CMPT 363: User Interface Design
Summer 2021

Week 10: Analytical Evaluation: Cognitive Walkthrough & Fitts' Law

Instructor: Victor Cheung, PhD

School of Computing Science, Simon Fraser University

Recap from Last Lecture

- Cognition
  - Attention, perception, memory, …etc.
- Cognitive frameworks
  - Distributed cognition, external cognition, embodied interaction

- Group-Instructor Meeting
  - It was great meeting you "in-person"! Hope the announcement for highlights of clarifications/questions helped

Assignment 2

- Individual assignment (available on Canvas https://canvas.sfu.ca/courses/60307/assignments/588189)
- Due on July 23, 11:59p
- Come up with 2 Questions & Answers based on materials we covered
  - Marked based on relevance, level, and clarity
- Part 1 (not marked, optional)
  - Submit 1 question by July 14 to get some feedback
- Part 2
  - Submit your actual work

Today

- Analytical evaluation
  - Cognitive walkthrough
  - Fitts' Law
  - GOMS & KLS
  - Involving users implicitly

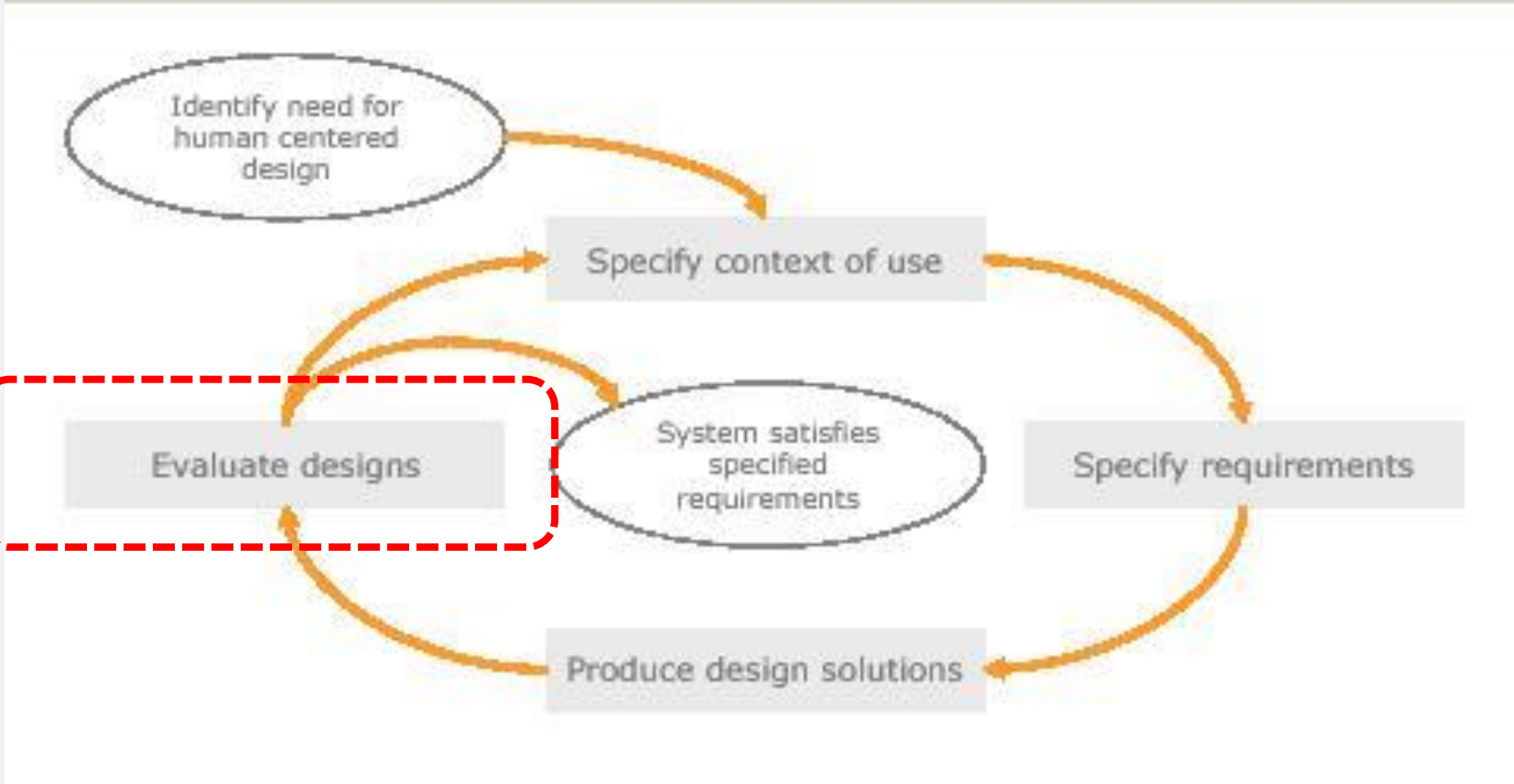
WE GATHERED REQUIREMENTS,

WE HAVE OUR DESIGNS,

WE HAVE OUR PROTOTYPES,

NOW WHAT?

The Human-Centered Design Process



ISO 13407:1999

Involving Users in Every Step

- Understand/specify context of use
  - Interview users & examine tasks
- Specify requirements
  - Verify & prioritize with users

