Correlations provide a way of understanding how one variable varies with another. (By the way you will not be required to memorize these formulas, you can always find them!) The next page provides visualizations of different sorts of correlations. Graphing really helps! One caution is that just because two variables are correlated does not mean that manipulating one variable causes an effect in the other variable, as Benton Underwood, a famous experimental psychologist, cautions.

# Examples of Correlations



<http://www.statsoft.com/textbook/stbasic.html>



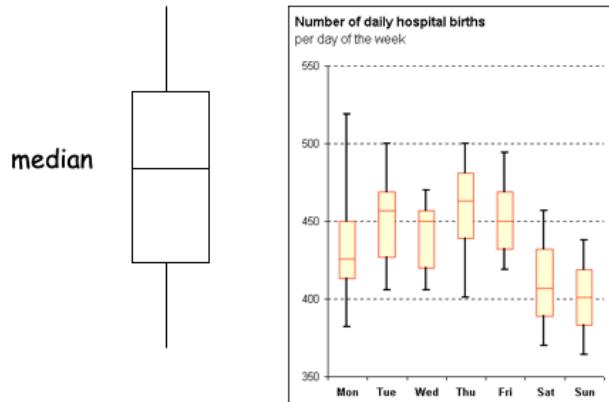
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I found these examples at <http://www.statsoft.com/textbook/stbasic.html>. If you plot the two variables you can “see” the presence, absence and type of correlation. The upper left hand quadrant shows a graph of a positive correlation because of the positive slope - slope is the relationship of what increases in X (the horizontal axis) do to Y(the vertical axis). It is positive if an increase in X results in an increase in Y. The slope is negative (and the correlation is too) if increases in X result in decrease in Y. If there is no correlation, the correlation coefficient moves to zero and there is no relationship between X and Y - usually showing up on the graph as a circle of points, with no negative or positive pattern. BY the way this type of plot is often called a scatterplot which I think is a great term.



## Simple Box Plots

- A method for combining descriptive statistics



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 From: <http://www.internetwhite.com/charts/boxplots/boxplot.htm>

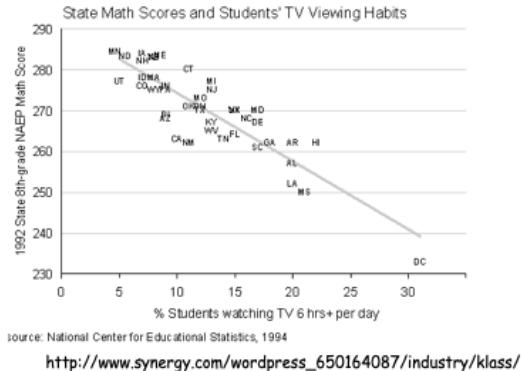
Box plots are simple ways to show dispersion and central tendency. The horizontal line in the middle is the median and the rectangles on either side of it each represent the 25<sup>th</sup> percentile above and below the median. The vertical lines extending from these percentile boxes represent the rest of the data with the lowest and the highest representing the entire range of collected data. Box plots present a lot of information in a concise form.

Bottom and top of box first quartile and third quartile



## Graph Conventions

Dependent Variable



Independent Variable  
 (discrete:continuous::barchart:line)  
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Some conventions on graphing data. The x axis is the independent variable that is experimentally varied, e.g., different designs. The dependent variable is what you are measuring: number of correct responses, reaction time, number of errors, time to complete task, .... If the measures are discrete, can be expressed as integers, one usually depicts with bar charts whereas if they are continuous, real numbers such as time, one uses lines.



# Visual Depiction

- Tufte is the master

EDWARD R. TUFTE

VISUAL EXPLANATIONS



IMAGES AND QUANTITIES. EVIDENCE AND NARRATIVE

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There are many good books on data visualization but Tufte's are the best!



## References

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