

IN4MATX 133: User Interface Software

Lecture 15:
Modeling human performance

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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

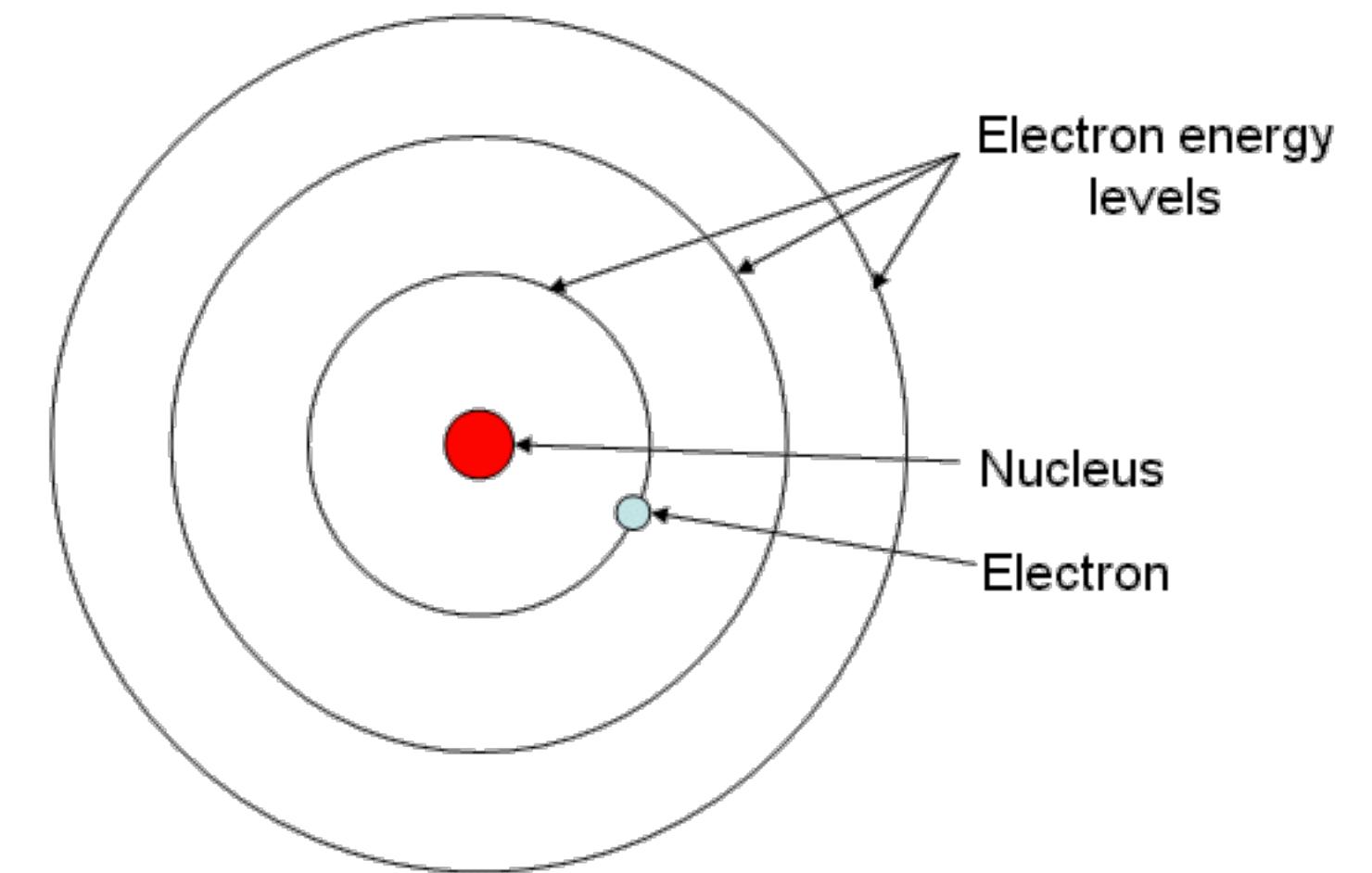
Models

- Models describe phenomena, isolating components and allowing a closer look
- Models inherently simplify complex processes
 - Allow us to *measure*: collect data, put it into a model, compare model terms
 - Allow us to *predict*: when new information arises; better models yield better predictions
- “*All models are wrong, but some are useful*” -George Box, statistician

https://en.wikipedia.org/wiki/All_models_are_wrong

Example of a model

- Bohr model of an atom
 - Electrons orbit the nucleus
 - Lower energy levels can hold fewer electrons
 - Helped explain some measured phenomena about atoms
 - As new elements were discovered, helped predict their layout
 - Has limitations, electrons do not orbit in neat rings

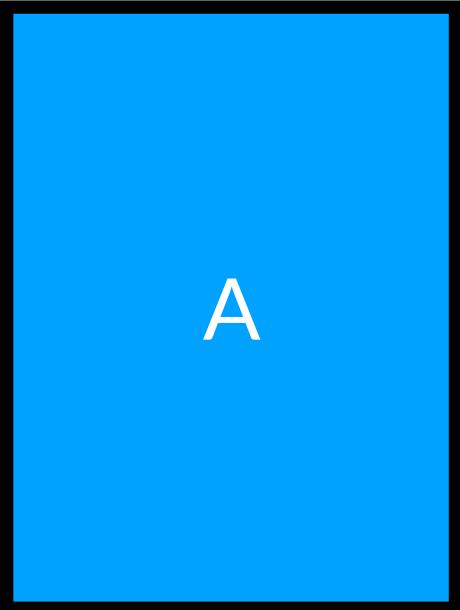


Modeling performance

Question



Which button would be faster to click on?



- A
- B
- C Roughly equal
- D
- E

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

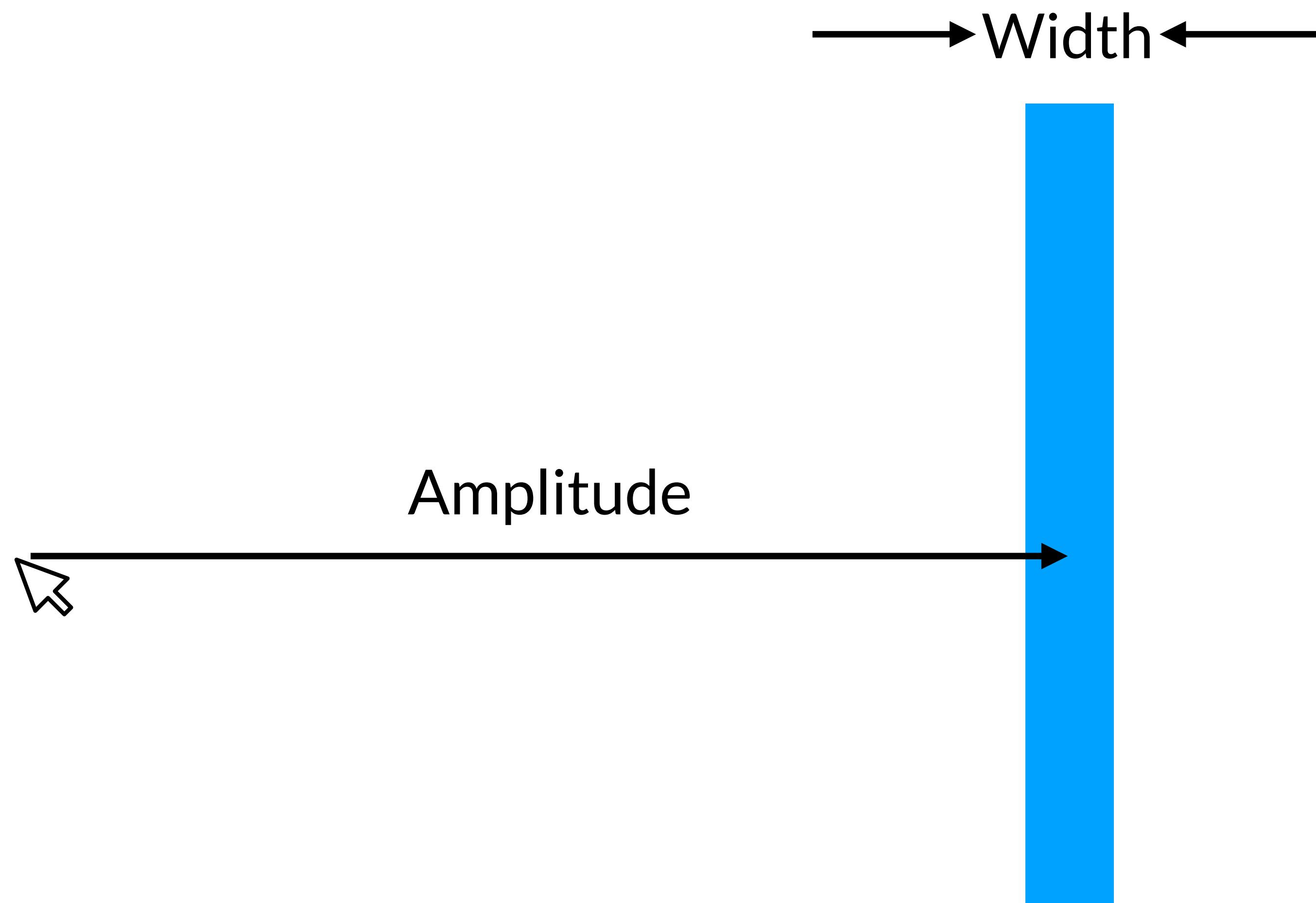
https://en.wikipedia.org/wiki/Fitts%27s_law

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

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

- $MT = a + b \log_2(A / W + 1)$
- Time, in seconds, to acquire the target (e.g., click on the button)

Index of Difficulty (ID)

- $\log_2(A / W + 1)$
 - 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)

- $\log_2(A / W + 1)$
 - 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)

- $\log_2(A / W + 1)$
 - 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)

- $MT = a + b \log_2(A / W + 1)$
 - 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

Question



Will a mouse or a touchpad have lower movement time (MT)?