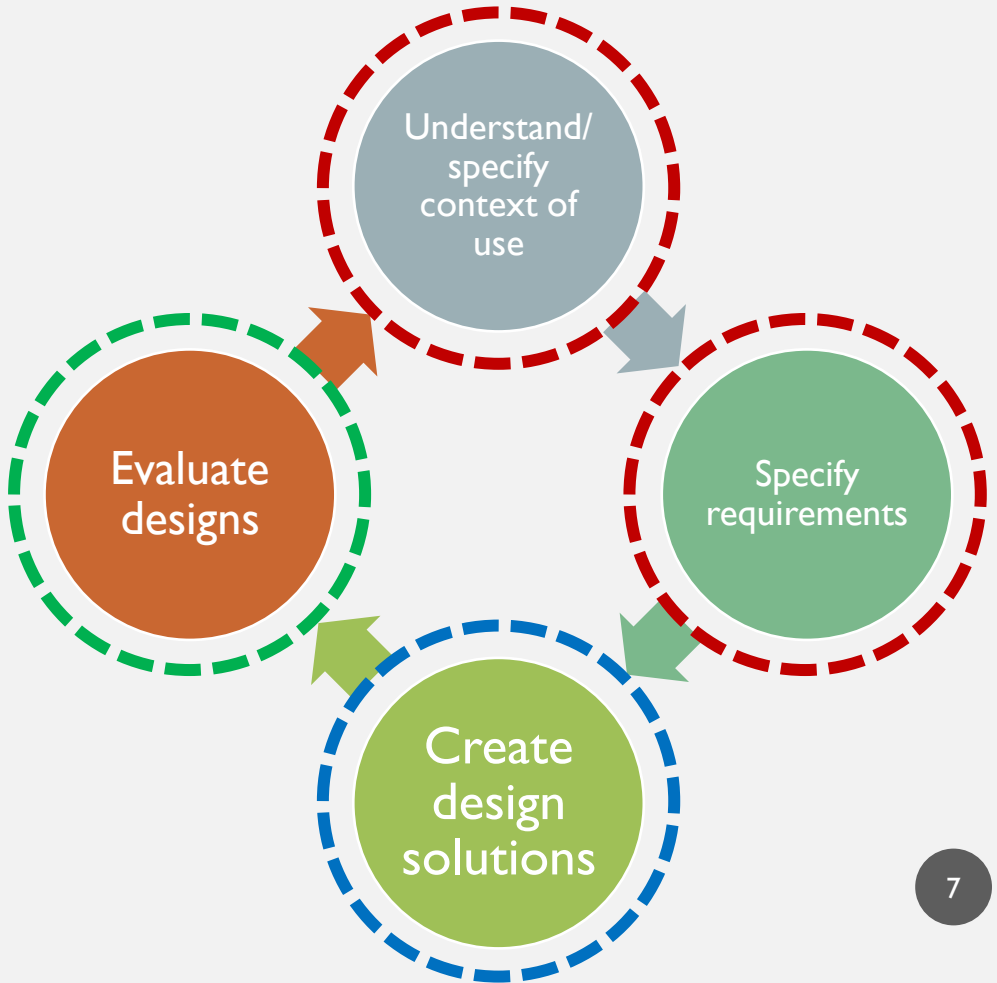
Week 4

- Create design solutions
  - Design with users (co-design)

Week 5

- Evaluate designs
  - Invite users to assess

Week 10



(Week 2) Types of Evaluation (ID-Book Ch 14.3)

- Controlled settings directly involving users
  - Usually done in labs to provide the most control (mostly called usability testing/studies/experiments)
- Natural settings involving users
  - Usually done outside labs where the interface is designed to be used at (mostly called in-the-wild studies)
  - Can either have user doing specific tasks as instructed or just observe how they work with minimal interference
- Any settings not directly involving users
  - Consultants/field experts instead of users (mostly called analytical evaluation)

(Week 2) Analytical Evaluation

- Done without involving users, instead by experts to predict user behaviour and to identify usability problems based on knowledge of usability, users' behaviour, the contexts in which the system will be used, and the kinds of activities that users undertake (ID-Book, 14.3.3)
- Useful for uncovering key design issues before usability testings are conducted
- Examples:
  - Heuristic Evaluation (covered in Week 2, practiced in assignments)
    - Experts evaluate the user interface using guidelines to "inspect" its usability
  - Cognitive Walkthrough (covering it today)
  - Fitts' Law Analysis (covering it today)

Cognitive Walkthrough

ID-Book Ch. 16.2.2

Another Way to Conduct Analytical Evaluation

- Consultants/field experts (e.g., designer, UX researchers) instead of users
- Focus on ease of learning and other aspects related to cognition (i.e., attention, perception, memory, …etc.)
- Focus more on identifying specific user problems at a detailed level (task-specific)
  - In contrast to heuristic evaluation that uses a set of common guidelines to look for general design/usability issues

https://www.interaction-design.org/literature/article/how-to-conduct-a-cognitive-walkthrough

Main Steps of Cognitive Walkthrough

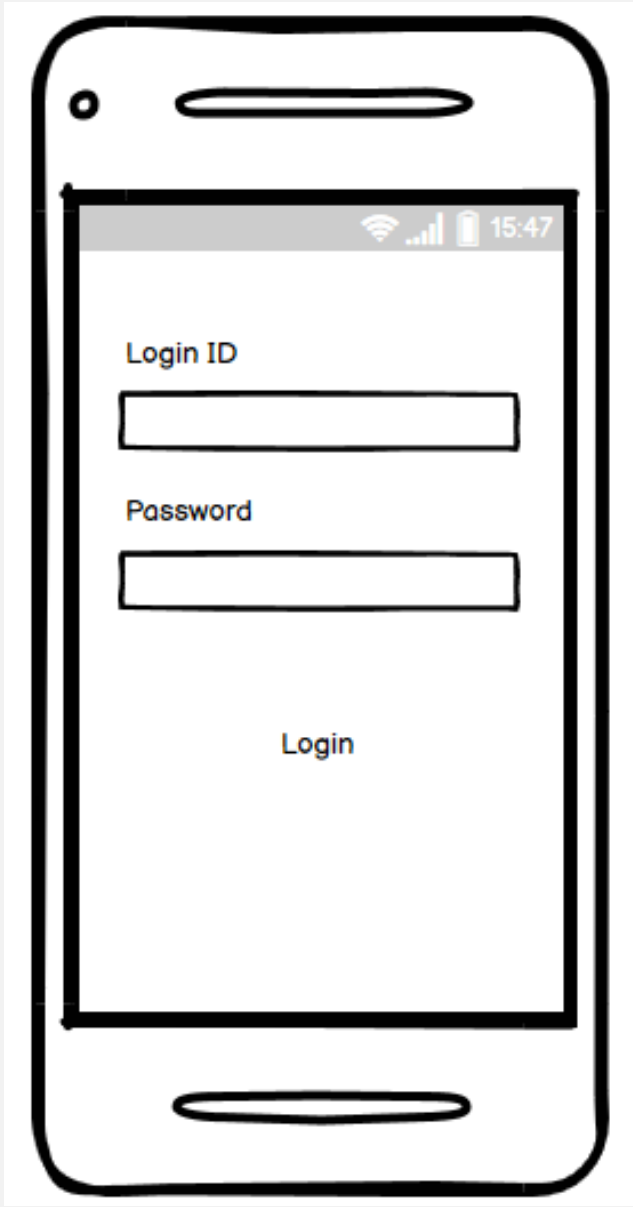
1. Identify & document typical users, sample tasks exposing aspects of designs to be evaluated, and prototypes
2. Gather designers & UX researchers (non-users)
3. The UX researchers walk through the action sequences for each task, placing themselves in the context/scenario, and for each action try to answer the following 4 questions:
    1. Will the correct action be sufficiently evident to the user? (know what to do)
    2. Will the user notice the correct action is available? (see how to do it)
    3. Will the user associate the correct action with the outcome they expect to achieve? (understand what is happening-1)
    4. Will the user interpret the response correctly and see progress from the correct action? (understand what is happening-2)
4. Compile results including problems identified and suggestions for improvement
5. Revise design to fix problems or improve. May contact users to verify insights

