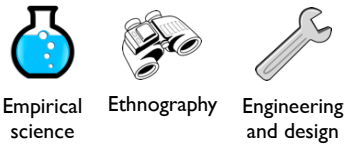
Announcements

- Applied for this course: 45 students vs. our capability: 30 students
  - Limitation: manpower to give detailed feedback to the assignments (7 submissions) and ideal group size (3–4 students/group)
- Compromise: Off-loading learning responsibility to you!
  - Groups of 6–7 students ⇒ Communication overload and other problems
  - You are responsible to organize your groups

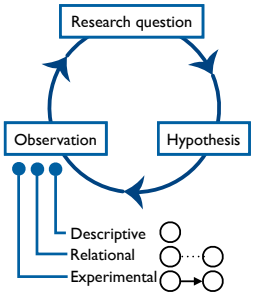
    Issues: Load-balancing, communication, sharing documents, drop-outs

    Strategies: Divide & Conquer, Mirroring
- Do: Find yourself a group for the first assignment, download the group registration form from our website, fill in the details and email Chat by tomorrow 17:00
  - You will be unregistered from the class if you cannot find a group
  - You are prohibited to stay in the same group for assignment 1–3
  - You may freely choose your group for the mini project

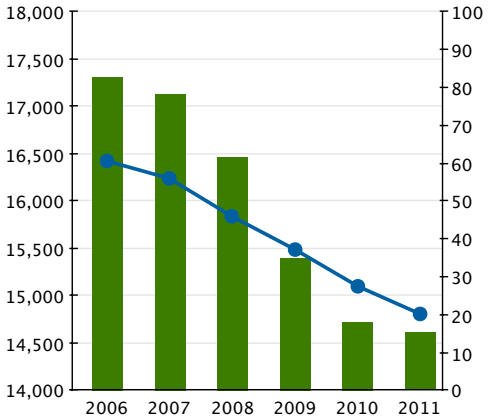
Last Tuesday in Current Topics…



- Three approaches to HCI research
- Three steps in the empirical science approach
- Three strategies in the planned observation

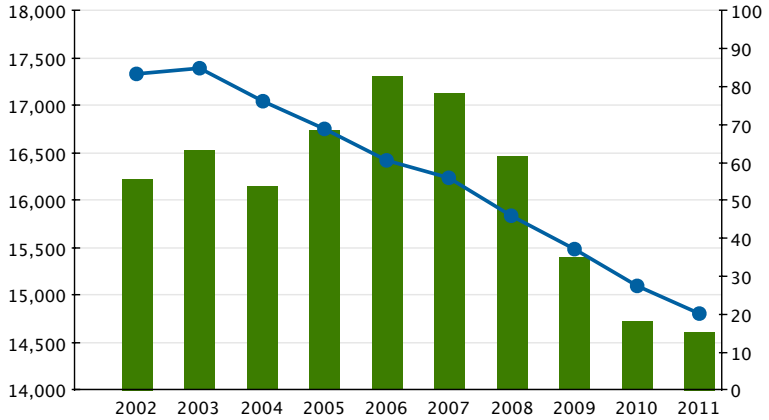


Correlation Does Not Imply Causation



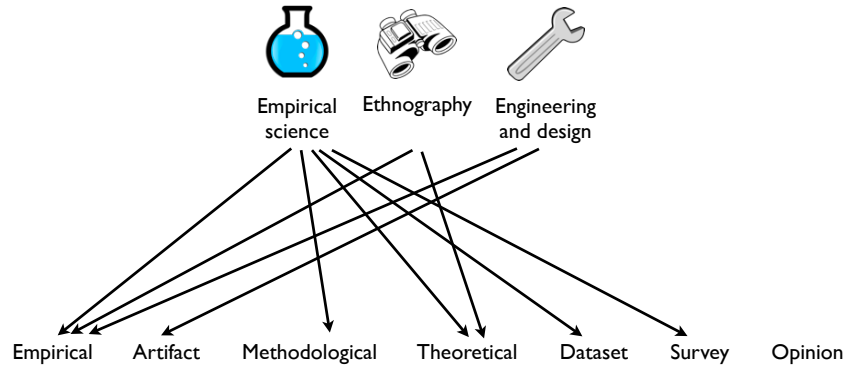
Adapted from a tweet of @altonncf with data from FBI and W3Schools

