Human Computer Interaction

UNIT-4
Lecture 2:
Empirical Research Methods in HCI

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Introduction to Empirical Research - II

Objective

- In the previous lecture, we got introduced to the concept of empirical research
  - Which is observation-based investigation
  - In the context of HCI, it refers to investigation about the usability of a system with end users

Objective

- The investigation is based on testable research questions
  - We saw how to formulate appropriate questions (the validity of questions, the trade-off and how to resolve the trade-off)
- We also discussed the process of observation and measurements

Themes of Empirical Research

- To recap, the three themes of empirical research are
  - Answer and raise questions (testable research questions)
  - Observe and measure (ratio scale of measurement is preferable)
  - User studies

Themes of Empirical Research

- In the previous lecture, we discussed about the first two themes (answer and raise questions, observe and measure)
- The third theme (user studies) is equally important since we perform observations in such studies

User Study

- A user study, in the context of HCI, is a scientific way of collecting and analyzing observational data from end users on an interactive system
- Collection of data involve experiments and design of experiments

Experiment Design

- Experiment design is a general term referring to the organization of variables, procedures, etc., in an experiment
- The process of designing an experiment is the process of deciding on which variables to use, what procedure to use, how many participant to use, how to solicit them etc.

Terminology

- Terms to know
  - Participant
  - Independent variable (test conditions)
  - Dependent variable
  - Control variable
  - Random variable
  - Confounding variable
  - Within subjects vs. between subjects
  - Counterbalancing and Latin square

Participant

- The people participating in an experiment are referred to as participants
  - When referring specifically to the experiment, use the term participants (e.g., “all participants exhibited a high error rate…”)
  - General comments on the problem or conclusions drawn from the results may use other terms (e.g., “these results suggest that users are less likely to…”

Independent Variable

- **An independent variable** is the manipulated variable in an experiment.
- It's called "manipulated" because it's the one you can change. In other words, you can decide ahead of time to increase it or decrease it.
- In an experiment you should only have one manipulated variable at a time.
- Examples include device, feedback mode, button layout, visual layout, gender, age, expertise, etc.
- The terms independent variable and factor are synonymous

Test Conditions

- The levels, values, or settings for an independent variable are the test conditions
- Provide names for both an independent variable (factor) and the test conditions (levels) for the controlled variable (see examples below)

Factor	**Levels (test condition)**
Device	Mouse, trackball, joystick
Feedback mode	Audio, tactile, visual
Task	Pointing, dragging
Visualization	2D, 3D, animated

Dependent Variable

- The dependent variable (DV) is just like the name sounds; it *depends* upon some factor that you, the researcher, controls. For example:
  - How well you perform in a race depends on your training.
  - How much you weight depends on your diet.
  - How much you earn depends upon the number of hours you work.
- "(Independent variable) causes a change in (Dependent Variable) and it isn't possible that (Dependent Variable) could cause a change in (Independent Variable)."

Dependent Variable

- A variable representing the measurements or observations on a independent variable
- It is required to provide a name for both the dependent variable and its unit
  - **Examples:** Task completion time (ms), speed (word per minute, selections per minute, etc), error rate (%), throughput (bits/s)

Control Variable

- Circumstances or factors that might influence a dependent variable, but are not under investigation need to be accommodated in some manner.
- One way is to control them or to treat them as control variables (e.g., room lighting, background noise, temperature)

Random Variable

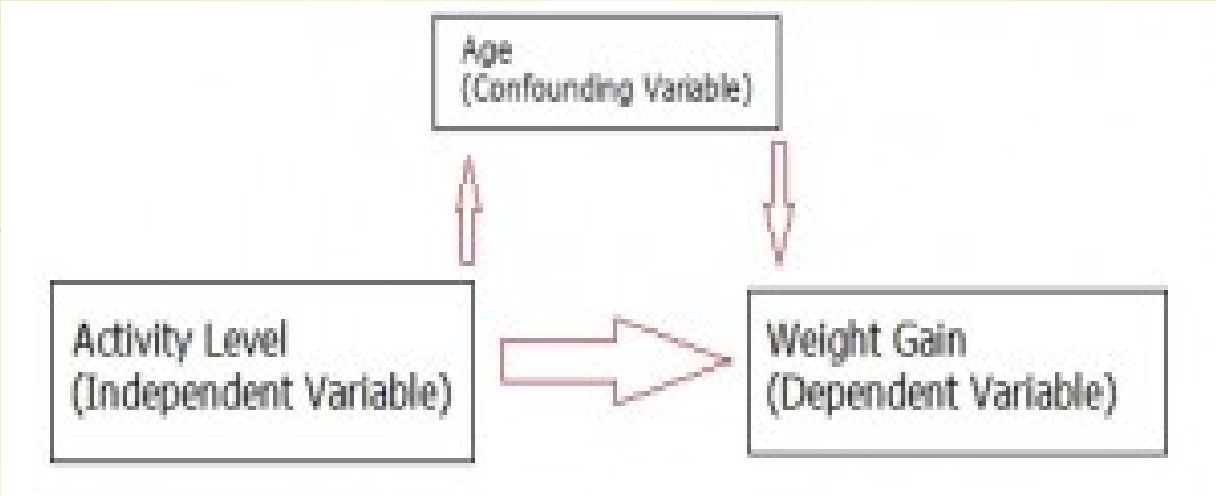
- Instead of controlling all circumstances or factors, some might be allowed to vary randomly
- Such circumstances are random variables