What to Prepare for A Cognitive Walkthrough?

1. The prototype (doesn't have to be complete, but should be fairly detailed with the necessary interface components such as buttons, labels, and images, best if has some interactivity)
2. Come up with a scenario within the context, then create representative tasks supported by the prototype
3. List out actions needed to complete the tasks (e.g., "input credentials and then proceed to login to the system")
   - Describe the exact sequence of actions to identify problems users might encounter when following it
   - But not too detailed so they just need to read the action description (e.g., "click the blue button at the bottom that says login")
4. Determine who the potential/target users are
   - Know their experience & knowledge (e.g., used a similar interface before, familiar with the terminologies)
   - Know where and with what are they using the prototype

An Example

- Task: Login to the system
- Action Sequence: 1) input login ID, 2) input password, 3) proceed to login
- What can go wrong?
  - Does the user know what to put in for login ID? (Q1)
  - Does the user know where in the interface lets them to proceed? (Q2)
  - If the user figures out how to proceed, will they be able to associate the result to what they just did? (Q3)
  - If the user figures out how to proceed, will they be able to understand the response provided by the system? (Q4)



Notes on Designing for Cognitive Walkthrough

- Representative/sample tasks: select tasks that the design is intended to support
- Story/scenario: tell a believable story to motivate each action a user has to take to do the task
  - Achieved by relying on the user's general knowledge, and prompts & feedback from the interface
    - E.g., user's experience in online shopping, information in the new interface helping them to search & buy a product
  - Can be aided by storyboards, and creating a mental picture of the actual environment of use
  - If you can't find a believable story about an action, then you have located a problem with the interface
- Focus mostly on first time usage of the interface without prior training of the interface
  - Not a technique for evaluating the system over time (e.g., how quickly a user moves from beginner to expert)

Pluralistic Walkthrough

- A variation of walkthrough that involves users (a panel of users, developers, & UX researchers)
- All members step through a task scenario by assuming the role of a typical user
  - Each go through the steps by themselves without conferring with each other
  - After each step (typically a screen transition) discuss with each other the sequence of actions taken
  - Repeat until all scenarios have been evaluated
- Benefits: strong focus on users' tasks at a detailed level, synergistic redesign, more empathetic & sensitive to users' needs
- Drawbacks: hard to schedule for everyone, tend to take more time, limited to tested scenarios, developers might be defensive to criticisms

Exercise

- Poll – Which of the following comparison between Heuristic Evaluation and Cognitive Walkthrough is correct?
  - A – HE typically takes less time than CW and both HE & CW require all parts of the interface working in some way
  - B – HE typically takes more time than CW and both HE & CW require all parts of the interface working in some way
  - C – HE typically takes less time than CW and neither HE & CW require all parts of the interface working in some way
  - D – HE typically takes more time than CW and neither HE & CW require all parts of the interface working in some way

5min+5min (break)

- Go through the following steps of cognitive walkthrough
  - Come up with a typical user & a task for online shopping (e.g., 363 student buying the "Design of Everything Things" book by Don Norman)
  - Write down the steps you take to perform that task, while answering these questions:
    - Will users know what to?
    - Will users see how to do it?
    - Will the user associate the correct action with the outcome they expect to achieve?
    - Will the user interpret the response correctly and see progress from the correct action?

Fitts' Law Analysis

Paul Fitts (1912-1965)

Another Way to Evaluate An Interface

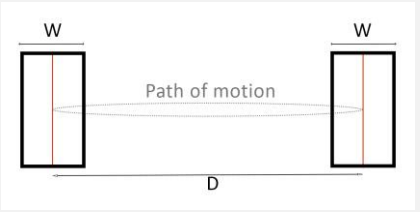
- Predictive models – the use of formulas to derive various measures of user performance
  - Without involving users
  - Without "role-playing" by user researchers
  - Without tracking behaviour using analytics
  - Produce numerical (quantitative) measurements instead of qualitative observations
    - Example: How much time is required to finish a given task, including typing and clicking certain buttons

Fitts' Law

- A mathematical model created in 1954 by Paul Fitts
- Models the act of pointing to a target on a screen and predicts how long it takes
  - I.e., the time it takes to move a pointer from its starting position to the target