- A mouse
- B A touchpad
- C Roughly equal
- D
- E

[Fitts's law demo]

<http://www.yorku.ca/mack/FittsLawSoftware/>

“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

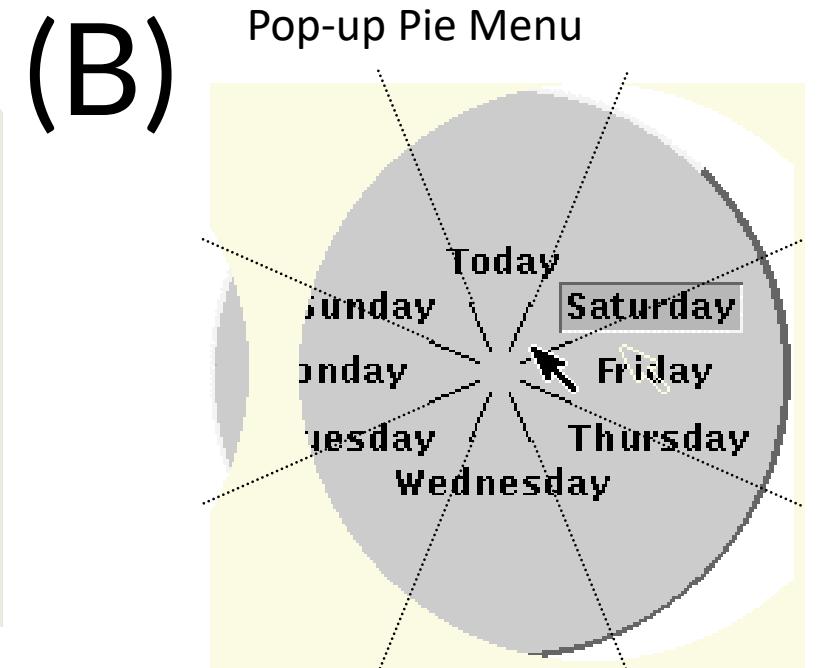
Question



Which menu will be faster on average?

(A) Pop-up Linear Menu

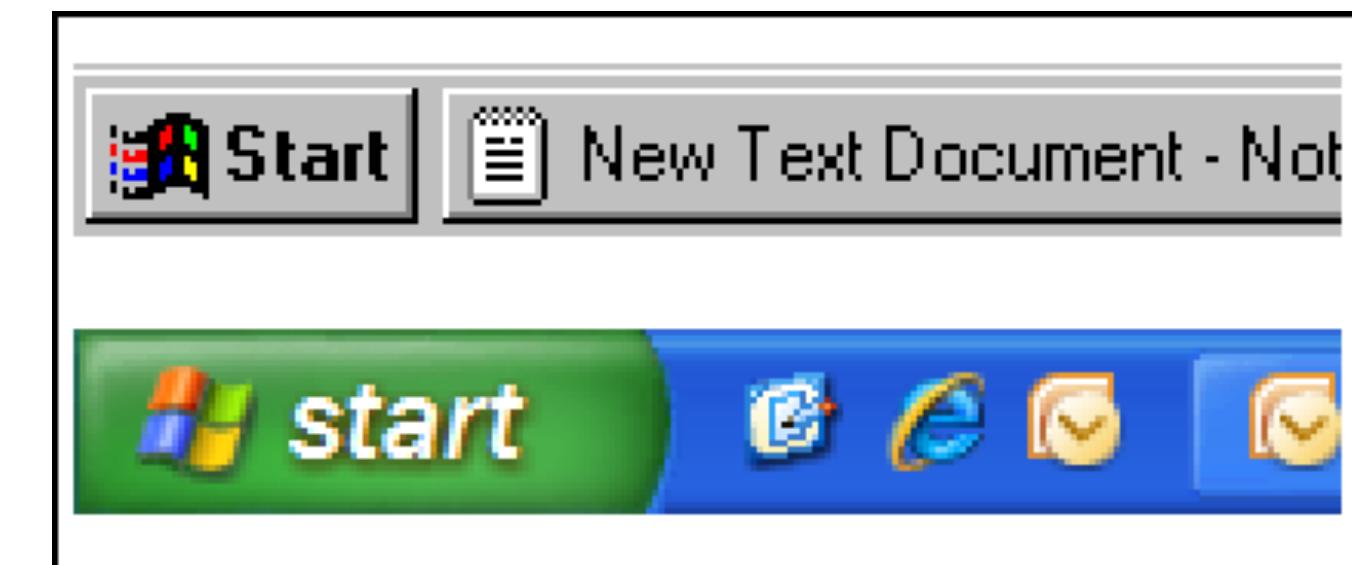
Today
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday



- A
- B
- C Roughly equal
- D
- E

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

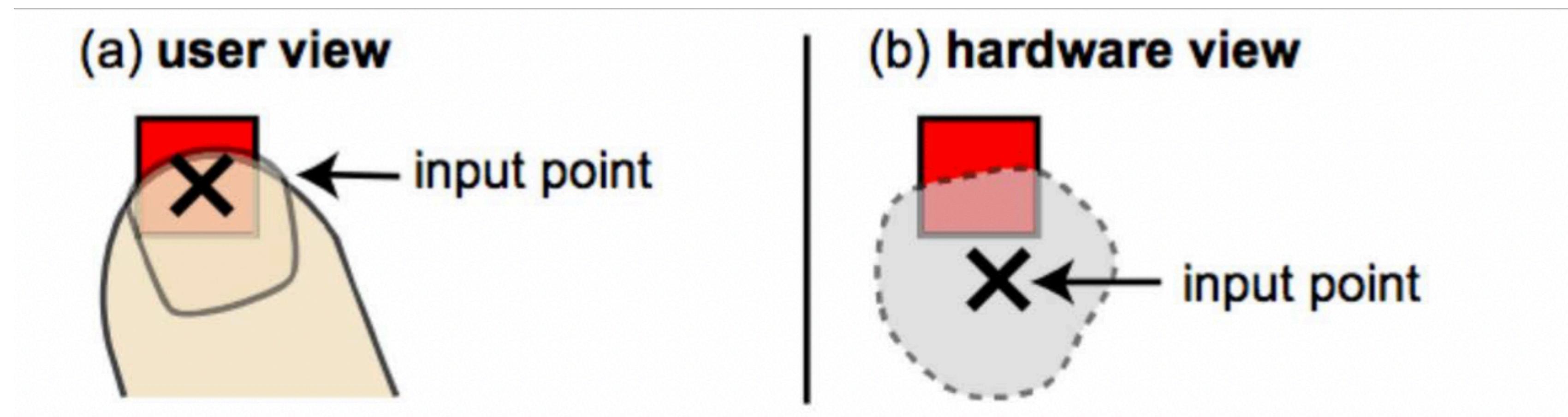
- But in practice, touchscreens on mobile tend not to be much faster
 - Buttons are smaller
 - People tend to be slower near the edges of touchscreens

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



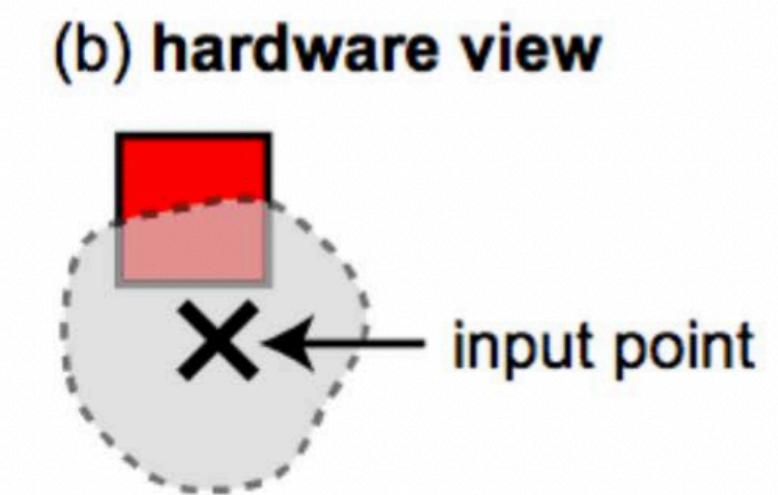
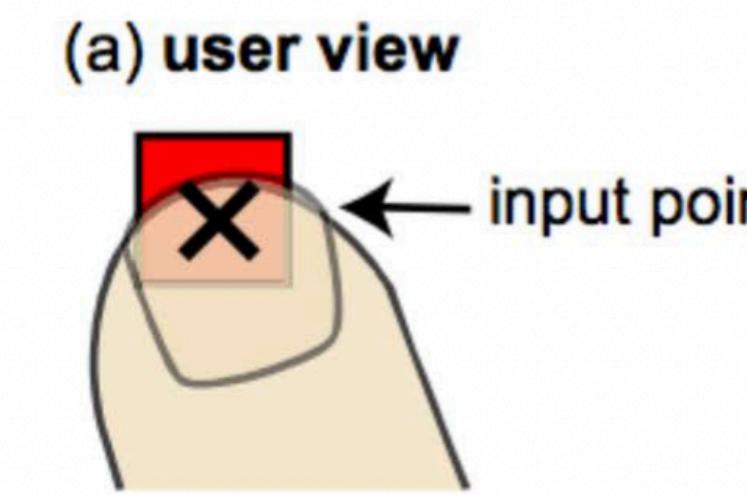
Modeling touch position