Confounding Variable

- Any variable that varies systematically with an independent variable is a confounding variable

  – For example, if three devices are always administered in the same order, participant performance might improve due to practice; i.e., from the 1st to the 2nd to the 3rd condition; thus "practice" is a confounding variable (because it varies systematically with "device")

Confounding Variable



- In an experiment, the independent variable typically has an effect on your dependent variable.
- For example, if you are researching whether lack of exercise leads to weight gain, lack of exercise is your independent variable and weight gain is your dependent variable.
- Confounding variables are any other variable that also has an effect on your dependent variable.

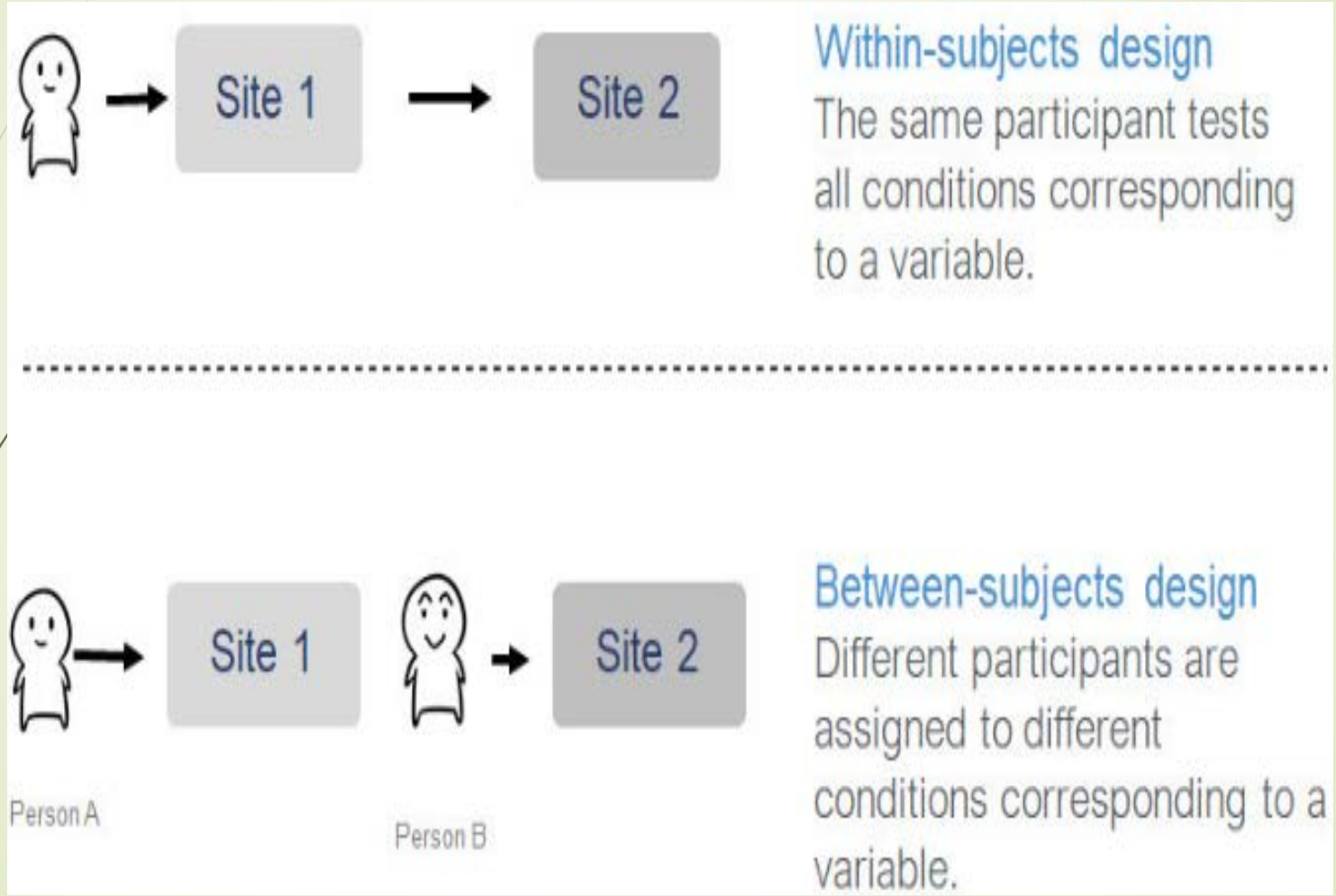
Within Subjects, Between Subjects

When you want to compare several user interfaces in a single study, there are two ways of assigning your test participants to these multiple conditions:

- **Between-subjects** (or **between-groups**) study design: different people test each condition, so that each person is only exposed to a single user interface.
- **Within-subjects (or repeated-measures)** study design: the same person tests all the conditions (i.e., all the user interfaces).

