# IN4MATX 231:
# User Interface Design & Evaluation

## Class 18:
## Modeling human performance

Daniel Epstein

# Announcements

- Tuesday: Human-Centered Design as a Research Method
  - What are you interested in learning more about here?
  - Reporting, Formative Work, Deployment, Ethics…
- Thursday: Design and Development tools?
  - A mix of conceptual (how tools are designed) and practical (what tools to use)

# Today’s goals

## By the end of today, you should be able to…

- Describe the major components of Fitts’s Law
- Explain how Fitts’s Law impacts how interfaces should be designed
- Describe approaches for correcting systematic errors in touch performance

# Which button would be faster to click on?

# Fitts’s Law (1954)

- Models time to acquire targets in aimed movement
  - Reaching for control in a cockpit
  - Moving across a dashboard
  - Pulling defective items from a conveyor belt
  - Clicking on icons using a mouse

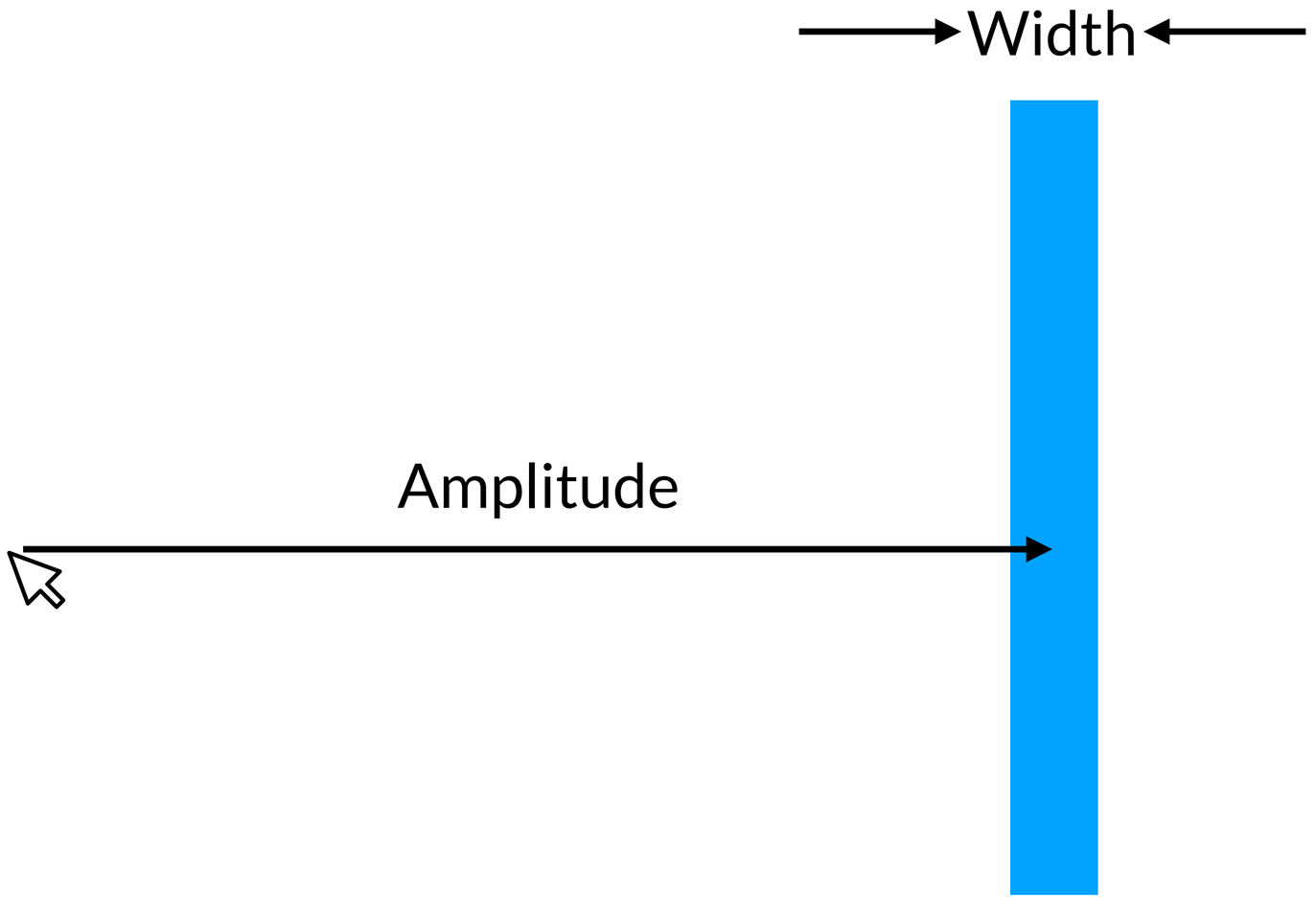
https://en.wikipedia.org/wiki/Fitts%27s_law

# Fitts’s Law (1954)

- Very powerful, widely used
  - Holds for many circumstances (e.g., under water)
  - Allows for comparison among different experiments
  - Used both to measure and predict

https://en.wikipedia.org/wiki/Fitts%27s_law

# Point-select task



# Fitts’s Law

- $MT = a + b \log_2(A / W + 1)$
  - What kind of equation does this look like?

# Fitts's Law

- MT = a + b log2(A / W + 1)
  - What kind of equation does this look like?
- y = mx + b
- MT = a + bx, where x = log2(A / W + 1)
  - x is called the Index of Difficulty (ID)
  - As "A" goes up, ID goes up
  - As "W" goes up, ID goes down

# Movement Time (MT)

- MT = a + b log2(A / W + 1)
- Time, in seconds, to acquire the target (e.g., click on the button)

# Index of Difficulty (ID)

- log2(A / W + 1)
  - Fitts's Law claims that the time to acquire a target increases linearly with the log of the ratio of the movement distance or amplitude (A) to target width (W)

# Index of Difficulty (ID)

- log2(A / W + 1)
  - Fitts's Law claims that the time to acquire a target increases linearly with the log of the ratio of the movement distance or amplitude (A) to target width (W)
- Why is it significant that it is a ratio?
  - Units of A and W don't matter
  - Allows comparison across experiments

# Index of Difficulty (ID)

- log2(A / W + 1)
  - Fitts's Law claims that the time to acquire a target increases linearly with the log of the ratio of the movement distance or amplitude (A) to target width (W)
- ID units typically in "bits"
  - Because of association with information capacity and somewhat arbitrary use of base-2 logarithm

# Index of Performance (IP)

- MT = a + b log2(A / W + 1)
  - b is slope
- 1/b is called Index of Performance (IP)
  - If MT is in seconds, IP is in bits/second
- Also called “throughput” or “bandwidth”
- **a and b depend on the input device**

# Fitts’s Law Activity

- Go to http://www.yorku.ca/mack/FittsLawSoftware/ and download GoFitts.jar
- Complete a trial with the default settings
- Stop at the last screen and record your times: https://bit.ly/37vSKEd