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

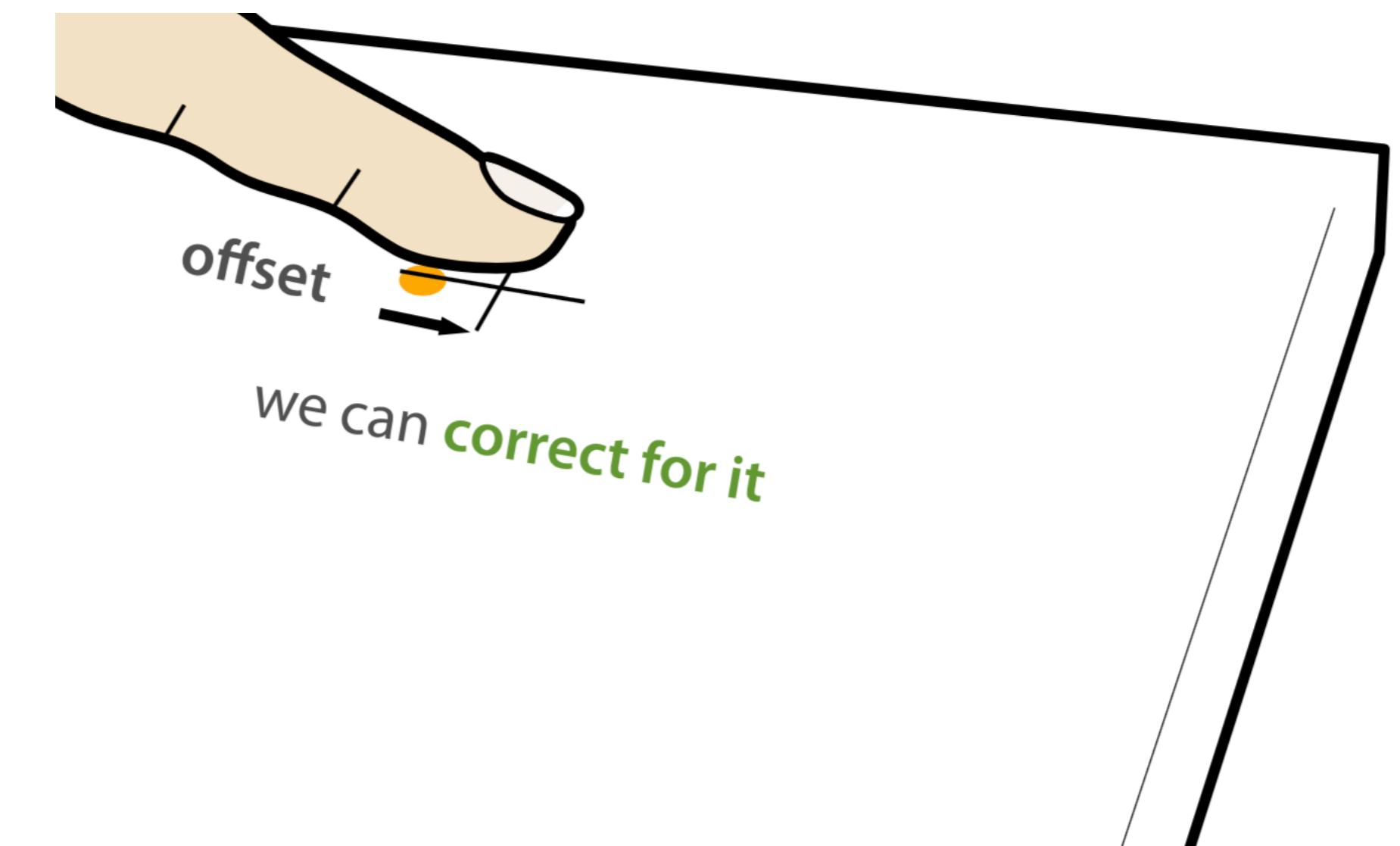
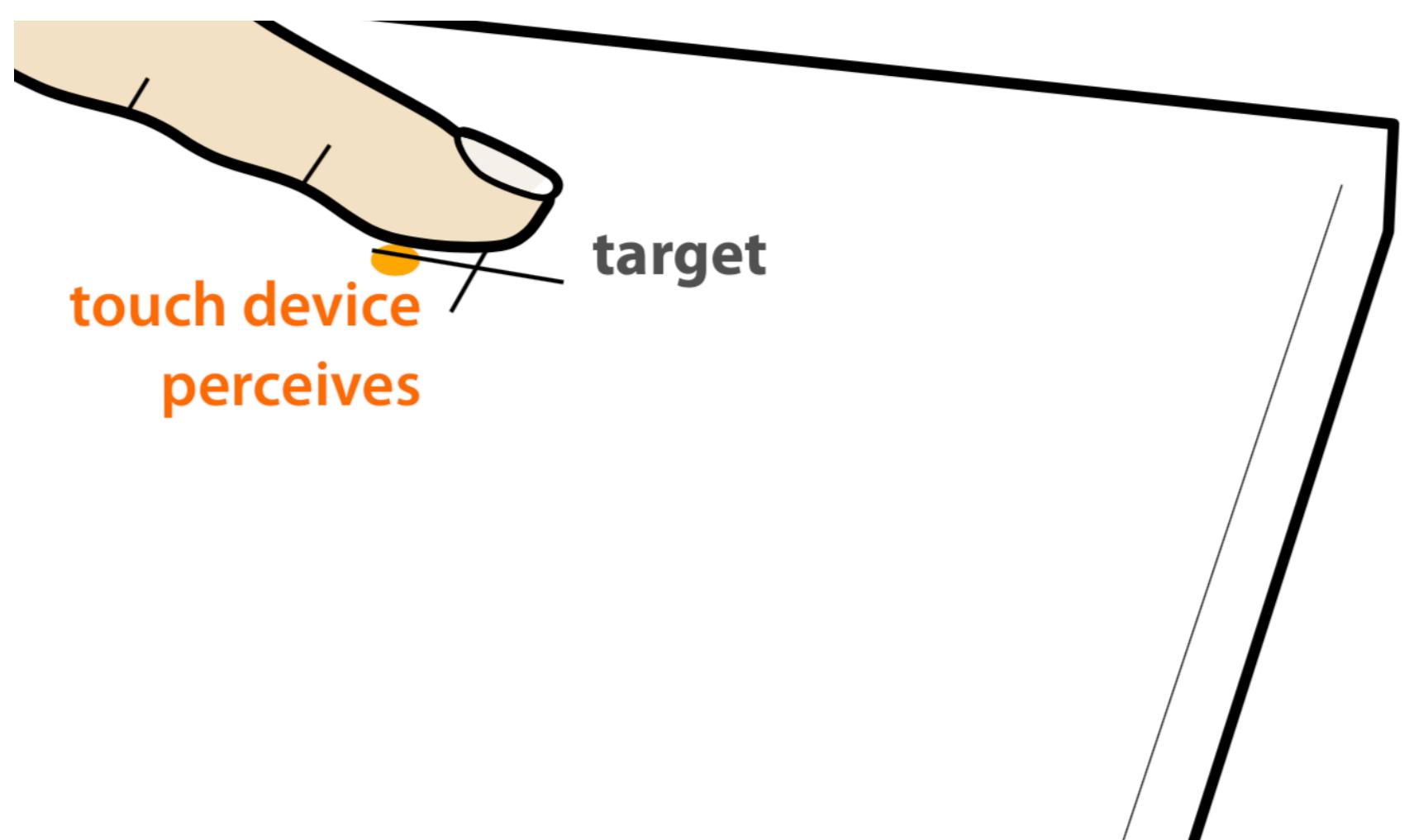


Modeling touch position

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

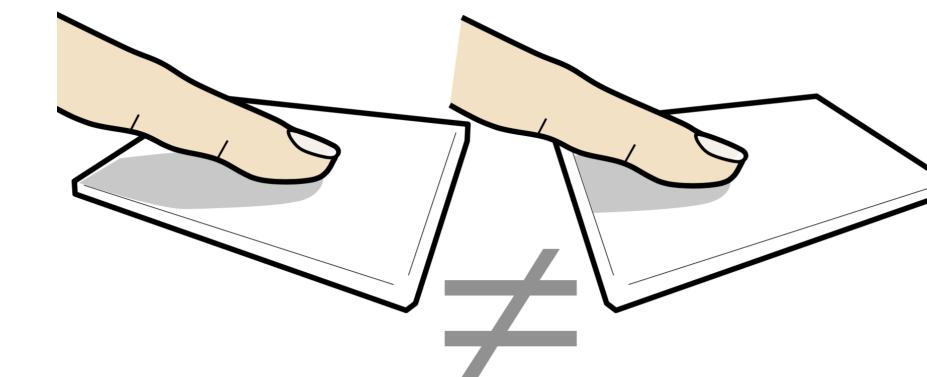


Modeling touch position

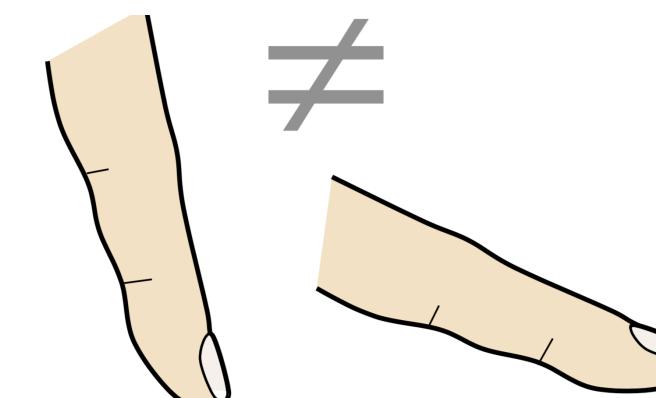


Modeling touch position

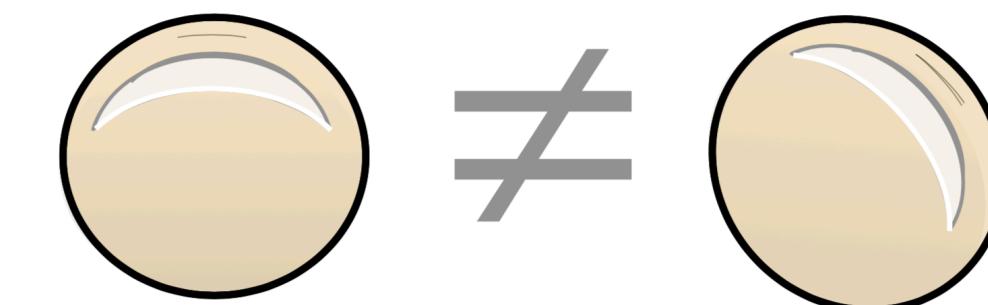
- Hypothesis: yaw, pitch, and roll all impact touch position
 - Additionally, for each person, finger size/shape and mental model impact touch position