Correlation Does Not Imply Causation



Adapted from a tweet of @altonncf with data from FBI and W3Schools

Research Approaches vs. Contribution Types



Seven Research Contribution types
[Wobbrock, 2014]

In-Class Exercise: Contributions and Benefits

Vulture: A Mid-Air Word-Gesture Keyboard
Markussen et al., CHI 2014

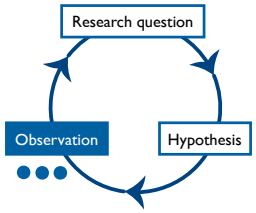
"Word-gesture keyboards enable fast text entry by letting users draw the shape of a word on the input surface. Such keyboards have been used extensively for touch devices, but not in mid-air, even though their fluent gestural input seems well suited for this modality. We present Vulture, a word-gesture keyboard for mid-air operation. Vulture adapts touch based word- gesture algorithms to work in mid-air, projects users' movement onto the display, and uses pinch as a word delimiter. A first 10-session study suggests text-entry rates of 20.6 Words Per Minute (WPM) and finds hand-movement speed to be the primary predictor of WPM. A second study shows that with training on a few phrases, participants do 28.1 WPM, 59% of the text-entry rate of direct touch input. Participants' recall of trained gestures in mid-air was low, suggesting that visual feedback is important but also limits performance. Based on data from the studies, we discuss improvements to Vulture and some alternative designs for mid-air text entry."

Vulture: A Mid-Air Word-Gesture Keyboard
Available at:
https://www.youtube.com/watch?v=7CKJ6B_dFhc

In-Class Exercise: Contributions and Benefits

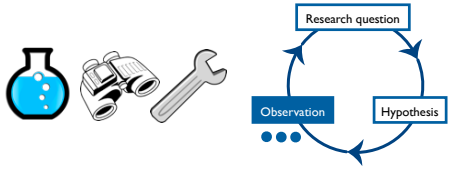
- Contributions & Benefits:
  - "Presents an empirical evaluation of the potential for Word-Gesture Keyboards (WGKs) in mid-air text entry and compares how performance compares to touch based WGKs." [Markussen et al., CHI 2014]

Experimental Research



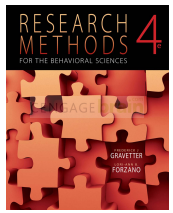
- Purpose: To infer cause-and-effect relationship
- Controlling independent variable
- Observe the change in the dependent variables
- In-class exercise: recall the following experimental designs
  - Between-group vs. within-group
  - Benefits and drawbacks
- More details in next lecture

From the last lecture

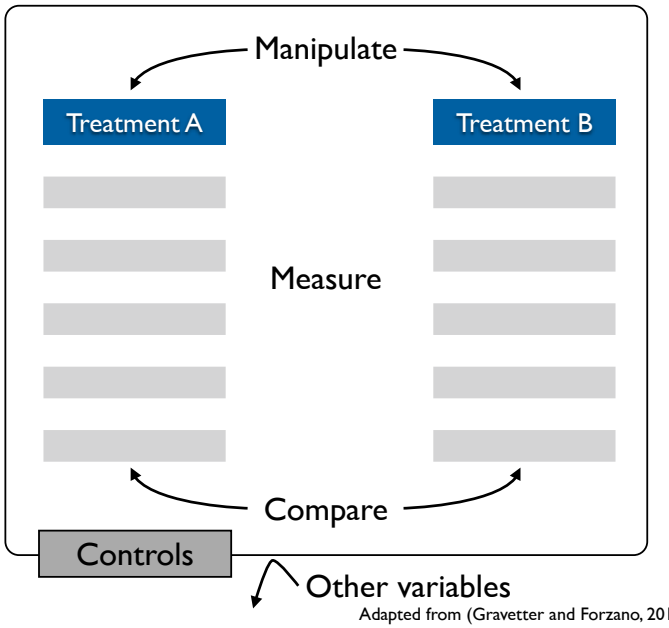


Experimental Research in HCI

Illustrated through Text Entry Research



Further reading:
Research Methods for the Behavioral Sciences (Gravetter and Forzano, 2012)