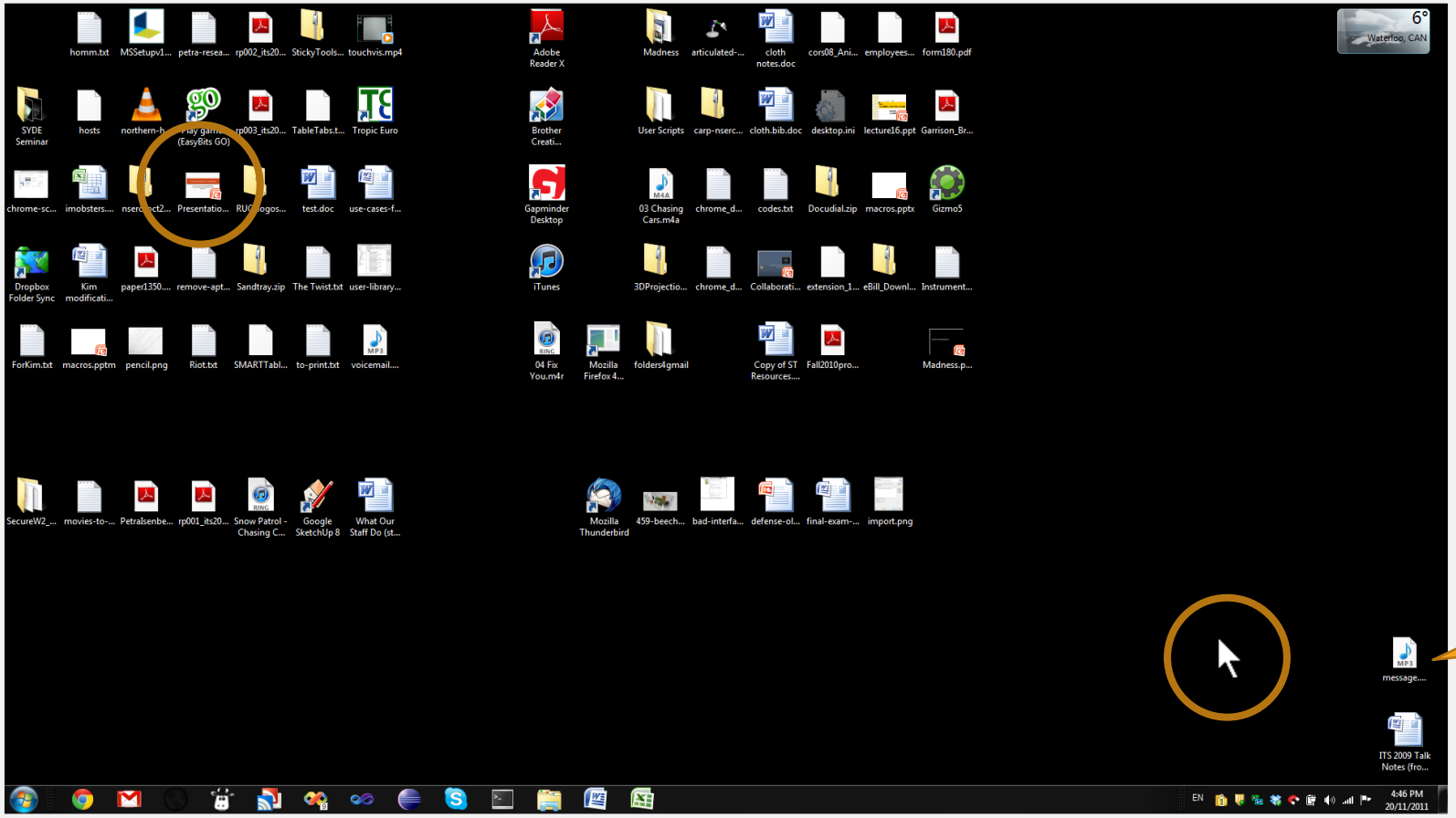
$$MT = a + b \log_2 \left(\frac{D}{W}\right)$$

- MT is the average movement time
- a & b are constants depends on the input device choice
- D is the distance from the starting position to the target centre
- W is the width of the target measured along the axis of motion



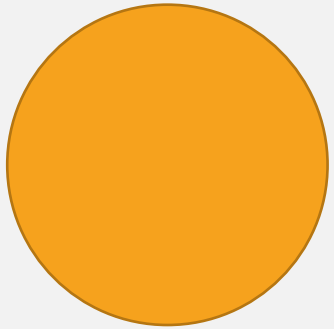
  - Watch the video in this link for application in GUI designs
    https://www.nngroup.com/videos/fittss-law/

How Difficult Is It to Reach The Presentation File?



Poll – Which Target Is More Difficult to Reach?

A: 

B: 

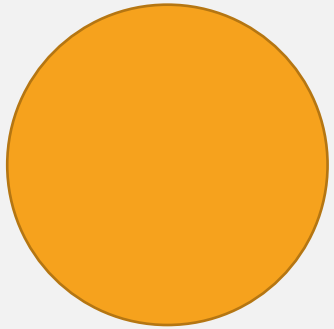
Poll – Which Target Is More Difficult to Reach?

A:

B:

Poll – Which Target Is More Difficult to Reach?

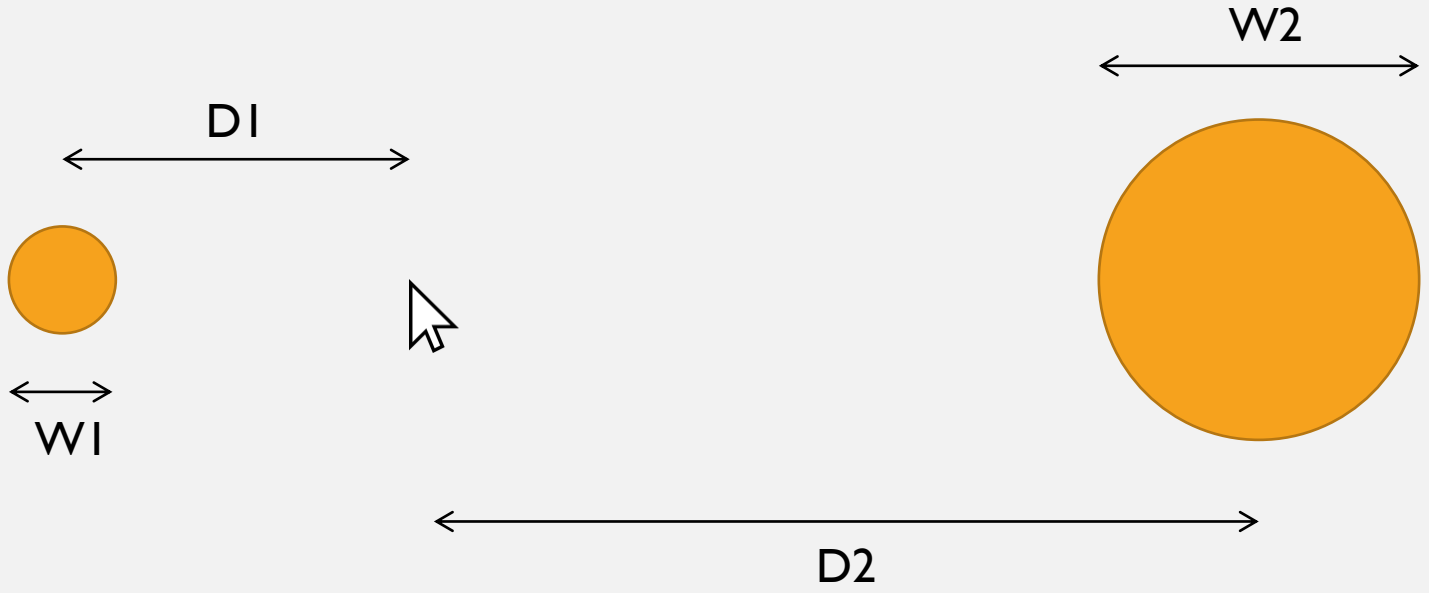
A:



B:

Core Idea of Fitts' Law: Distance & Size

- The farther a target is & the smaller it is in size → more difficult for the user to correctly acquire the target
  - Needs to physically move more
  - Needs more fine movements to prevent over shoot



Fitts' Law

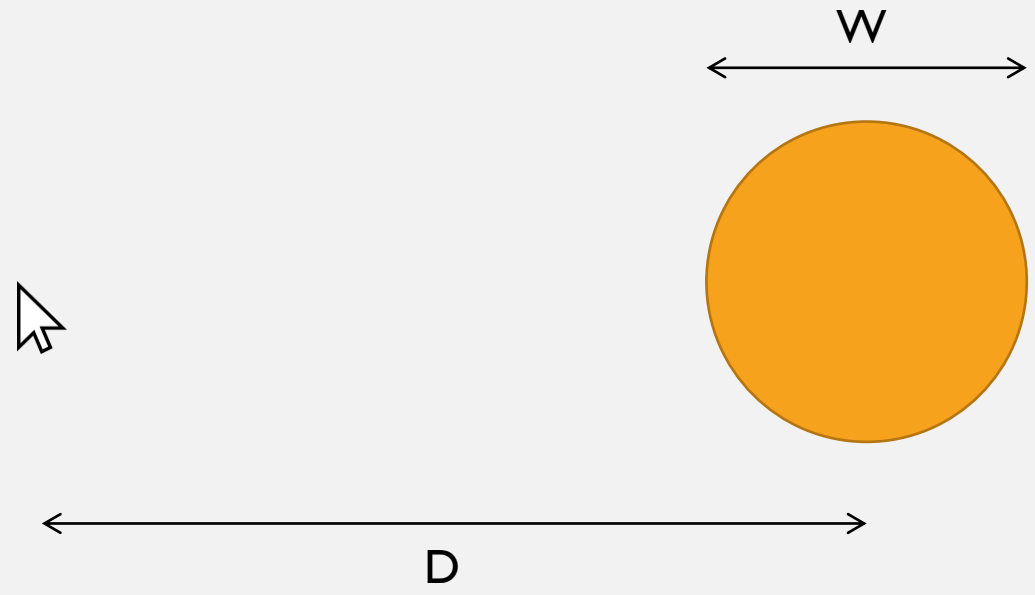
- Originally developed to determine how difficult it is to move the pointer from starting position to target
  - Target width (W)
  - Target distance (D)

$$ID = \log_2\left(\frac{D}{W}\right)$$

Target distance

Index of Difficulty (measured in bits)