Yaw: angle of touch device



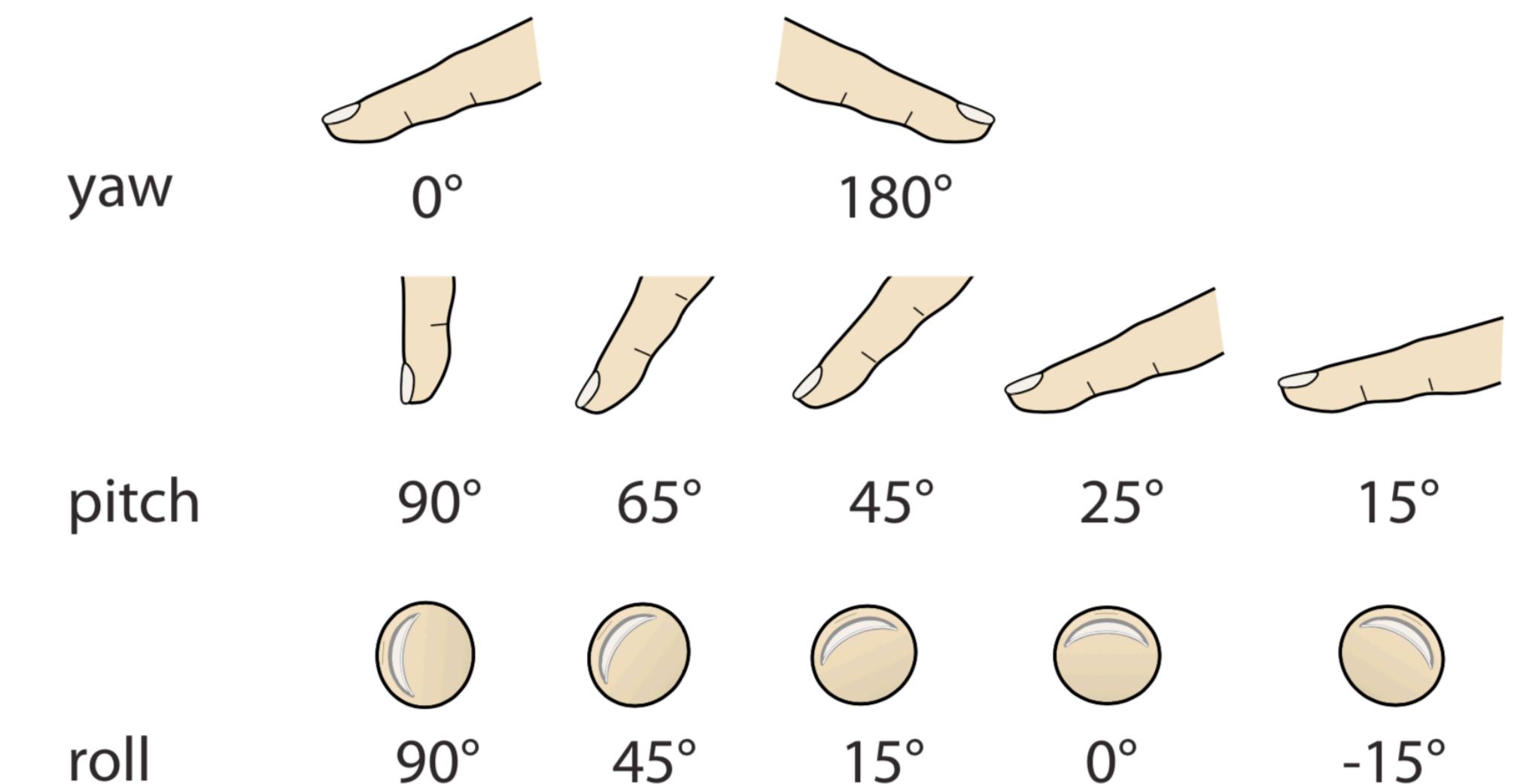
Pitch: angle of finger



Roll: rotation of finger

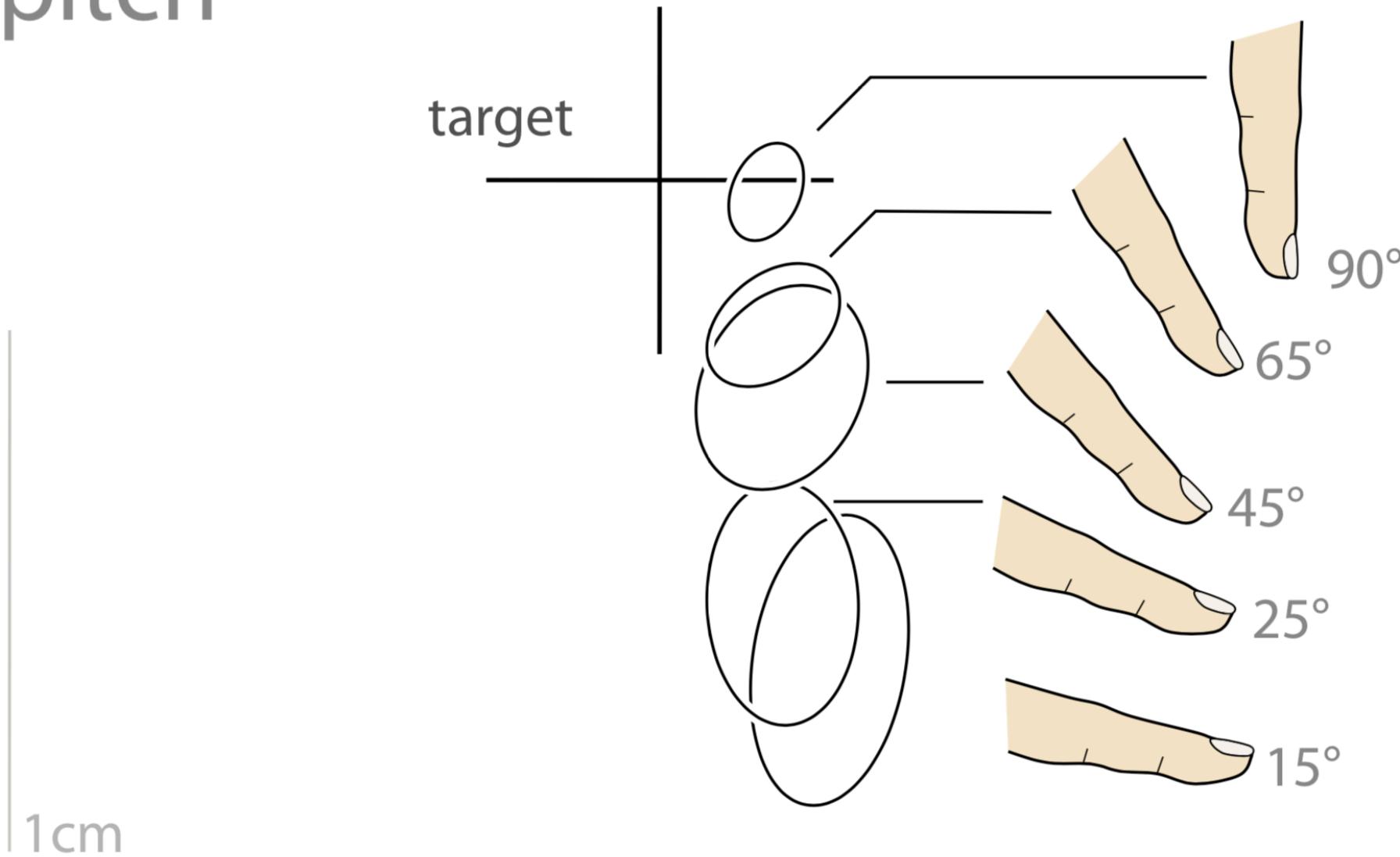
Modeling touch position

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

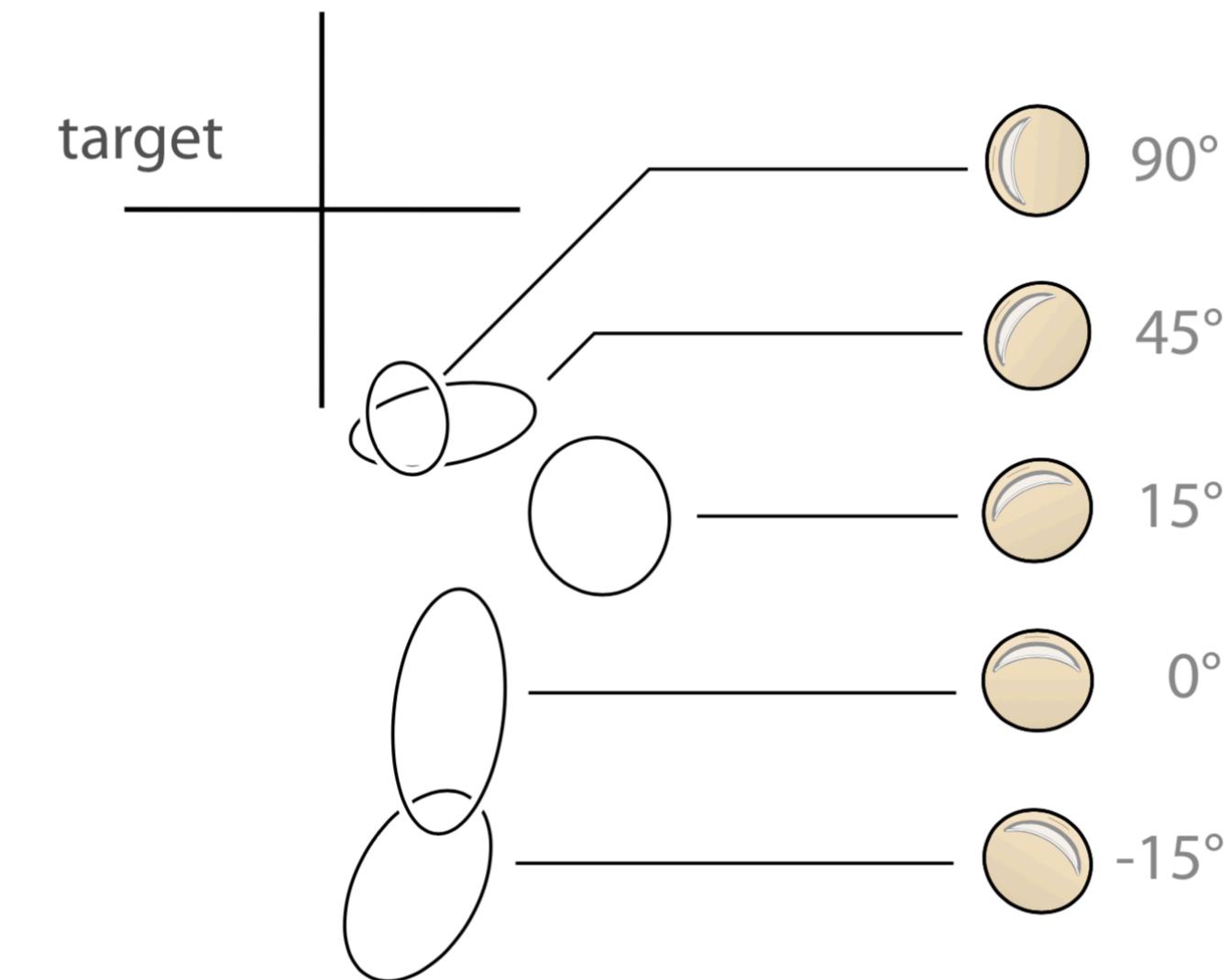