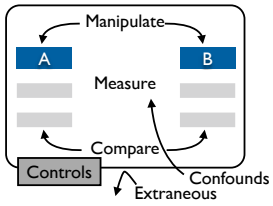
Adapted from (Gravetter and Forzano, 2012)

Basic Elements of Experimental Study

- Manipulation: Changing the value of the independent variable to create treatment conditions
- Measurement: Measure the value of the dependent variable in each treatment condition
- Comparison: The score of one treatment condition is compared with another. Consistent differences between treatments ⇒ evidence of causality
- Control: Other variables are controlled to be sure that they do not influence the two variables being examined

Definitions from (Gravetter and Forzano, 2012)

Variables



- Independent variable is manipulated by the researcher
- Dependent variable is observed for changes to assess the effect of the independent variable
- All other variables: extraneous variables
- A confounding variable is an extraneous variable that changes systematically along with IV and DVs ⇒ alternative explanation of the relationship between the two variables

Scales of Measurement

- Nominal scale: discrete, qualitative, categorical differences, ignoring the order
  - E.g., input techniques: mouse vs. touchscreen (IV), whether the user made an error or not (DV)
- Ordinal scale: sequentially ranked categories, ignoring magnitude of differences
  - E.g., size of keyboard buttons (IV), Likert (5-point) scale answers* (DV)
- Interval scale: sequentially organized categories, all categories have the same size (possible to determine relative distances)
- Ratio scale: interval scale that zero represents complete absence (possible to determine absolute distances)
  - E.g., Task completion time in seconds (DV), error rate in percent (DV)

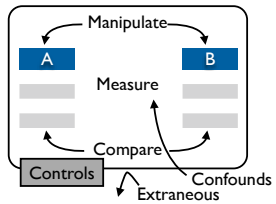
* Can be treated as ordinal (strictly according to the definition) or interval (empirically verified over 50 years to be OK)

Dealing Extraneous Variables

- Include them as IVs ⇒ too many experimental conditions!

Leave as random	⟷	Control
Reflects variation in natural use		Higher confidence to infer causality in the results
↑ external validity		↑ internal validity

Validity



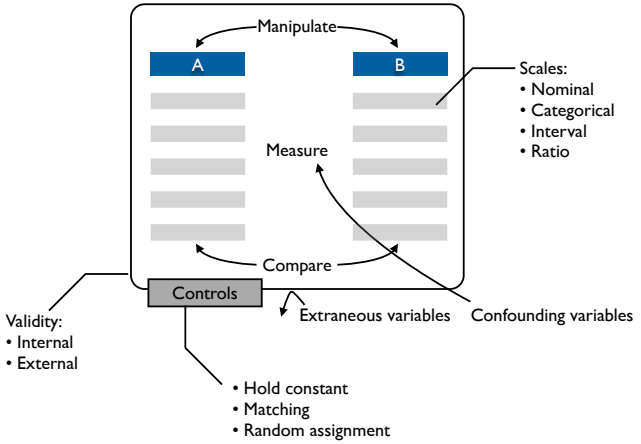
- A study has internal validity if it produces a single, unambiguous explanation for the relationship between two variables
  - Threats: e.g., confounding variables, experimenter bias, learning effect, Hawthorne effect (being observed causes the changes)
- External validity refers to the extent to which we can generalize the results to people, settings, times, measures, and characteristics other than those used in that study
  - Threats: e.g., generalizing across participants, multiple IVs interference
- Always a trade-off, strike an appropriate balance depending on the goal of your research

Definitions from (Gravetter and Forzano, 2012)

Controlling Extraneous Variables

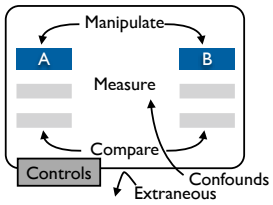
- Hold constant, e.g., selecting participants in the same gender/age
- Matching the same number of participants with the same extraneous variable
  - E.g., gender, age, or level of expertise
- Random assignment of participants to treatment conditions
  - Other random assignment, e.g., time slot