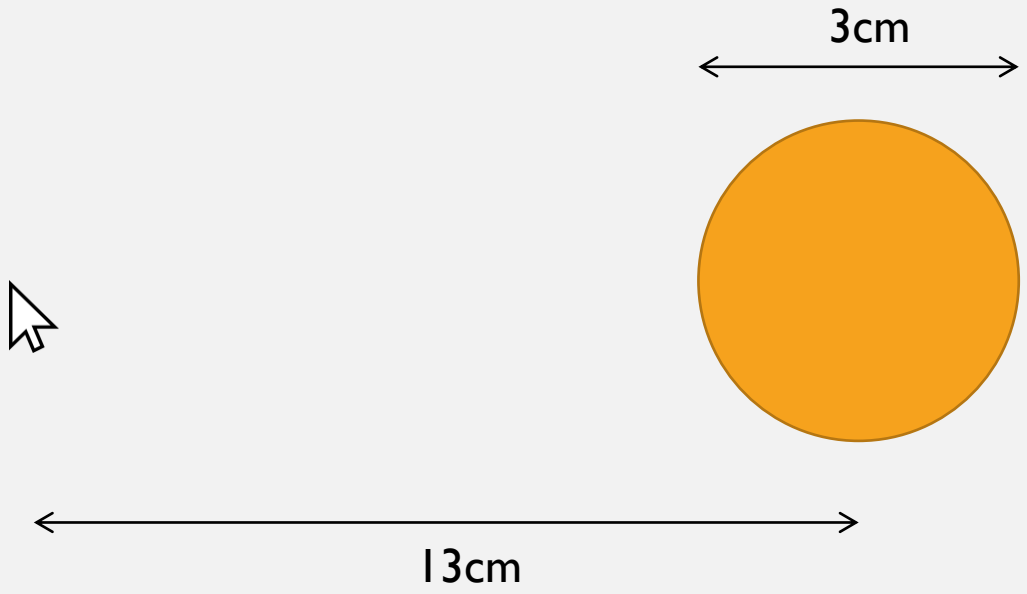
Target width



Calculating Index of Difficulty

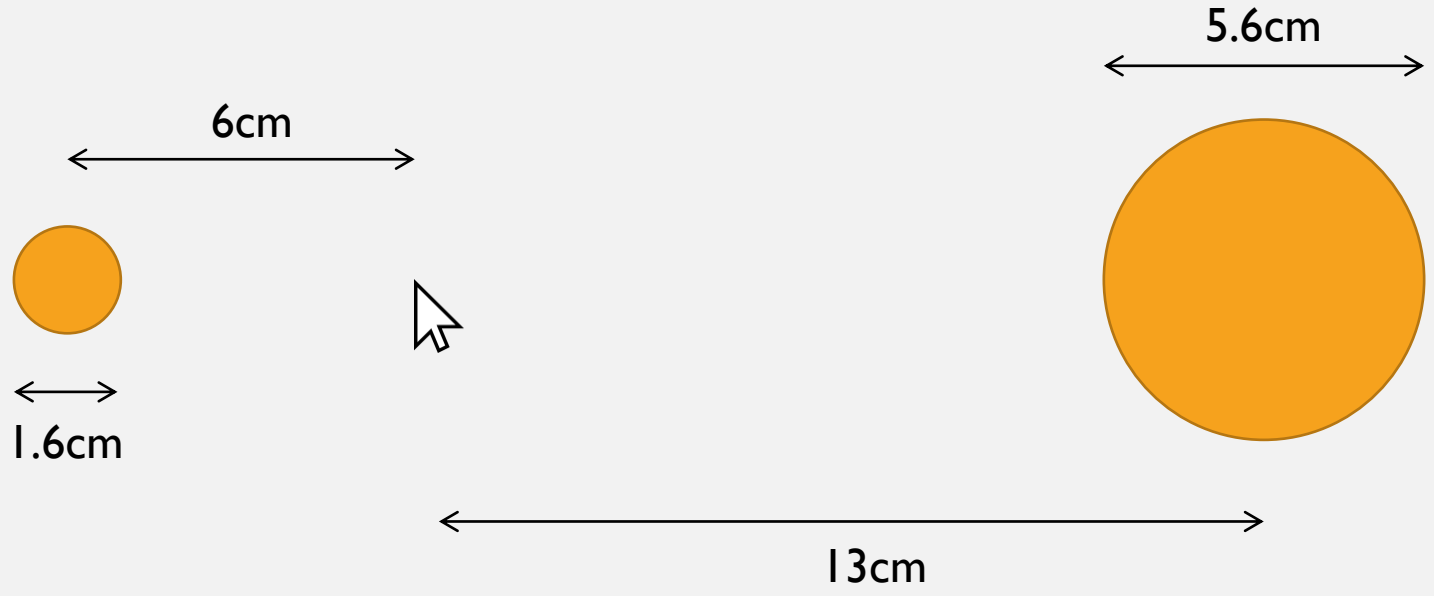
- D = 12
- W = 3

$$ID = \log_2\left(\frac{13}{3}\right) = 2.1bits$$



Quantifying Difficulty

- Allows us to compare cases like this
  - Exercise: which target is more difficult to acquire (higher index of difficulty)?



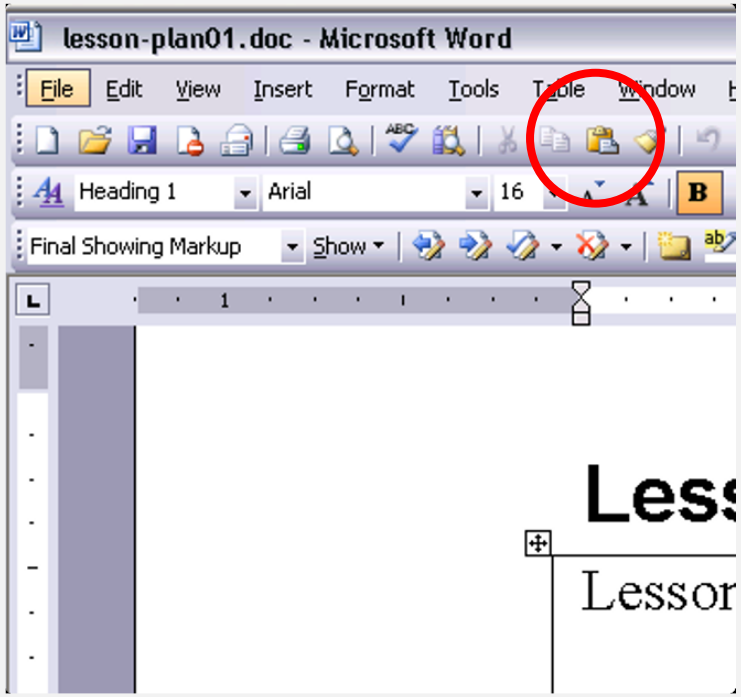
Implications of Fitts' Law on Interface Design

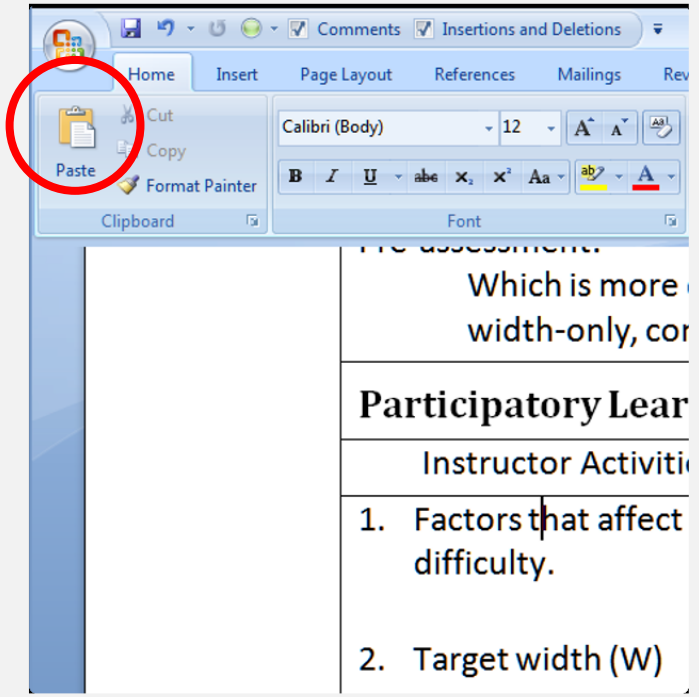
- Large targets & small distances between targets are advantageous
  - Allows user to acquire targets easier and quicker
  - Further justifies the proximity visual design guideline
- Screen elements should occupy as much of the available screen space as possible
  - Bigger targets and can reach any one from any point easier and quicker
- Use corners/sides as "hot zones" (aka pinning)
  - Because of the constraints of the edges these targets have infinite widths as users will never overshoot