Within Subjects, Between Subjects

Condition 1 Condition 2



Within Subjects, Between Subjects

- A relevant question is, which of the two approaches (within subject and between subject) should be chosen in designing an experiment
- **Answer: It depends!**

  –Sometimes a factor must be between subjects (e.g., gender, age)

  –Sometimes a factor must be within subjects (e.g., session, block)

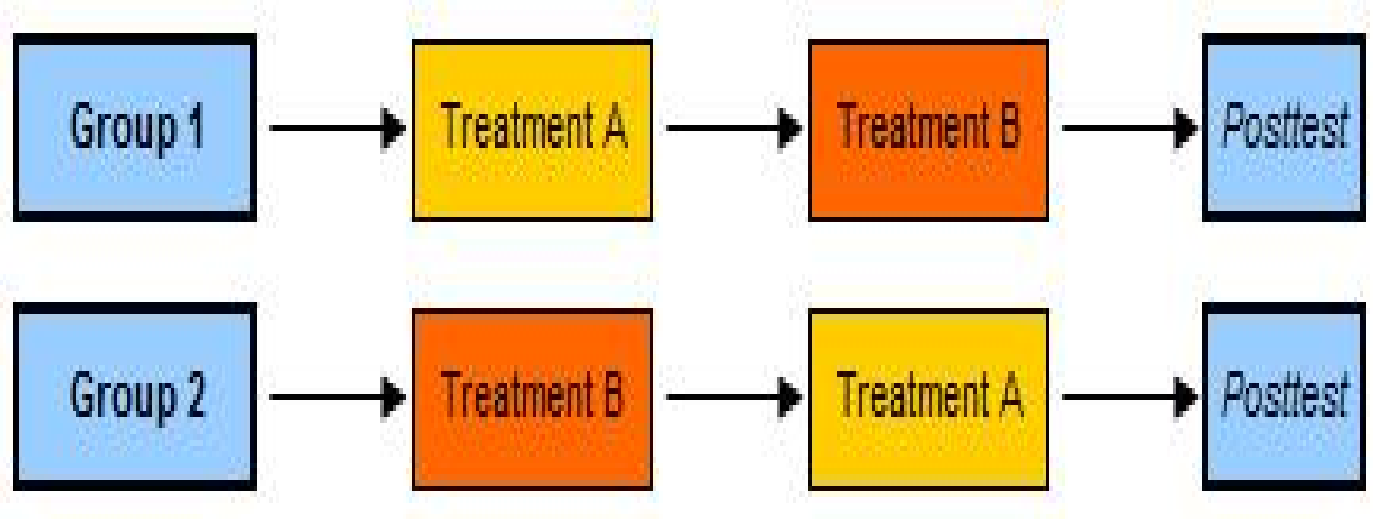
  –Sometimes there is a choice. In this case there is a trade-off
- The advantage of within subject design is, the variance due to participants' pre-dispositions should be the same across test conditions
- Between subjects design, on the other hand, has the advantage of avoiding interference effects (e.g., the practice effect while typing on two different layouts of keyboards)

Counterbalancing

- For repeated measures designs, participants' performance may tend to improve with practice as they progress from one level to the next.
  - Thus, participants may perform better on the second level simply because they benefited from practice on the first (this is undesirable)
- To compensate, the order of presenting conditions is counterbalanced.

Counterbalancing

- The simplest type of counterbalanced measures design is used when there are two possible conditions, A and B. As with the standard repeated measures design, the researchers want to test every subject for both conditions. They divide the subjects into two groups and one group is treated with condition A, followed by condition B, and the other is tested with condition B followed by condition A.



Latin Square

- Participants are divided into groups, and a different order of administration is used for each group.
- The order is best governed by a Latin Square (The defining characteristic of a Latin Square is that each condition occurs only once in each row and column).

Latin Square

- Example: suppose we want to administer 4 levels (denoted by A, B, C and D) of a factor to 4 participants (represented by P1, P2, P3 and P4)
  - We can construct a 4×4 Latin square arrangement to depict the order of administering the levels to each participant

P1	A	B	C	D
P2	B	C	D	A
P3	C	D	A	B
P4	D	A	B	C

Latin Square

- In a *balanced* Latin Square, each condition both precedes and follows each other condition an equal number of times
  - We can construct a balanced 4×4 Latin square arrangement for the previous example

P1	A	B	C	D
P2	B	D	A	C
P3	D	C	B	A
P4	C	A	D	B

Expressing Experiment Design

- Consider the statement “3 x 2 repeated-measures design”
  - It refers to an experiment with two factors, having three levels on the first, and two levels on the second. There are six test conditions in total. Both factors are repeated measures, meaning all participants were tested on all test conditions
- Any type of experiment is expressed similarly