Basic Elements of Experimental Study



Example: Text Entry Research

- You have designed a new keyboard layout, and you want to know how good it is
- Strategy: compare it with existing techniques
- Basic research questions
  - How fast is it?
  - How accurate is it?
  - How satisfied the users are?
- In-class exercise: Identify
  - Independent variables
  - Dependent variables
  - Extraneous variables and potential confounding variables



Dependent Variables in Text Entry Experiments

- Speed
- Accuracy

Trade-off

- Qualitative feedback
  - Comfort
  - Device impressions
  - Report as anecdotes or quotes
- In-class exercise:
  Give an operational definition of each variable, and indicate on which scale it is measured

Speed Measures: Words per Minute

$$\text{WPM} = \frac{|T| - 1}{S} \times 60 \times \frac{1}{5}$$

$|T|$ Length of the transcribed string

-1 Timing begins after the first character was pressed

S Duration in seconds

$\frac{1}{5}$ Estimated length of a word: 5 characters including spaces (Yamada, 1980)

\+ Easiest measure, you just need a watch

– Disregards errors in the final text

- Alternative: insist on the user correcting all errors, but may lead to user frustration

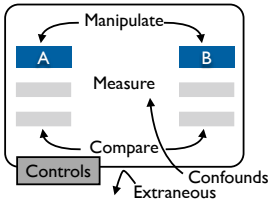
– Disregards the process of entering

- E.g., it doesn't matter how many times you pressed the backspace key.

```
there will be some fog tonight
```

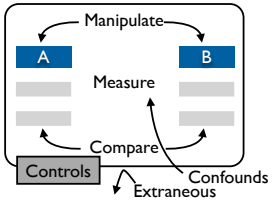
```
there w_
```

Text Entry Tasks



- Composition: user create his own text
  - More realistic
  - Users may take inconsistent durations to think about what to write
  - Error identification is difficult
- Transcription: copy text
  - Exclude behaviors that may compromise the measures, e.g., pondering what to write
  - Allows identifying error because the content is known
  - Can control the distribution of letters and words
- Read and memorize a short sentence before entering
  - Reduce participants' tendency to switch between the displayed text and the entry text field
  - Faster typing but the overall experiment takes longer due to the memorizing [Kristensson & Vertanen, IUI'12]

Standard Dataset for Transcription Task



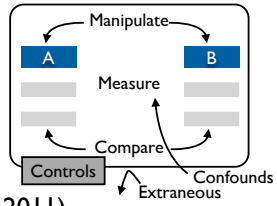
- MacKenzie and Soukoreff (CHI 2003)
- 500 English phrases in moderate length, easy to remember, and representative of the target language (in term of letter frequency correlation)
- Ignore case and enter all characters in lowercase.

\+ Allows replication

- Examples:

```
there will be some fog tonight
round robin scheduling
time to go shopping
frequently asked questions
```


Standard Dataset for Transcription Task



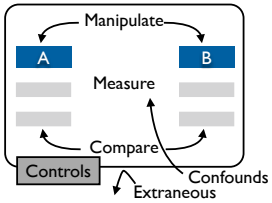
- EnronMobile: Vertanen & Kristensson (MobileHCI 2011)
- 200 sentences extracted from real-world mobile phone text entry (BlackBerry QWERTY), tested for memorability and representative character distribution of mobile texting

+ Better external validity for mobile phone text entry studies

- Examples:

MacKenzie & Soukoreff	EnronMobile
there will be some fog tonight	Thanks, I will look at it tonight.
round robin scheduling	Interesting, are you around for a late lunch?
time to go shopping	Are you going to join us for lunch?
frequently asked questions	Thanks for the surprise

Text Composition Task



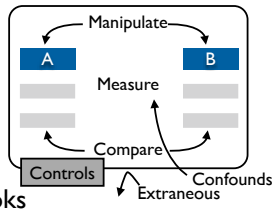
- Problem:
  - Users may take inconsistent durations to think about what to write
  - Error identification is difficult
- Vertanen and Kristensson (TOCHI 2014) characterizes and fine-tune text composition task with four experiments with Amazon Mechanical Turks
- Composition task variants:
  - Copy, reply, situational composition, free composition, aiding communication
- Instructions variants
  - E.g., "Say the intended message before typing" or "Do not use slang"
- Results: Composition tasks take longer and have more edits