- Watch this for a bit more https://www.youtube.com/watch?v=95RoKSFyQ_k

Examples of Easier & Faster UIs Due to Fitts' Law

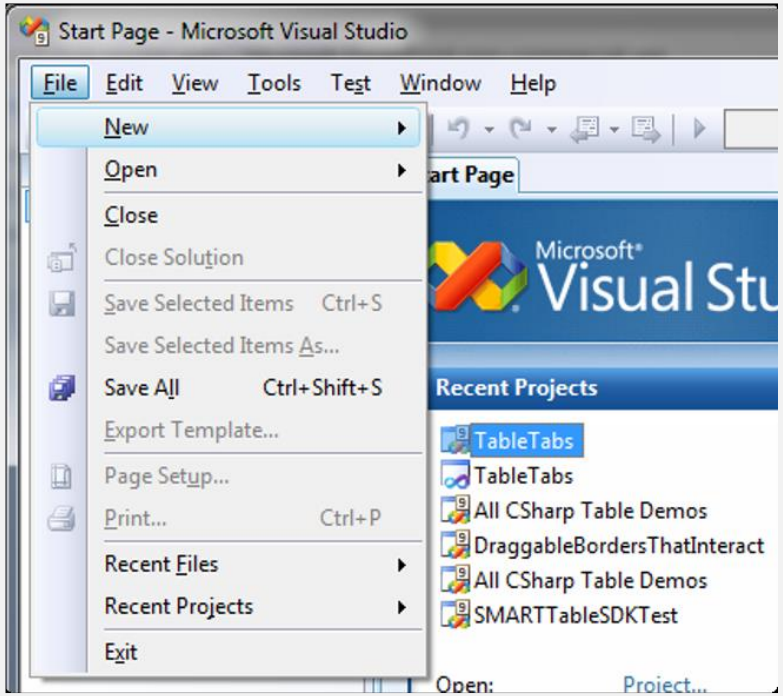
- Example 1: Access to the paste button (Left: Word 2003, Right: Word 2007)

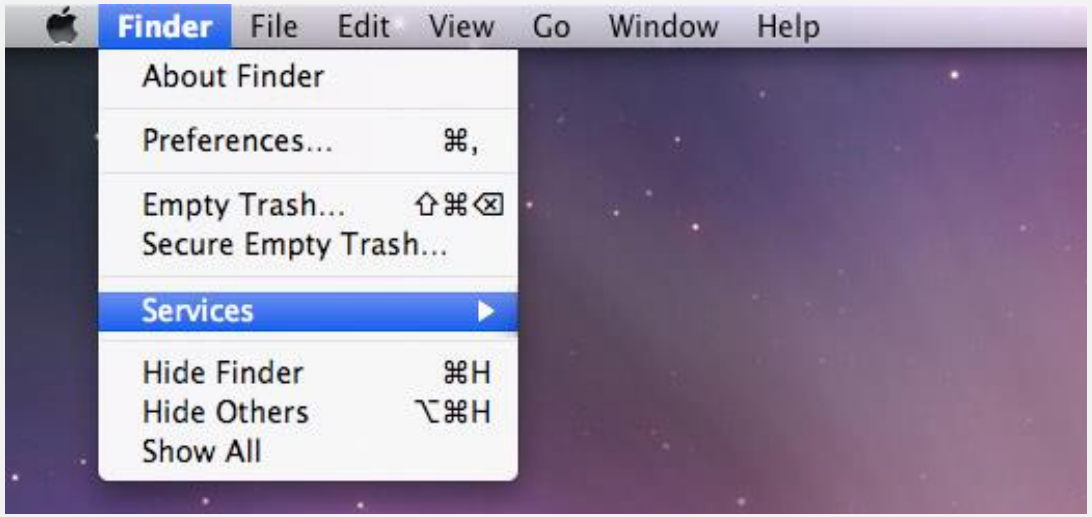




Examples of Easier & Faster UIs Due to Fitts' Law

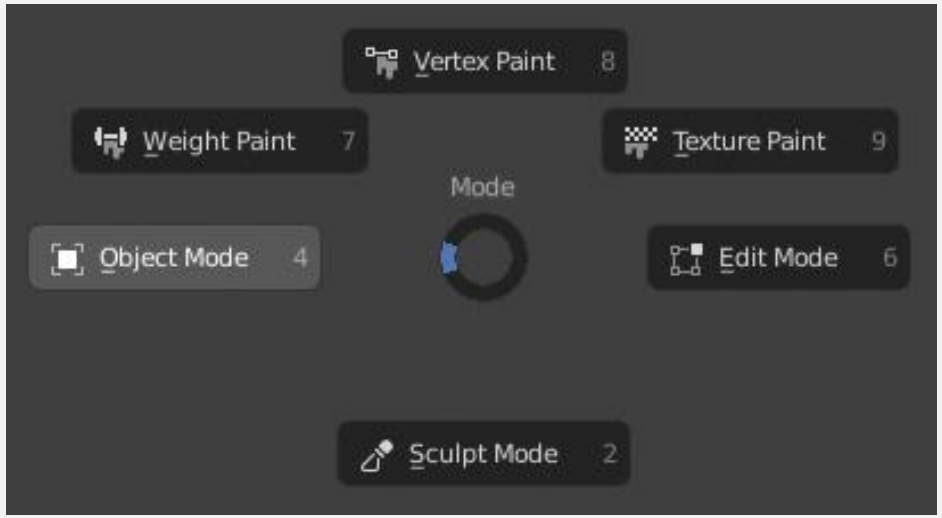
- Example 2: Access to application menu
  (Left: Windows – goes with the window, Right: OSX – always on top)