Modeling touch position

pitch

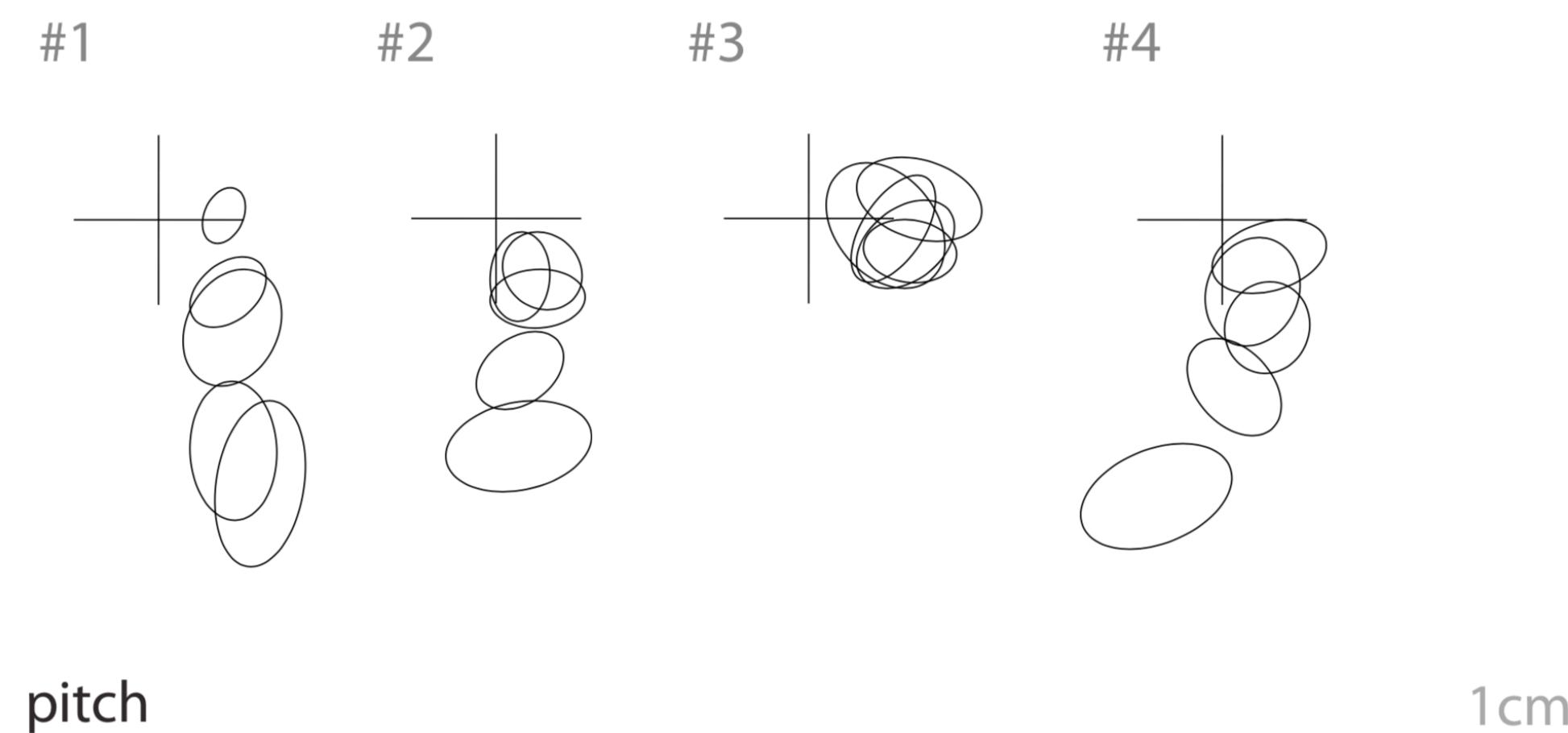


roll



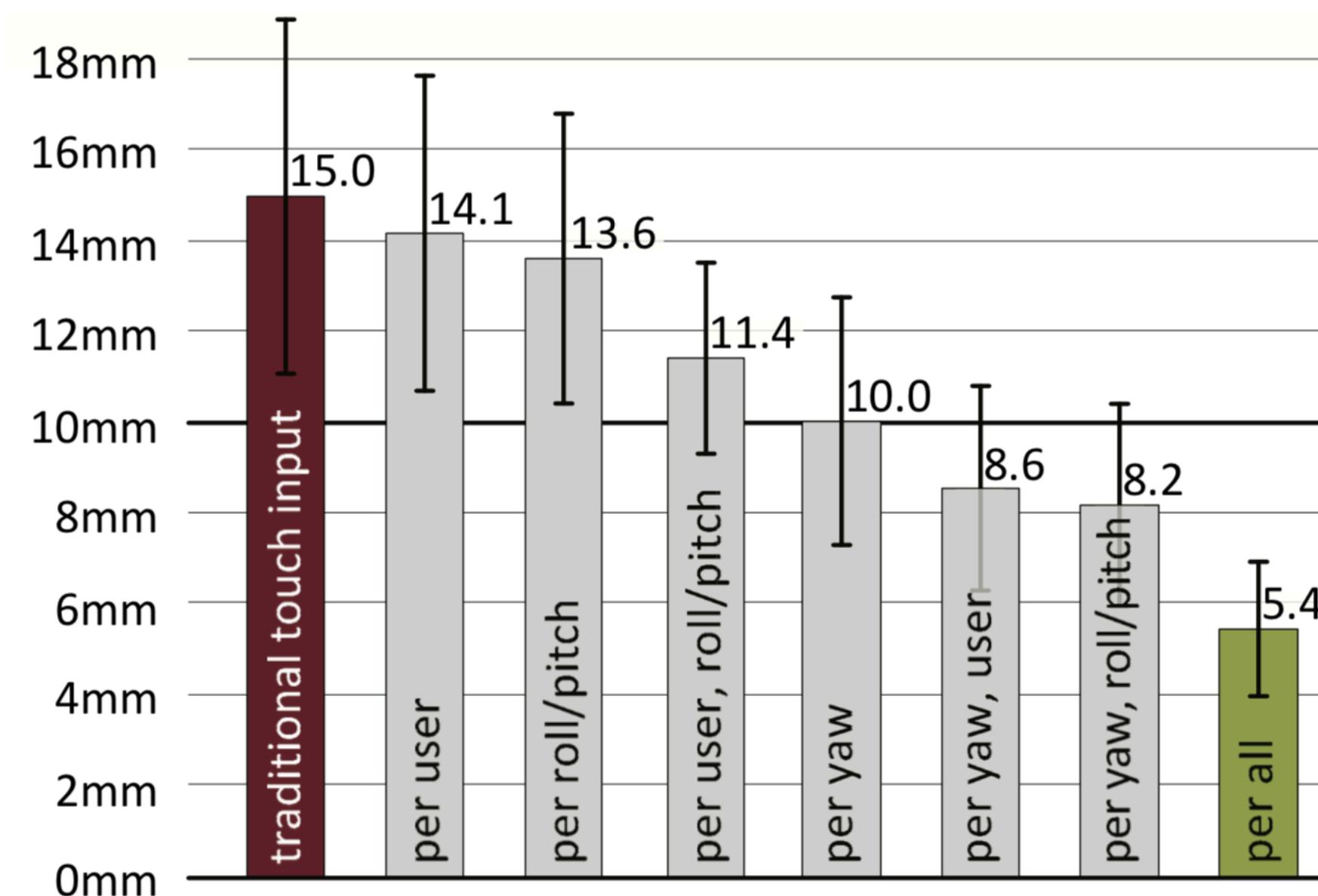
Modeling touch position

user



Modeling touch position

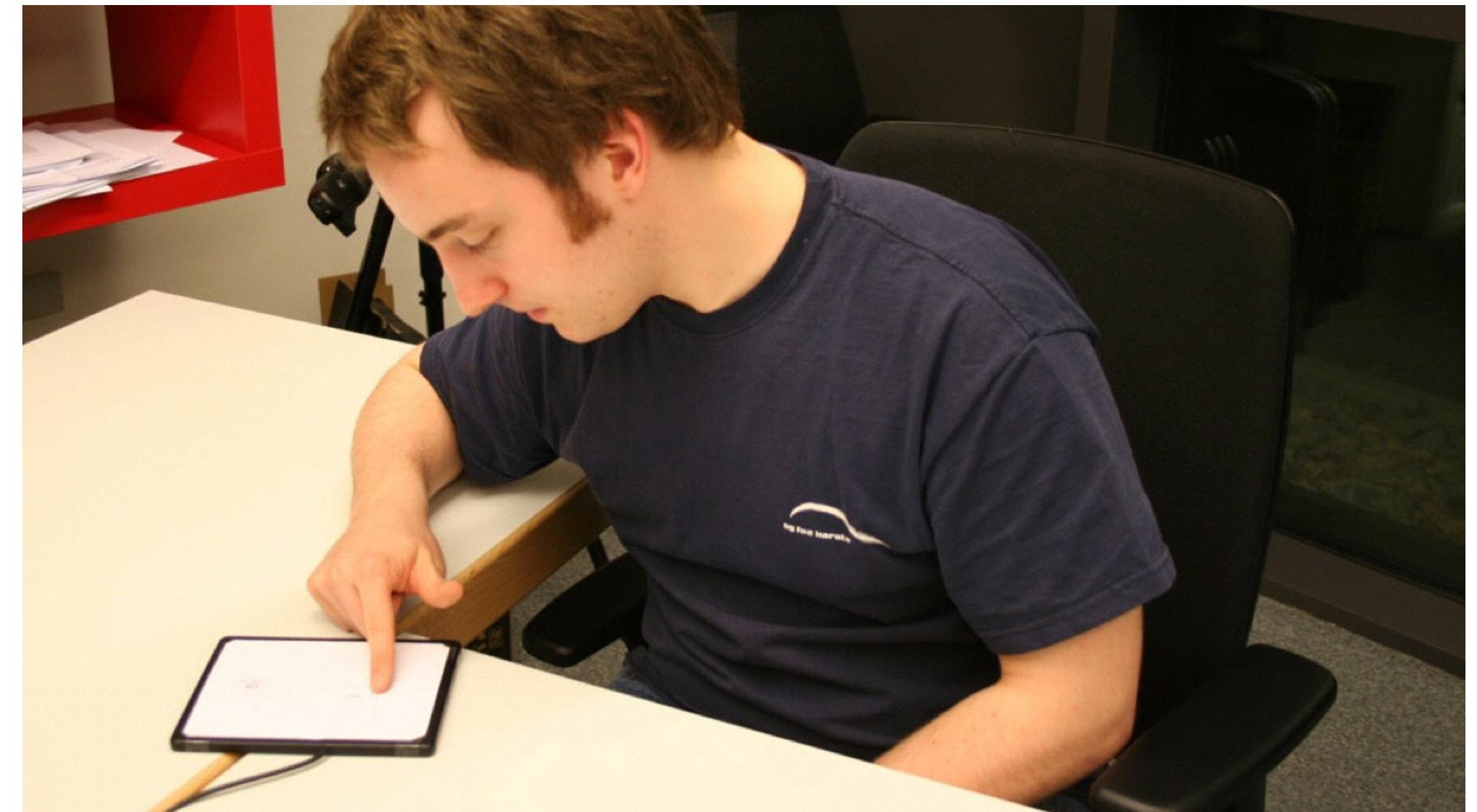
minimum button size