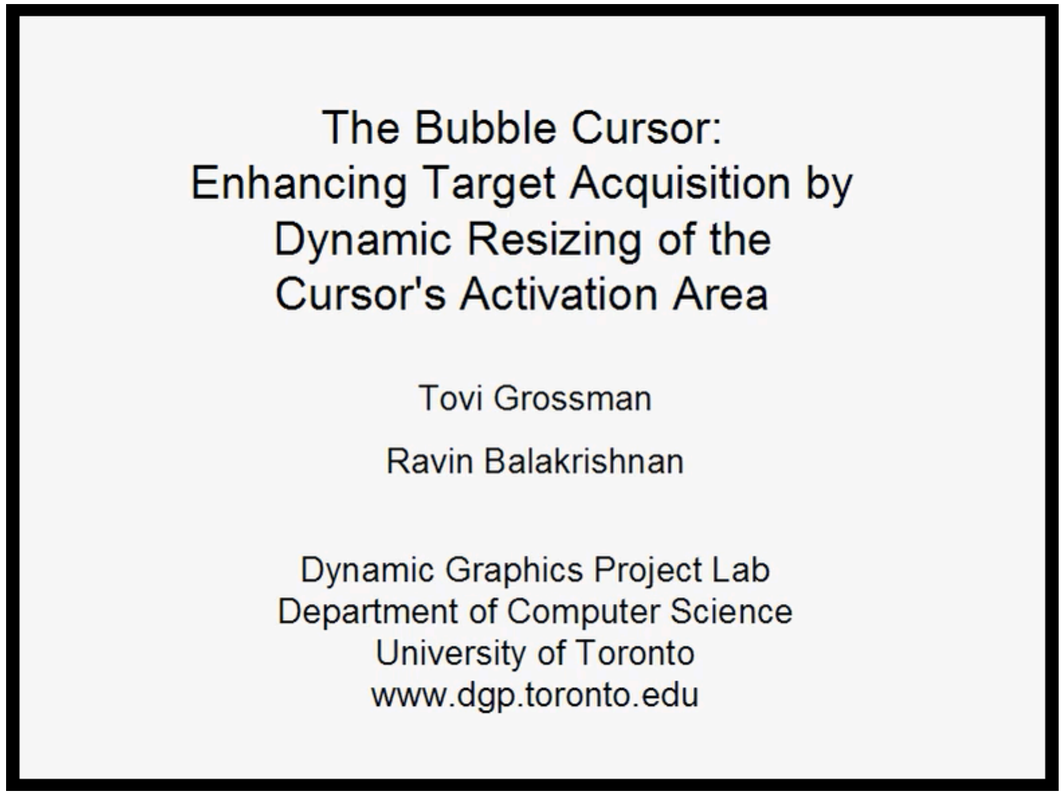
# “Beating” Fitts’s law

- It is the law, right?
  - $MT = a + b \log_2(A/W + 1)$
- So how can we reduce movement time?
  - Reduce amplitude (A)
  - Increase width (W)

# “Beating” Fitts’s law

- Put targets closer together
- Make targets bigger
- Make cursor bigger
- Make impenetrable edges

# Bubble Cursor


The Bubble Cursor:
Enhancing Target Acquisition by
Dynamic Resizing of the
Cursor's Activation Area

Tovi Grossman

Ravin Balakrishnan

Dynamic Graphics Project Lab
Department of Computer Science
University of Toronto
www.dgp.toronto.edu

Tovi Grossman, Ravin Balakrishnan. 2005. The Bubble Cursor: Enhancing Target Acquisition by Dynamic Resizing of the Cursor's Activation Area. CHI 2005. https://dl.acm.org/citation.cfm?id=1055012

# Bubble Cursor on Desktops

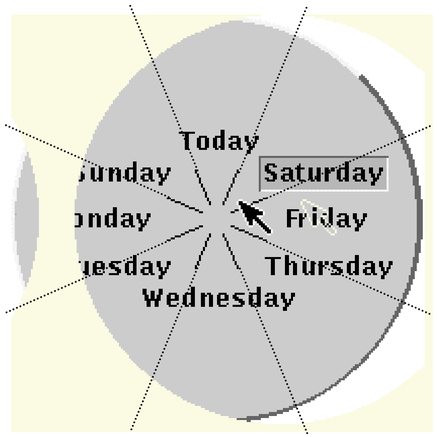

Morgan Dixon, James Fogarty, Jacob O. Wobbrock. 2012. Pixel-Based Identification and Interpretation in a General-Purpose Target-Aware Pointing Environment. CHI 2012. https://dl.acm.org/citation.cfm?id=2208734

# Radial menus

- Better from a Fitts's law perspective
- But they trade off familiarity
- They show up some in games

Pop-up Linear Menu


Pop-up Pie Menu



# Fitts’s Law in windowing

- Windows 95: missed by a pixel
- Windows XP: good to the end
- Corners and edges make great targets
  - Do not have to move precisely to trigger them
  - They have “infinite” width

# Fitts’s Law in other domains

- How would Fitts’s Law apply to using touch input on a phone?
  - Shorter distances (smaller screen)
- All things being equal, movement times *should* be lower
  - Shorter distances, faster to move your finger than a mouse

# Fitts’s Law in other domains

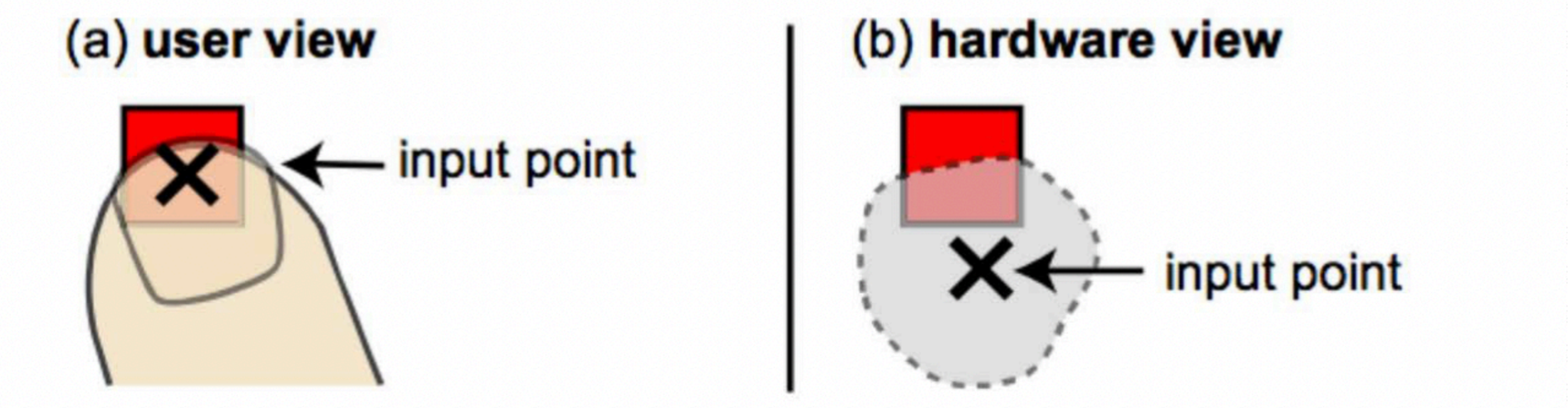
- But in practice, touchscreens on mobile tend not to be much faster
  - Buttons are smaller
  - People tend to be slower near the edges of touchscreens

# Modeling input

# Modeling mouse position

- Mouse pointer is relatively small
- We model it via X, Y position on the screen
- See whether that X, Y overlaps with a button, for example
  - Targets are usually large enough that “exact” position does not matter