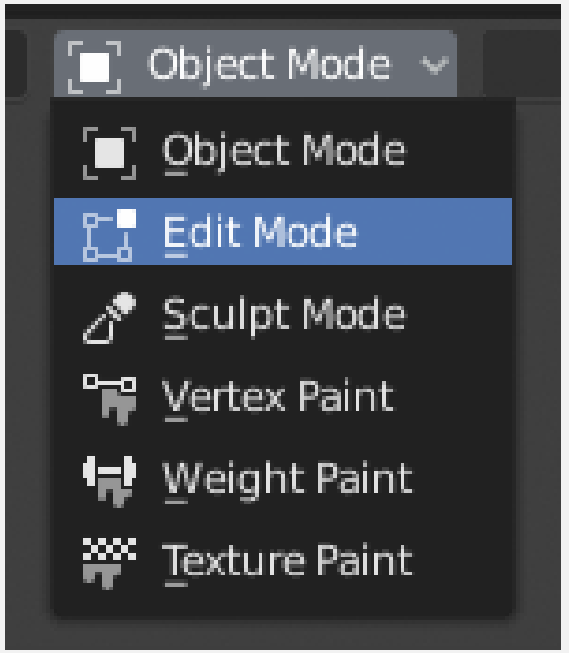




Examples of Easier & Faster UIs Due to Fitts' Law

- Example 3: Access to menu items (Left: pie menus, Right: vertical menus)



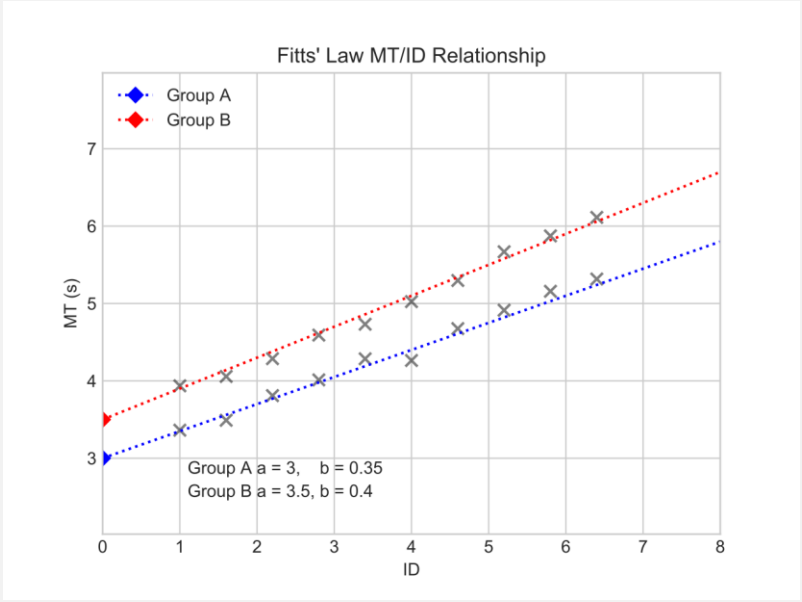


Source: https://docs.blender.org/manual/en/latest/interface/controls/buttons/menus.html

Developed to Predict Movement Time

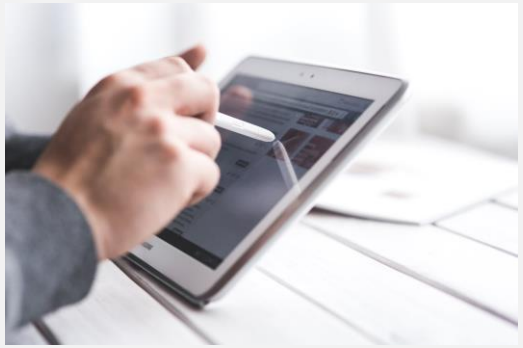
- Researchers later use linear regression to develop a relationship between movement time and index of difficulty
  - Briefly, the more difficult it is the longer it takes
  - Choice of input device affects the actual time, hence a & b
    - Control-Display ratio – ratio between movement of input device and corresponding movement of object it controls

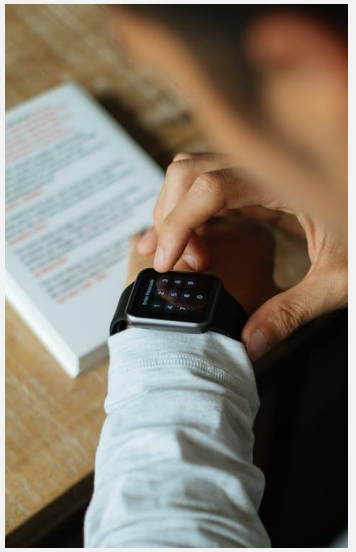
$$MT = a + b \log_2 \left(\frac{D}{W} \right)$$

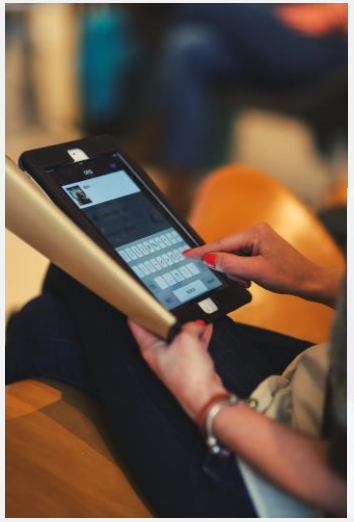


Applications of Fitts' Law

- Gestures (mid-air, touchscreens)
- Styluses on tablets
- Touches on touchscreens
- Key presses on keyboards & numpads
- Text entry in mobile phones
- Between multiple displays
- Selections & pointing in AR/VR







Summary

- Analytical evaluation
  - Cognitive walkthrough
    - Parts involved – prototype, scenario, action, target users
    - Focus – first time usage without prior training
  - Fitts' Law
    - What it is – began with measuring difficulty in reach a target, adapted to predicting movement time
    - Examples of use – commonly used in interface design to speed up selection

Post-Lecture Activity

- Read/watch these (and those in the slides)
  - ID-Book Ch. 16.2.2
  - Literature on Cognitive Walkthrough (8min read)
    https://www.interaction-design.org/literature/topics/cognitive-walkthrough
  - What is Fitts's Law (and some of its applications) by Denis Nguyen (5min watch)
    https://vimeo.com/200436363
  - Putting A/B Testing in Its Place
    https://www.nngroup.com/articles/putting-ab-testing-in-its-place/

- Exercise
  - Watch the following cognitive walkthrough example and identify what task it was testing, and what steps are involved
    https://www.youtube.com/watch?v=Op9huZ_GNAk
  - Think about how Fitts' Law changes from a WIMP paradigm to touch-interfaces. How are they different from VR?