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

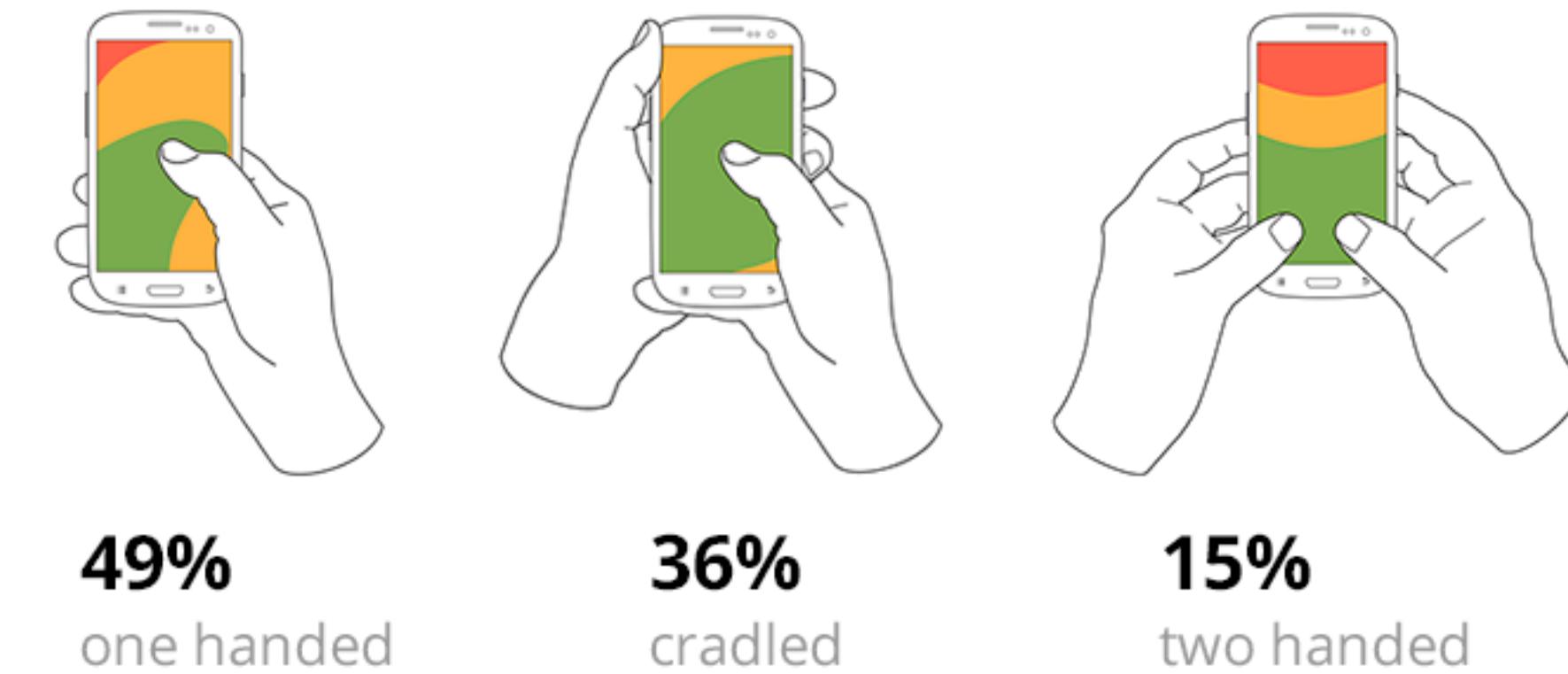
Modeling touch input

- 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?



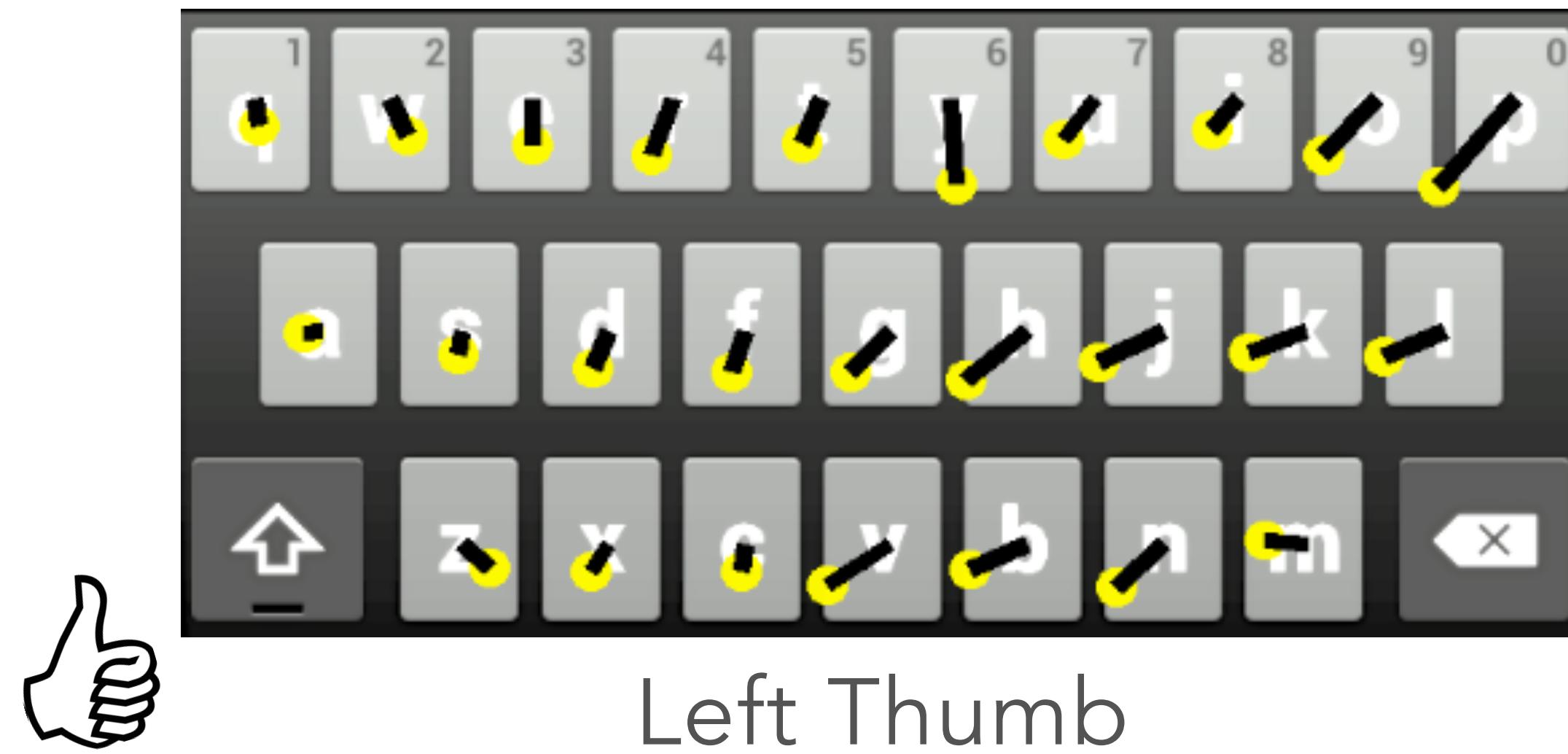
Modeling phone grip

- 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?