# Modeling touch position



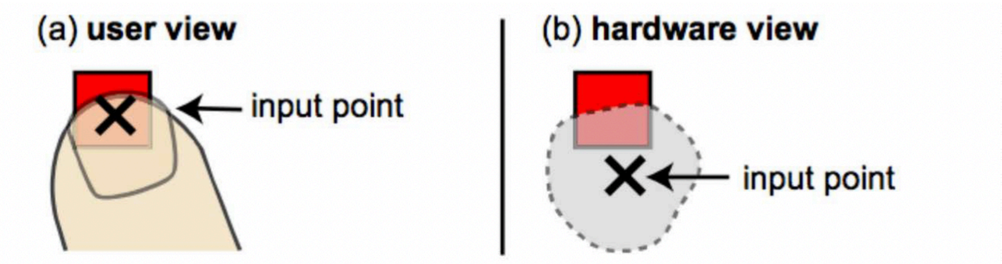

Daniel Vogel and Patrick Baudisch. 2007. Shift: a technique for operating pen-based interfaces using touch. CHI 2007. https://doi.org/10.1145/1240624.1240727

# Modeling touch position

- One interpretation of the problem:
  *our fingers are fat*
  - We should use tiny styluses to make our our selection more accurate
- Another interpretation:
  *our model of touch position is inaccurate*
  - We should make our model better

# Modeling touch position

- How can we improve our model?
- Make the hardware view more closely match the user view



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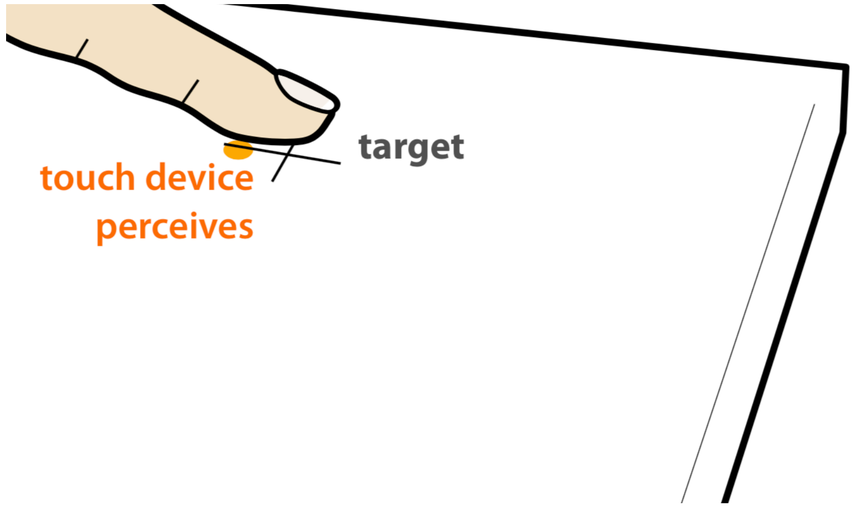
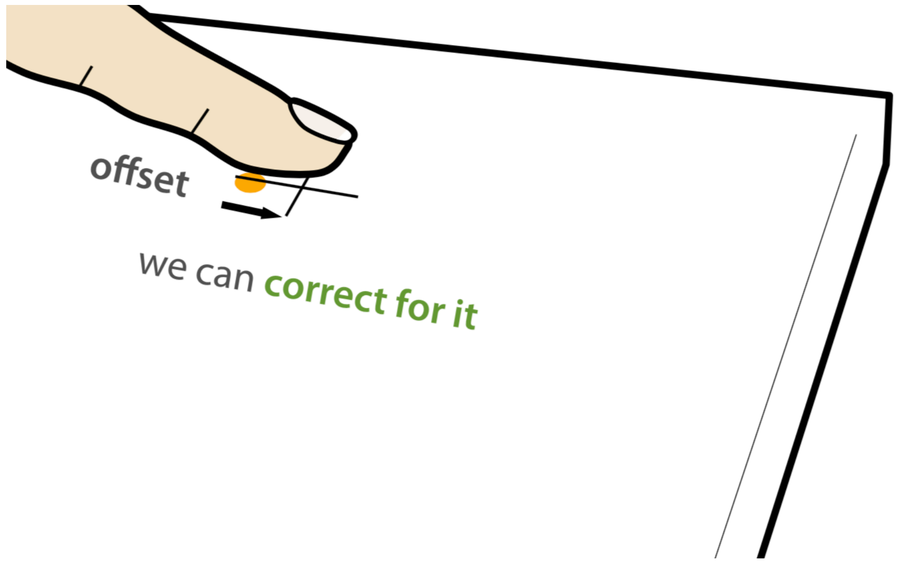
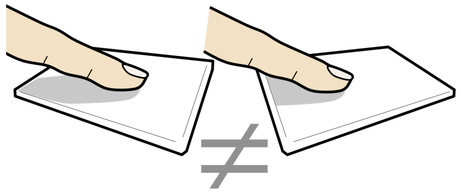


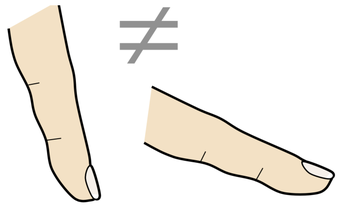

Christian Holz and Patrick Baudisch. 2011. Understanding touch. CHI 2011. https://doi.org/10.1145/1978942.1979308

# Modeling touch position

- Hypothesis: yaw, pitch, and roll all impact touch position
  - Additionally, for each person, finger size/shape and mental model impact touch position



Yaw: angle of touch device



Pitch: angle of finger

Roll: rotation of finger

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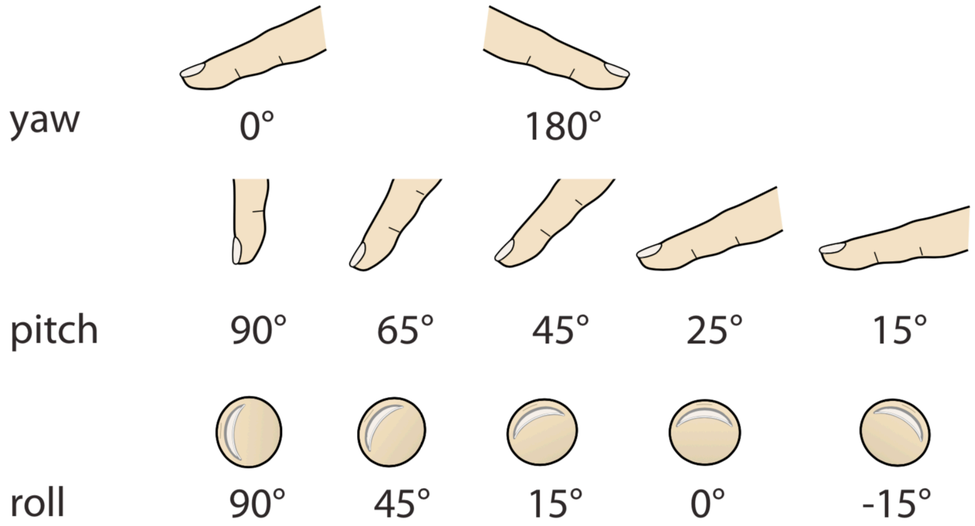
# Modeling touch position

- Ran a study
  - 12 participants touched 600 points each
  - Varied yaw, pitch, and roll