Text Composition Task

- Task description is adequate to control the quality
  - "Imagine you are using a mobile device and need to write a message. We want you to invent and type in a fictitious (but plausible) message. Use your imagination. If you are struggling for ideas, think about things you often write about using your own mobile device

    Please write complete sentences with good grammar and spelling. Do NOT use texting abbreviations or slang."
- Error identification: Use median score from multiple judges or crowdsourcing

Real-world Text Entry

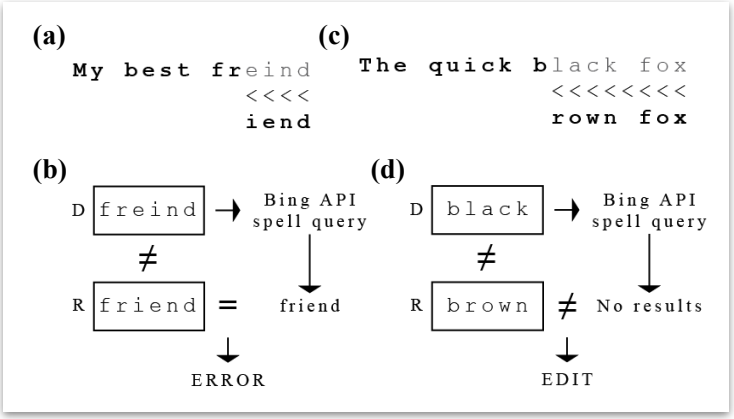


- Evans and Wobbrock, CHI 2012
- Observe keyboards and mouse with low-level hooks
- Segmenting trials by heuristics
  - Segment on Enter key, end-of-sentence punctuations, and pauses
  - At least 24 characters

    Close to average length of the MacKenzie & Soukoreff phrase set
- Use online search engine for distinguishing edits from errors and to calculate uncorrected error rate
- Found correlation between the WPM and error measures extracted from this method and the lab study

+ Better external validity

Real-world Text Entry



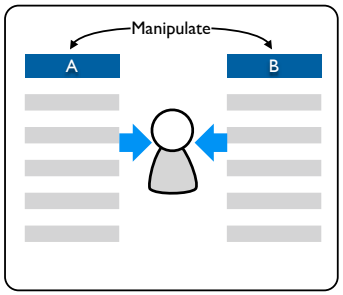
[Evans and Wobbrock, CHI 2012]

Basic Experimental Designs

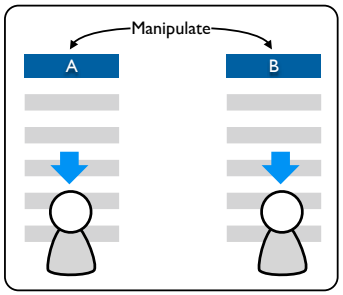
From DISI

- Between-subjects design
  - Each subject only does one variant of the experiment
  - There are at least 2 groups to isolate effect of manipulation:
    Treatment group and control group
  - \+ No practice effects across variants
    Good for tasks that are simple and involve limited cognitive processes, e.g., tapping, dragging, or visual search
  - – But: requires more users
- Within-subjects design
  - Each subject does all variants of the experiment
  - \+ Fewer users required, individual differences canceled out
    Good for complex tasks, e.g., typing ,reading, composition, problem solving
  - – But: practice effects may occur

Basic Experimental Designs



Within-subjects design



Between-subjects design

Order Effects

- Within-subjects design
- The behavior may be influenced by experience that occurred earlier in the sequence
- Carryover effects: changes caused by the lingering aftereffects of an earlier treatment condition.
  - E.g., Testing the first condition causes users finger to hurt, degrading their performance in the second condition
- Progressive error: changes that are related to general experience in the study but unrelated to specific treatments
  - Practice effects and fatigue
  - E.g., The experiment overall takes too long