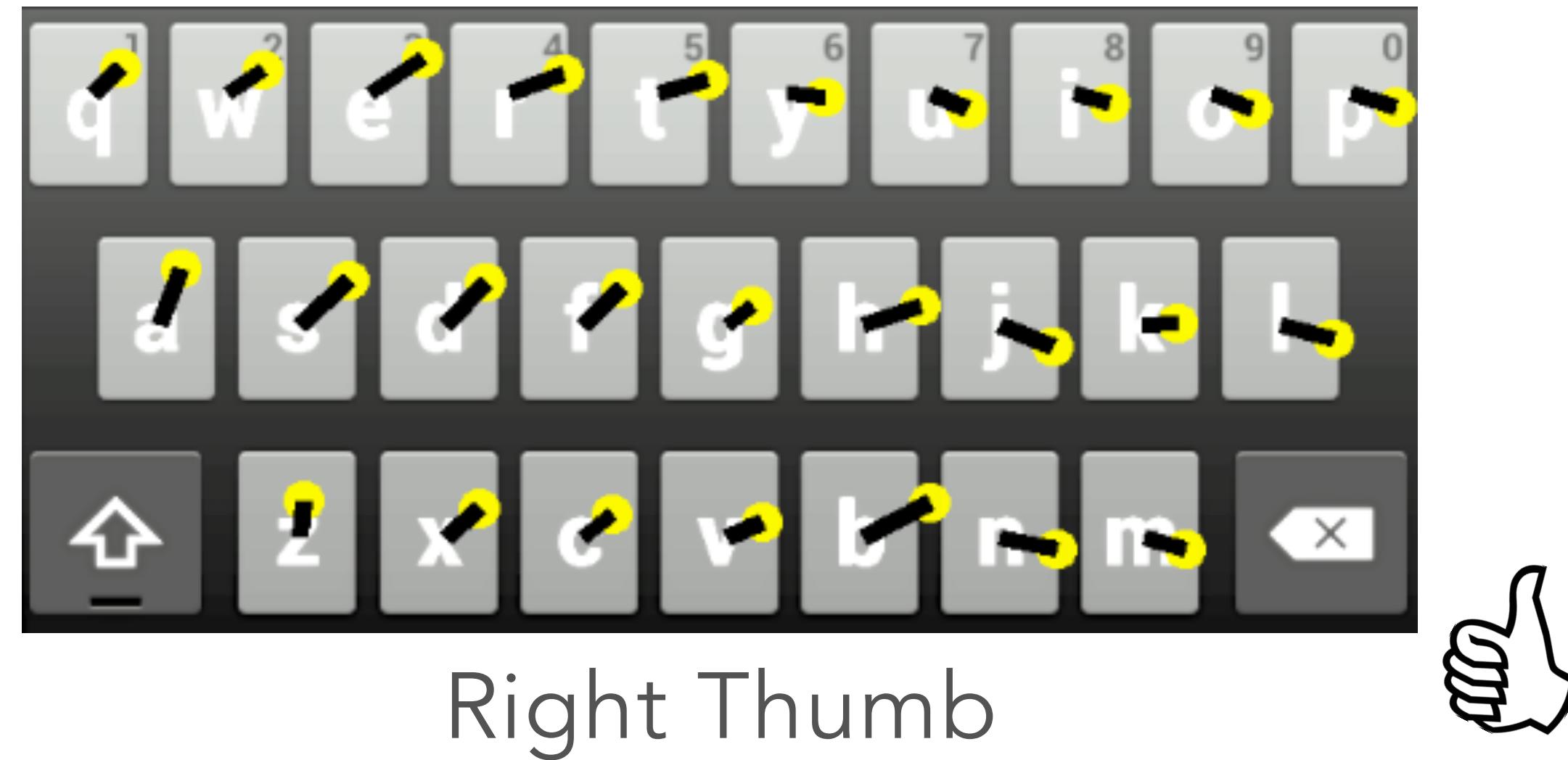


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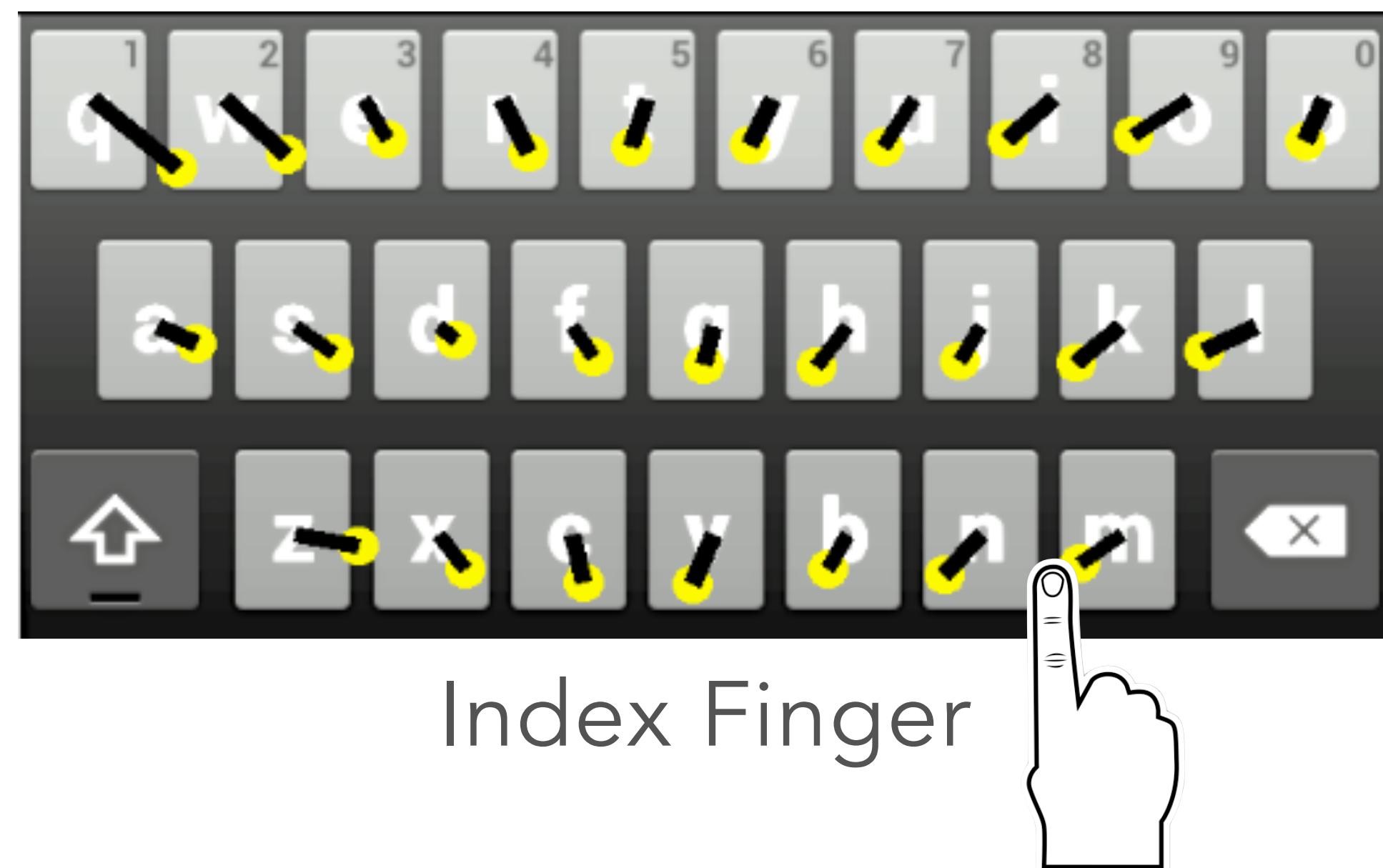
Modeling phone grip