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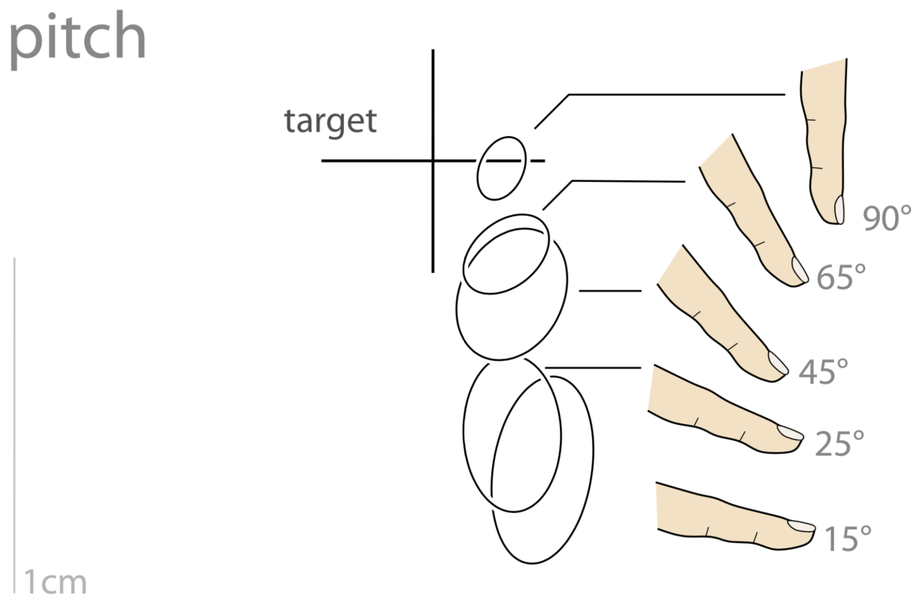


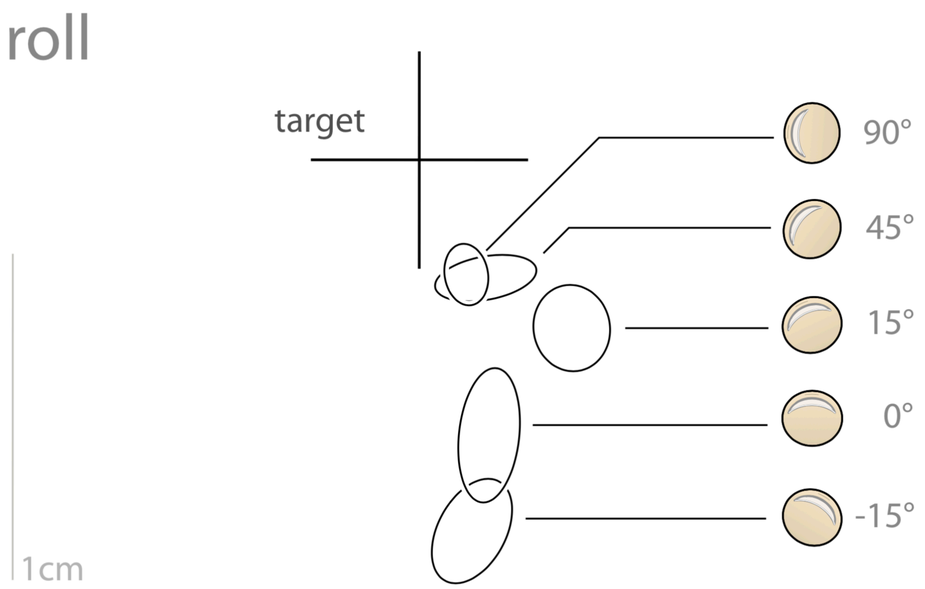


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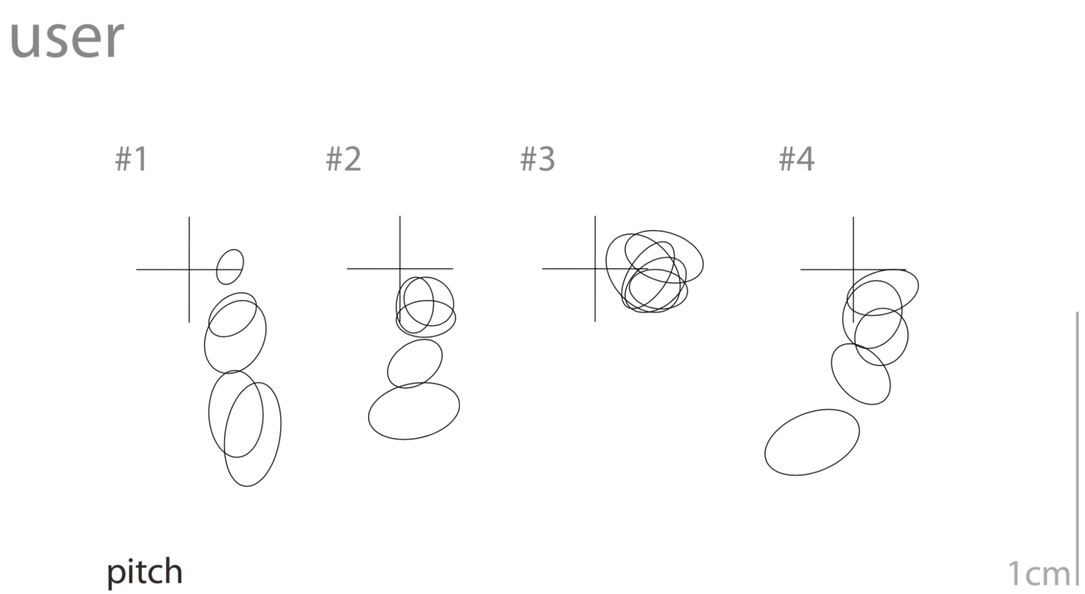


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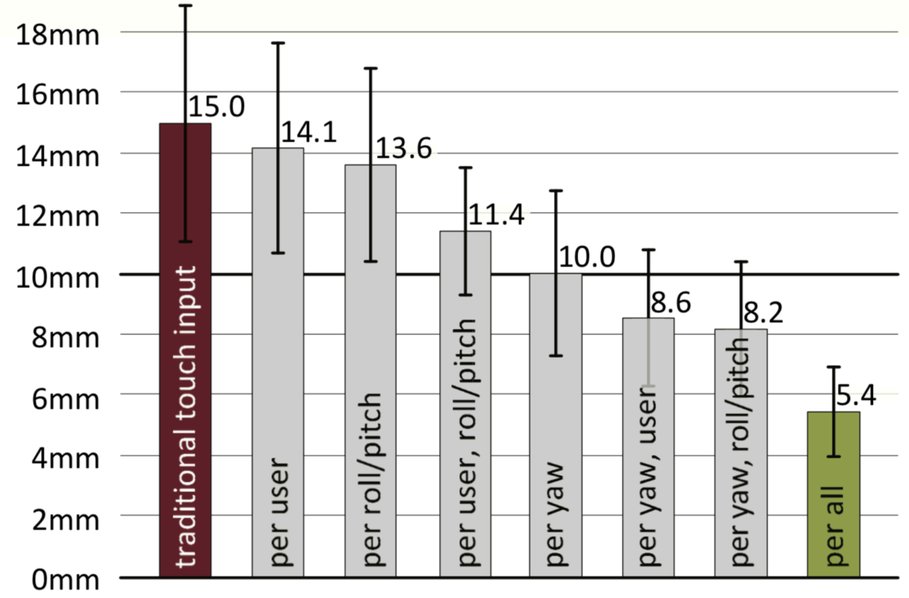
# Modeling touch position

minimum button size




Improving the model means that buttons can be **3x** smaller and not be any harder to click

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# Modeling touch input

- Study was *very* controlled
  - Participant sat in a chair, the screen was on a desk
- How about the other ways that people use their phones?