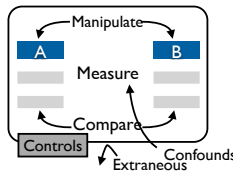
Counterbalancing

From DIS1

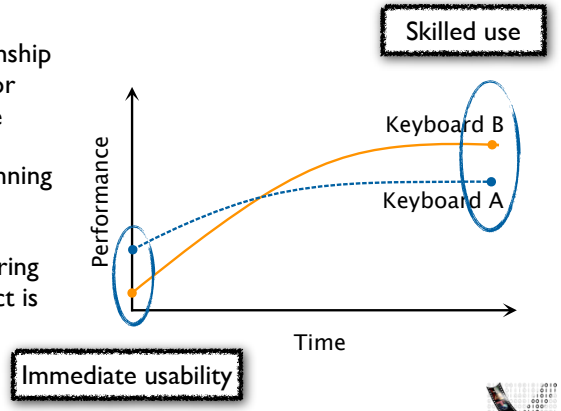
- Use every possible order of treatments with an equal number of individual participants
- Latin Square
  - Each condition appears at each ordinal position
  - Each condition precedes and follows each condition one time
  - Example: six treatments: A, B, C, D, E, F

1	A	B	F	C	E	D
2	B	C	A	D	F	E
3	C	D	B	E	A	F
4	D	E	C	F	B	A
5	E	F	D	A	C	B
6	F	A	E	B	D	C

Learning Curve



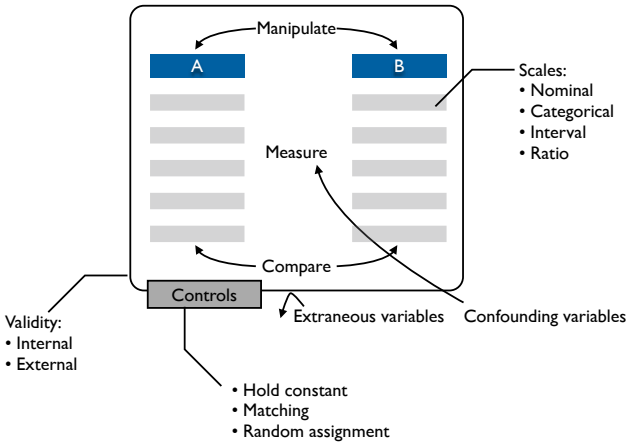
- Learning curve: relationship between experience (or time) and performance
- Rapid raise at the beginning follow by a plateau
- In general, start measuring when the learning effect is gone!



Experimental Design in Text Entry Research

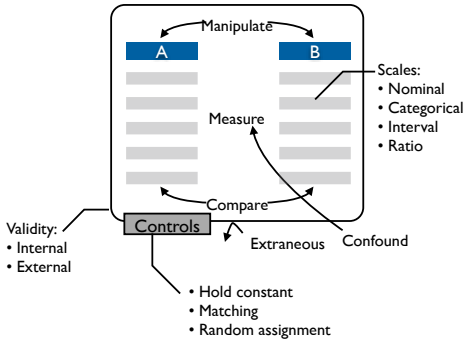
- Usually preferred: within-group design
  - Minimizes confounding effects from the behavioral differences between participants
- Sometimes, we need a between-groups design
  - E.g., when testing whether a keyboard favors users with right-handedness over those with left-handedness
  - When there are interferences between conditions, e.g., different keyboard layouts on the same hardware

Basic Elements of Experimental Study in Text Entry Studies



Reverse-Engineer An Experimental Study

- Gestures and widgets: performance in text editing on multi-touch capable mobile devices
- Fuccella et al., CHI '13
- Contributions & Benefits
  - "We present the design and evaluation of a gestural text editing technique for touchscreens. Gestures drawn on the soft keyboard are often faster than conventional editing techniques."



What You Need To Do Now

- Read this paper this week
  - Evaluation of Text Entry Techniques — MacKenzie, 2007
- Optional reading
  - Complementing Text Entry Evaluations with a Composition Task — Vertanen and Kristensson, TOCHI 2014
  - Measures of Text Entry Performance — Wobbrock, 2007
- First assignment is out tomorrow!
  - Identifying contributions and benefits of research articles
  - Find yourself a group for the first assignment, download the group registration form from our website, fill in the details and email Chat by tomorrow 17:00
  - Submission deadline for peer review: April 23