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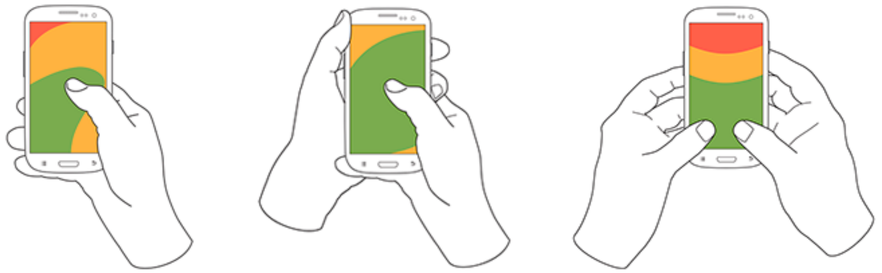
# Modeling phone grip

- People grip their phones in different ways
- Grip changes with phone size, hand size
  - Situational changes (e.g., walking, holding something)
- Can we detect phone grip and update our model?



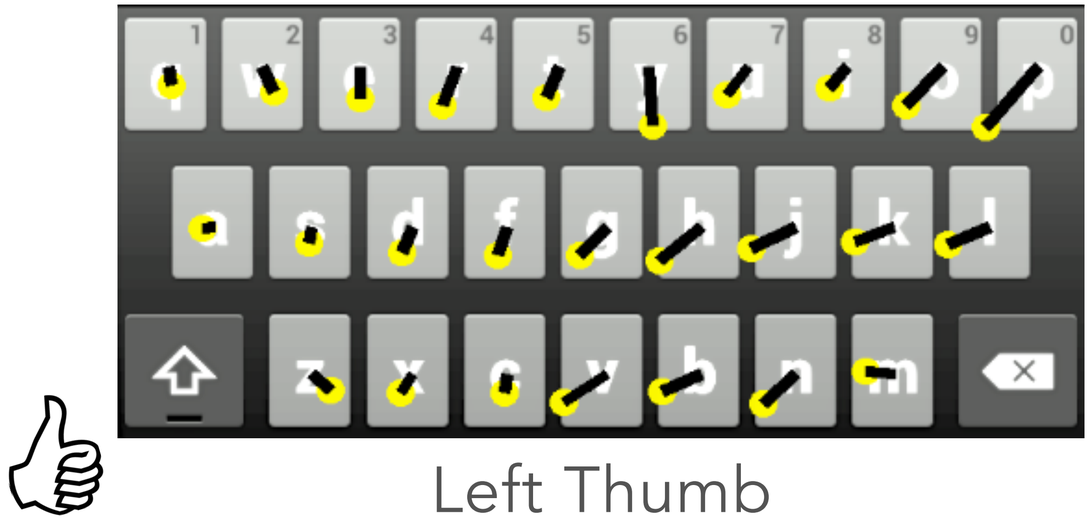
**49%** one handed

**36%** cradled

**15%** two handed

http://static.googleusercontent.com/media/www.google.com/en//intl/ALL_ALL/think/multiscreen/pdf/multi-screen-moblie-whitepaper_research-studies.pdf

# Modeling phone grip



Left Thumb

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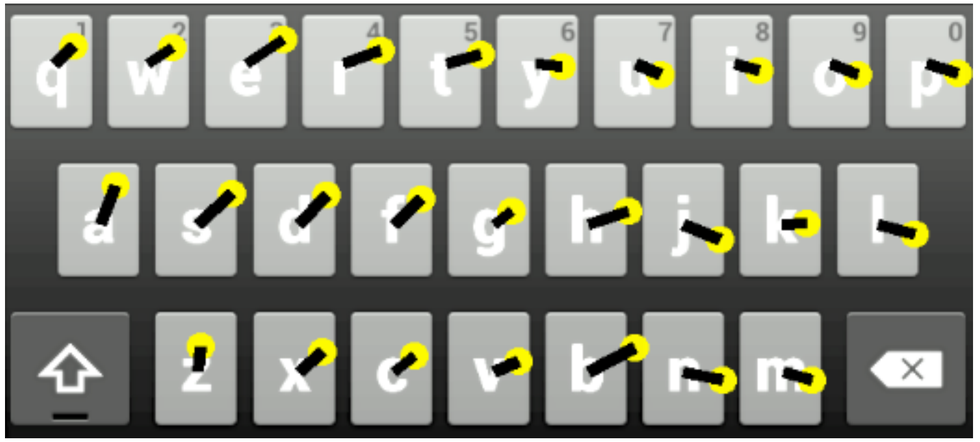

Right Thumb

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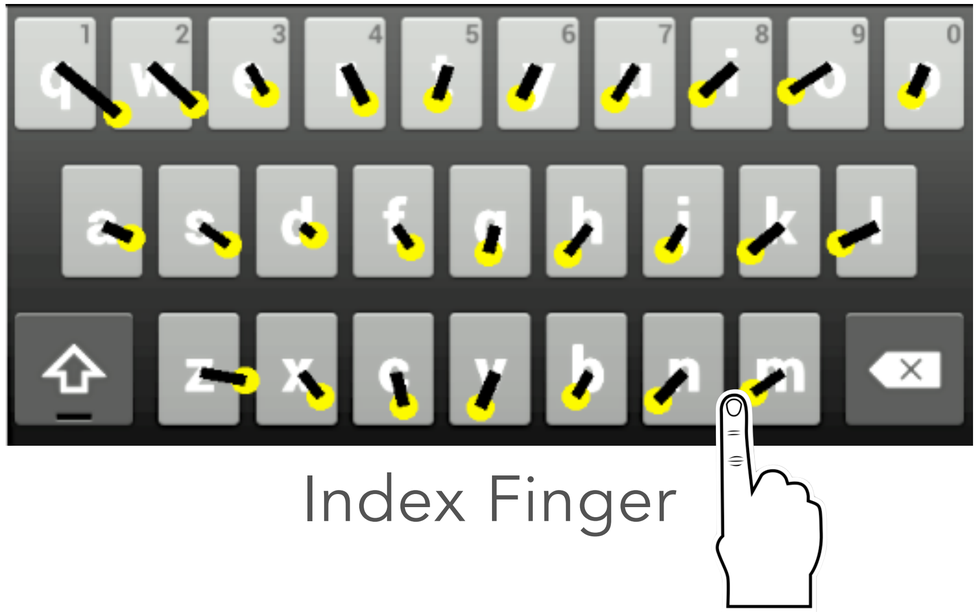


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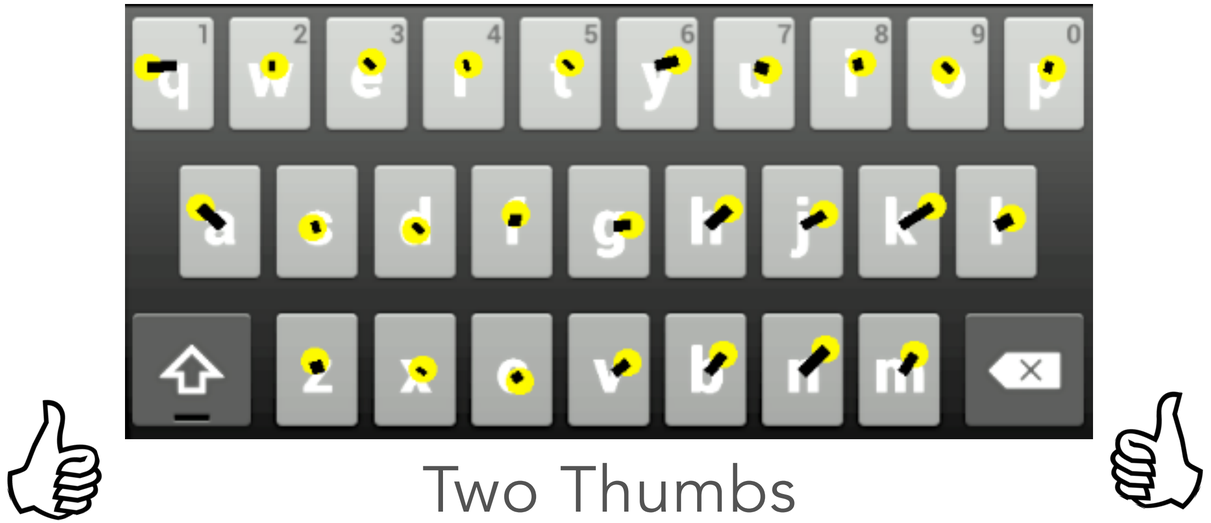


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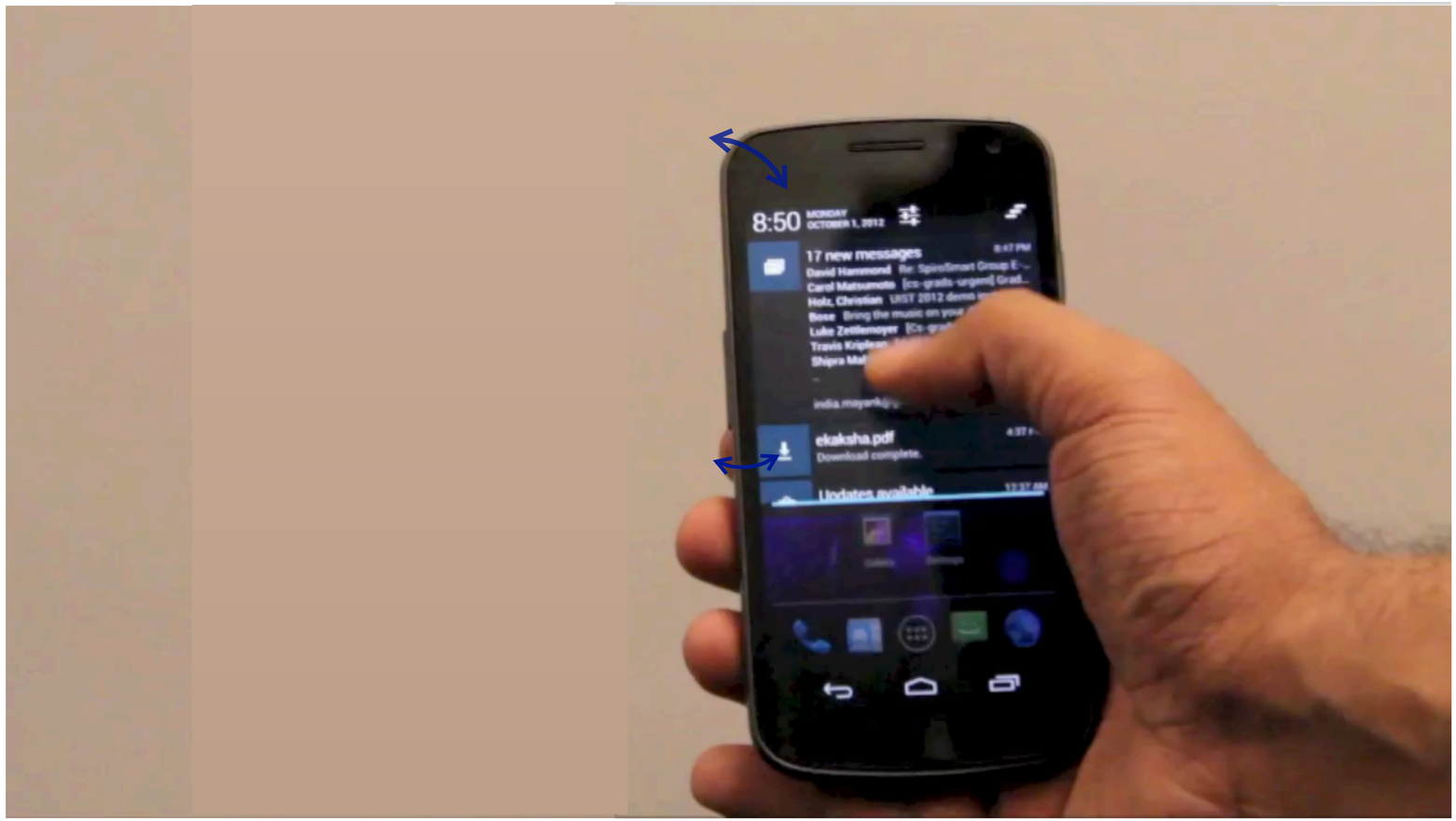
# Detecting phone grip with sensors

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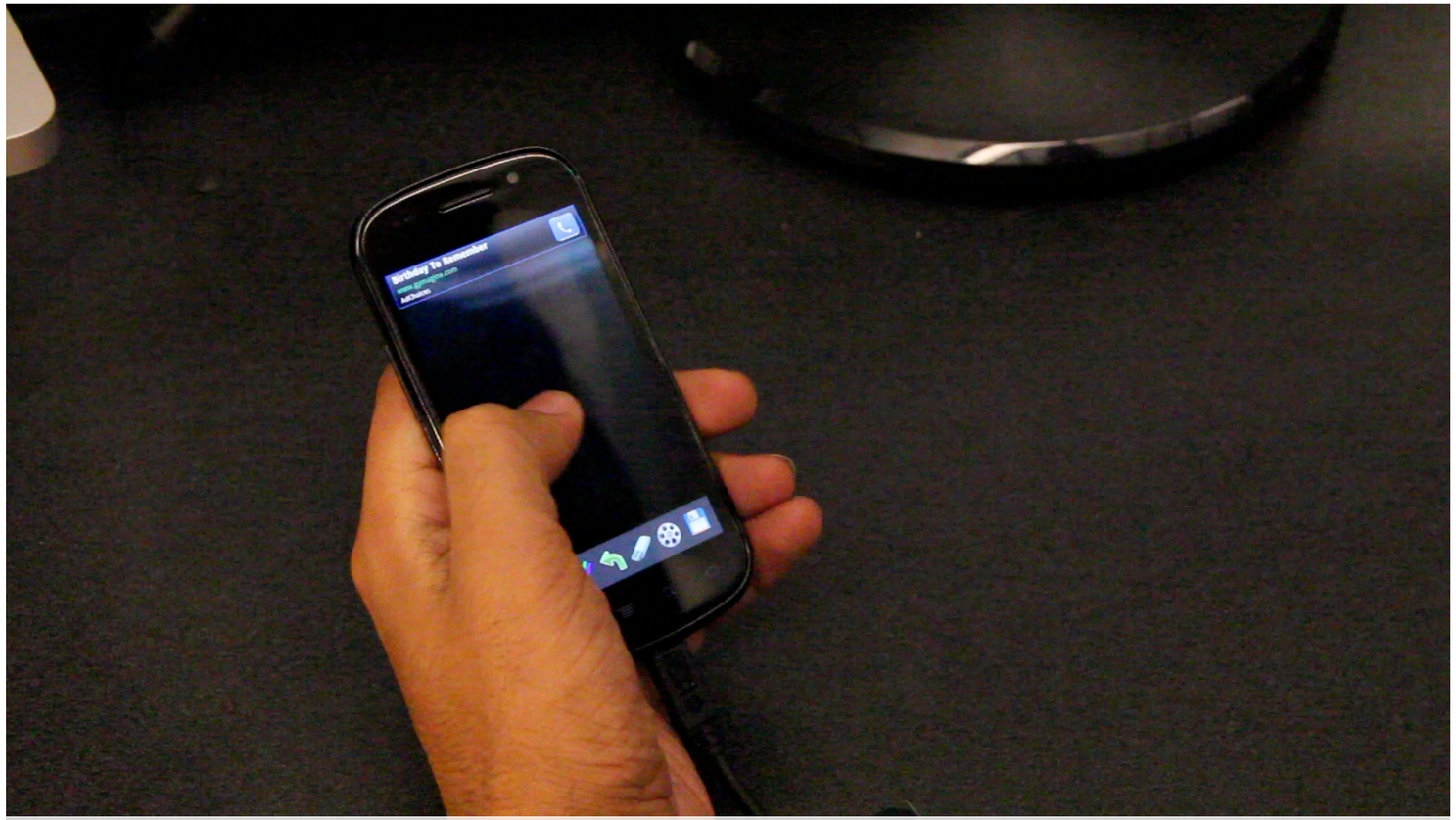

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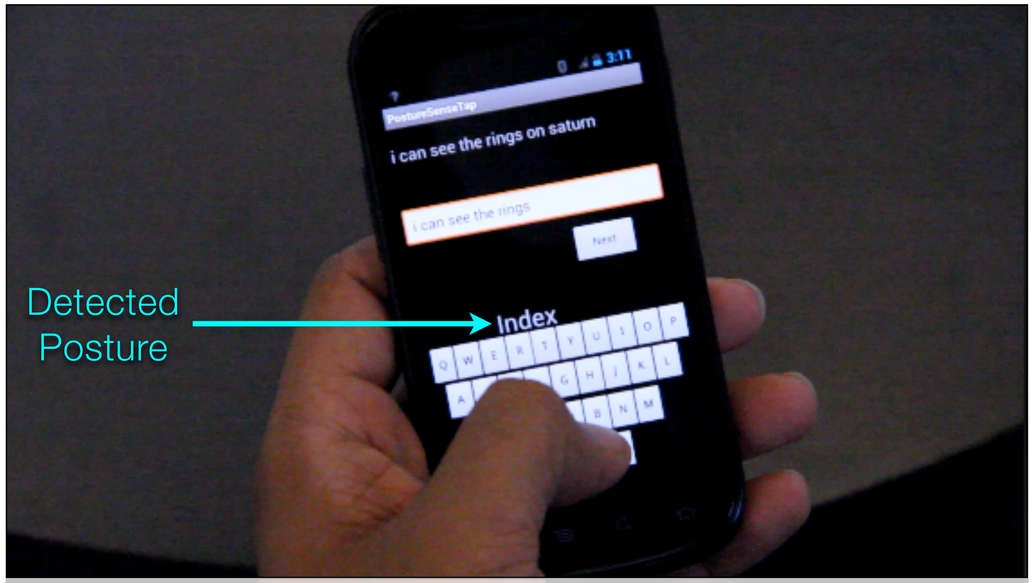


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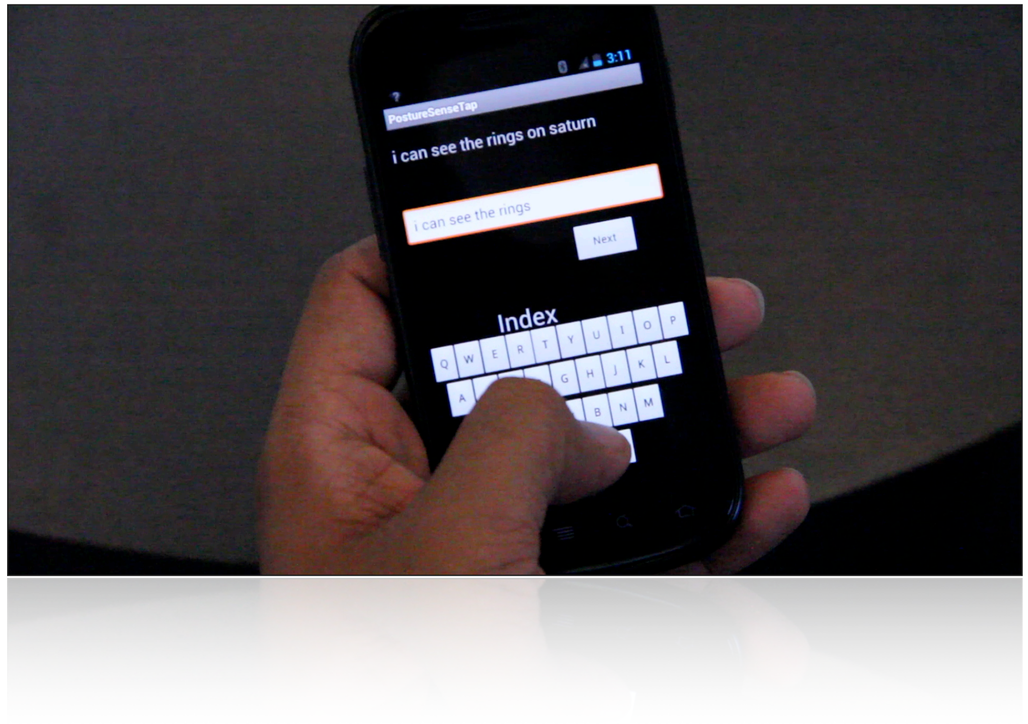


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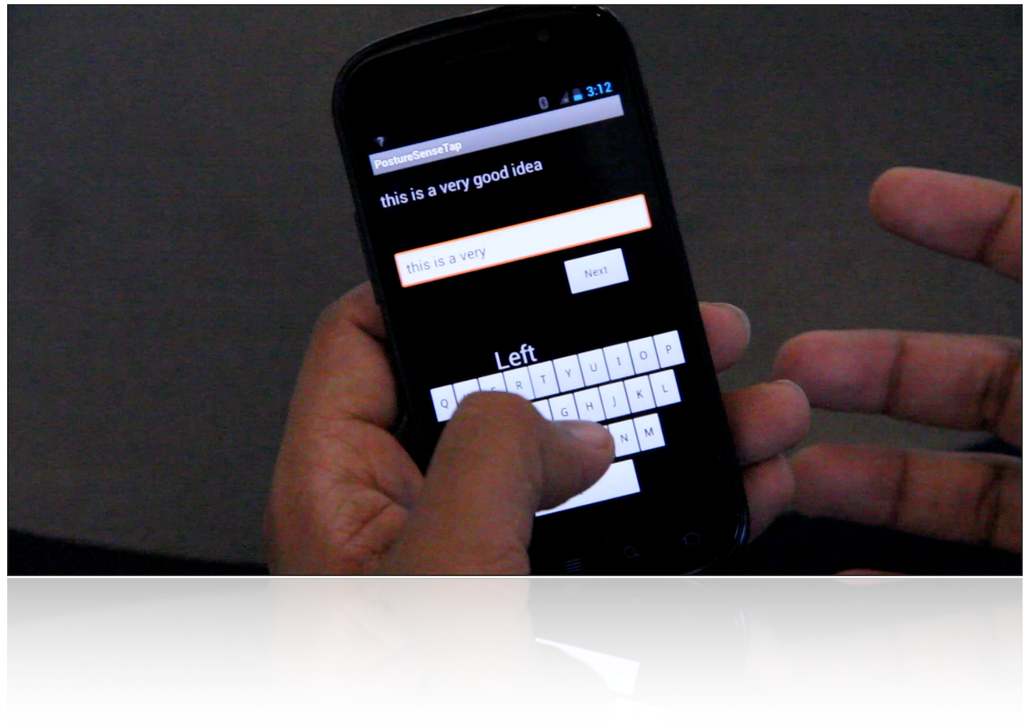


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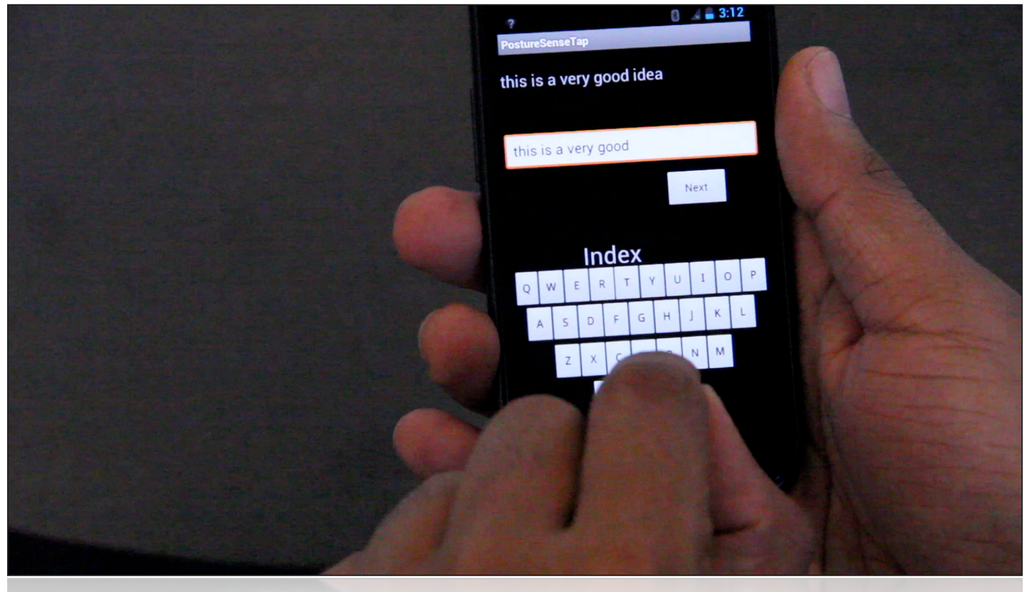


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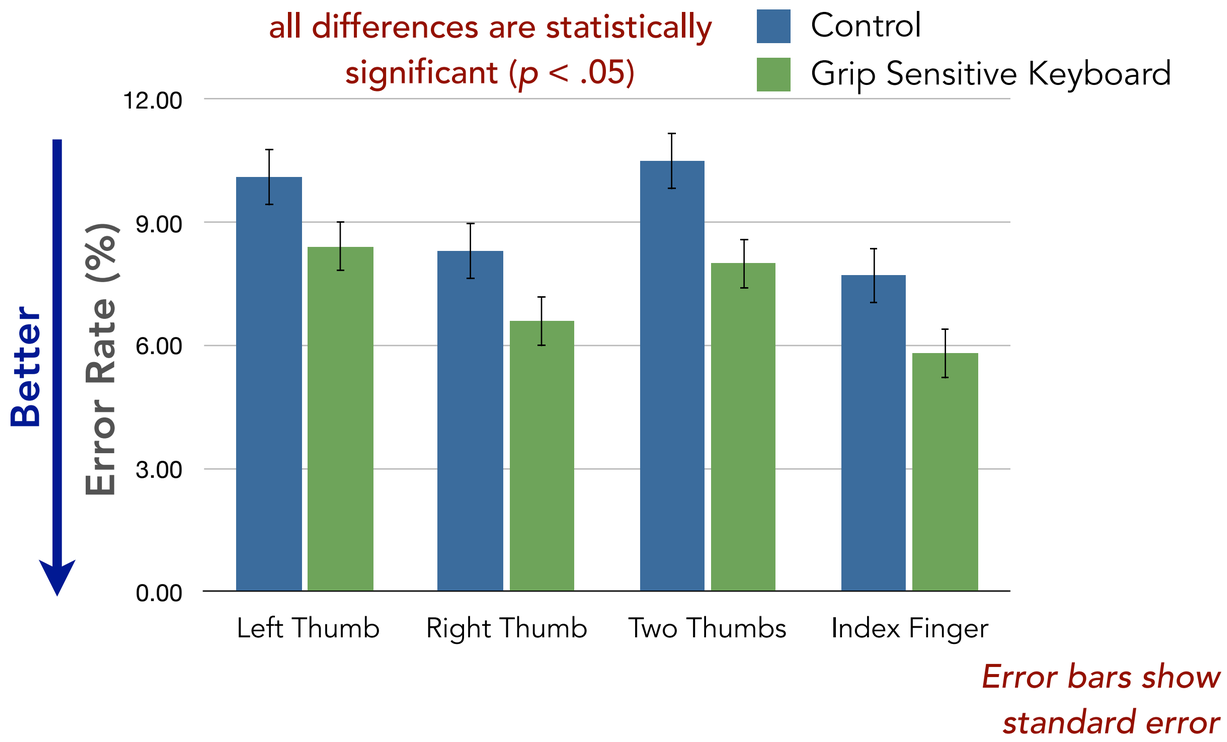


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# Summary

- Modeling helps us measure and predict whether a tool or approach is beneficial for a task
- Fitts's law models time taken to click on a target
  - Demonstrates that larger, nearer buttons reduce time taken
- Improved models lead to higher accuracy
  - Adjust for finger angle and rotation rather than assuming that a user intends to touch with the center of their finger
  - Infer grip using phone sensors to improve typing accuracy

# Summary

- Some of these models can improve accuracy without a person needing to update their mental model or involve special software

- Apple, Google, etc. could already be implementing these methods! We have no idea :-)

# Today’s goals

## By the end of today, you should be able to…

- Describe the major components of Fitts’s Law
- Explain how Fitts’s Law impacts how interfaces should be designed
- Describe approaches for correcting systematic errors in touch performance

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