Modeling phone grip

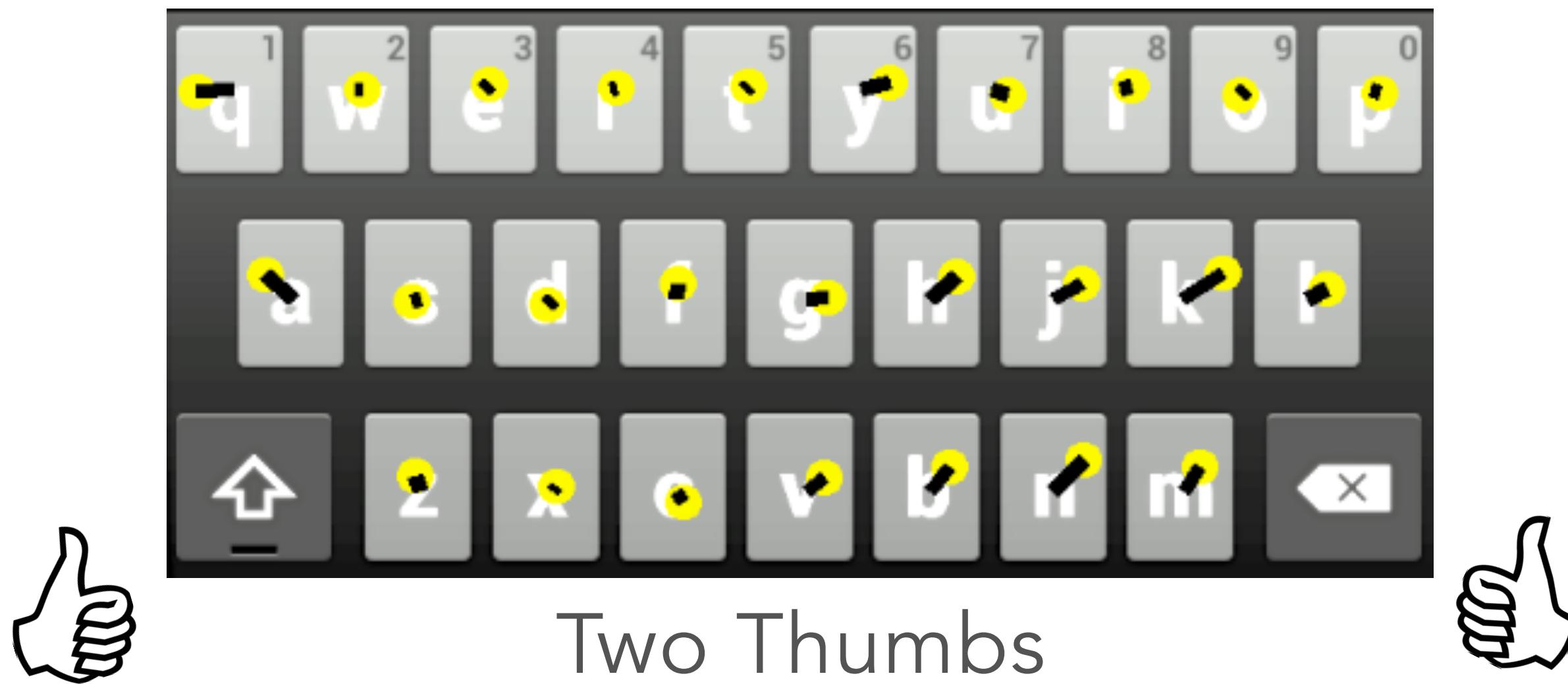


Modeling phone grip



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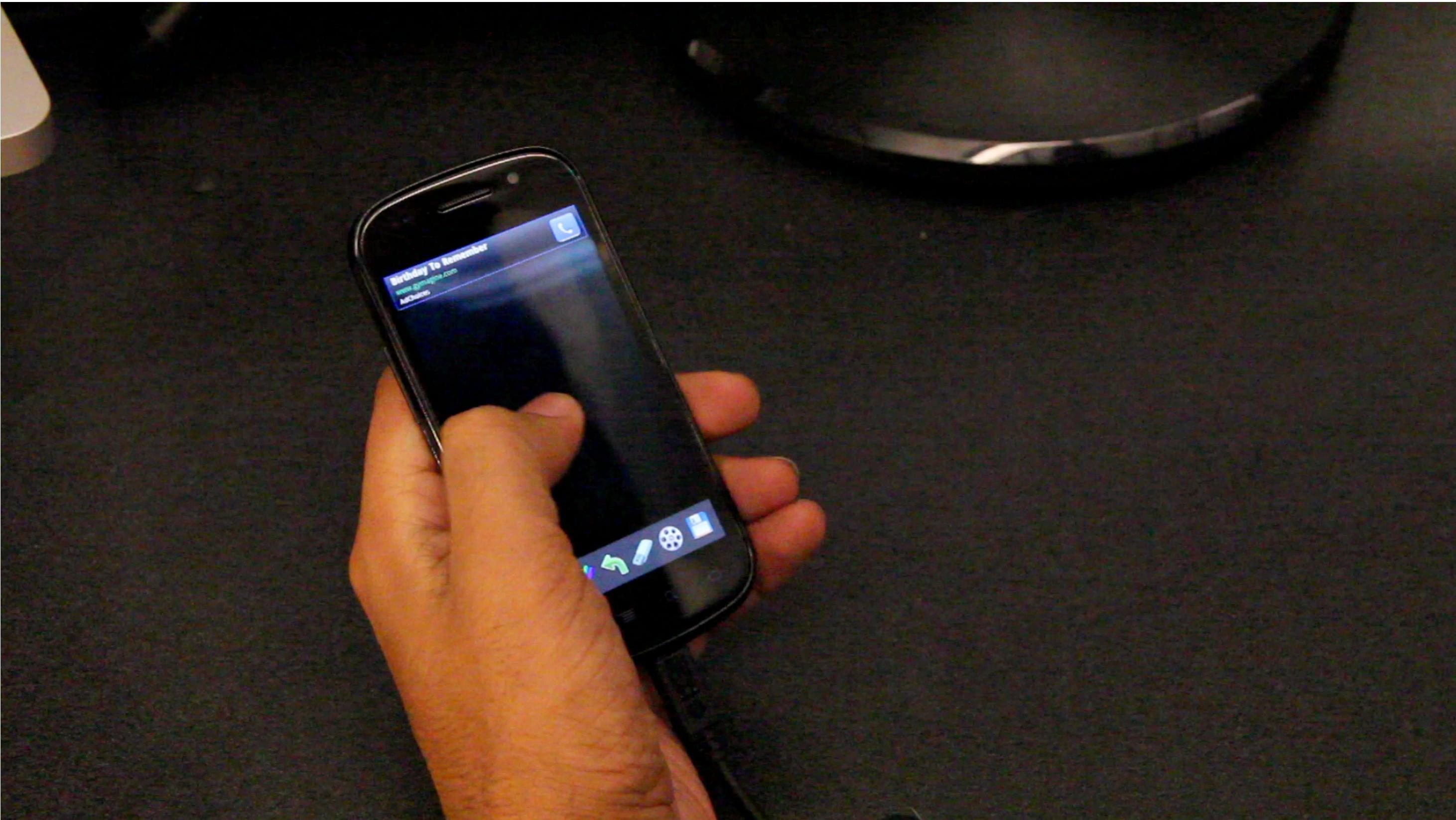


Detecting phone grip with sensors



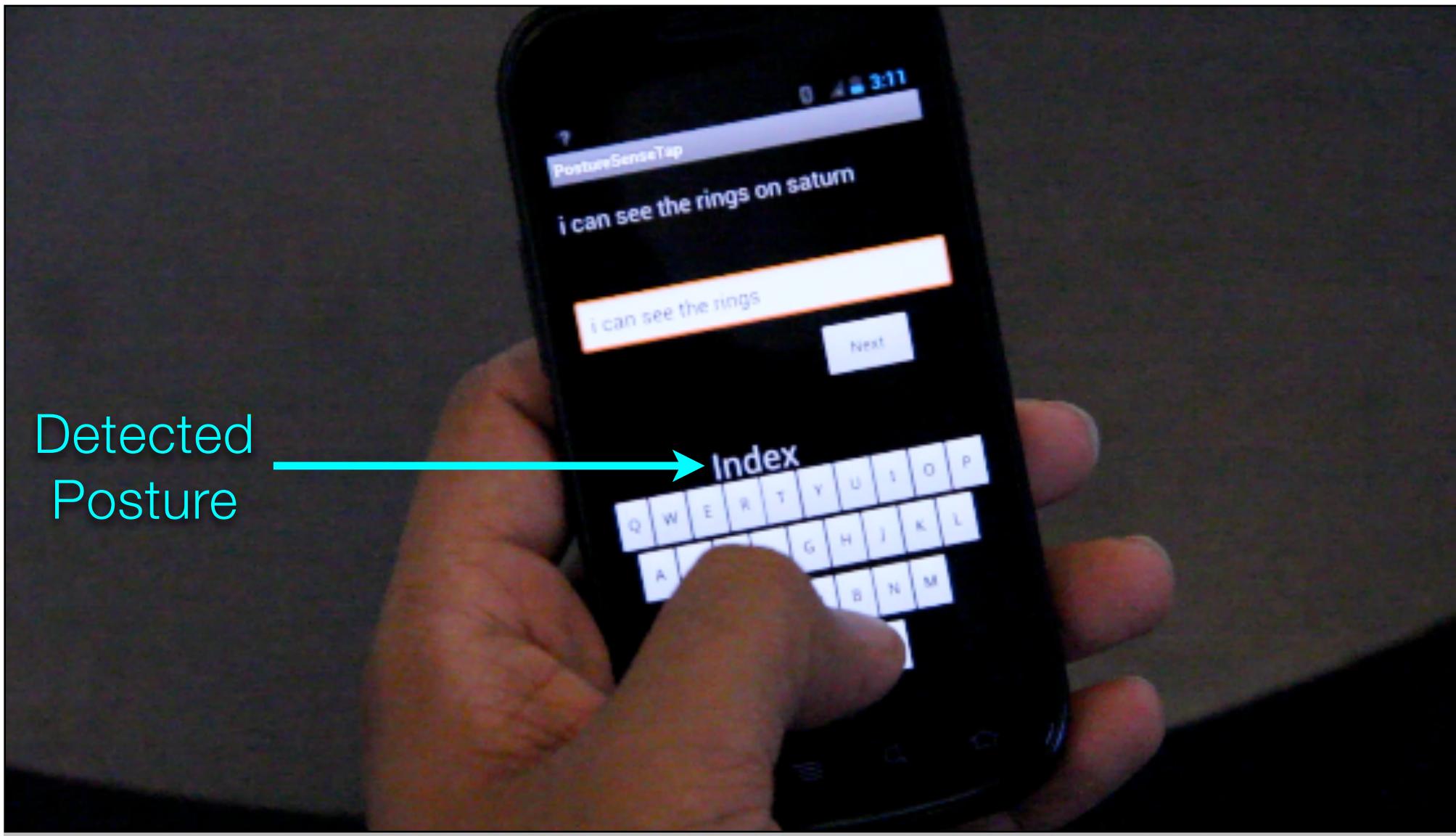
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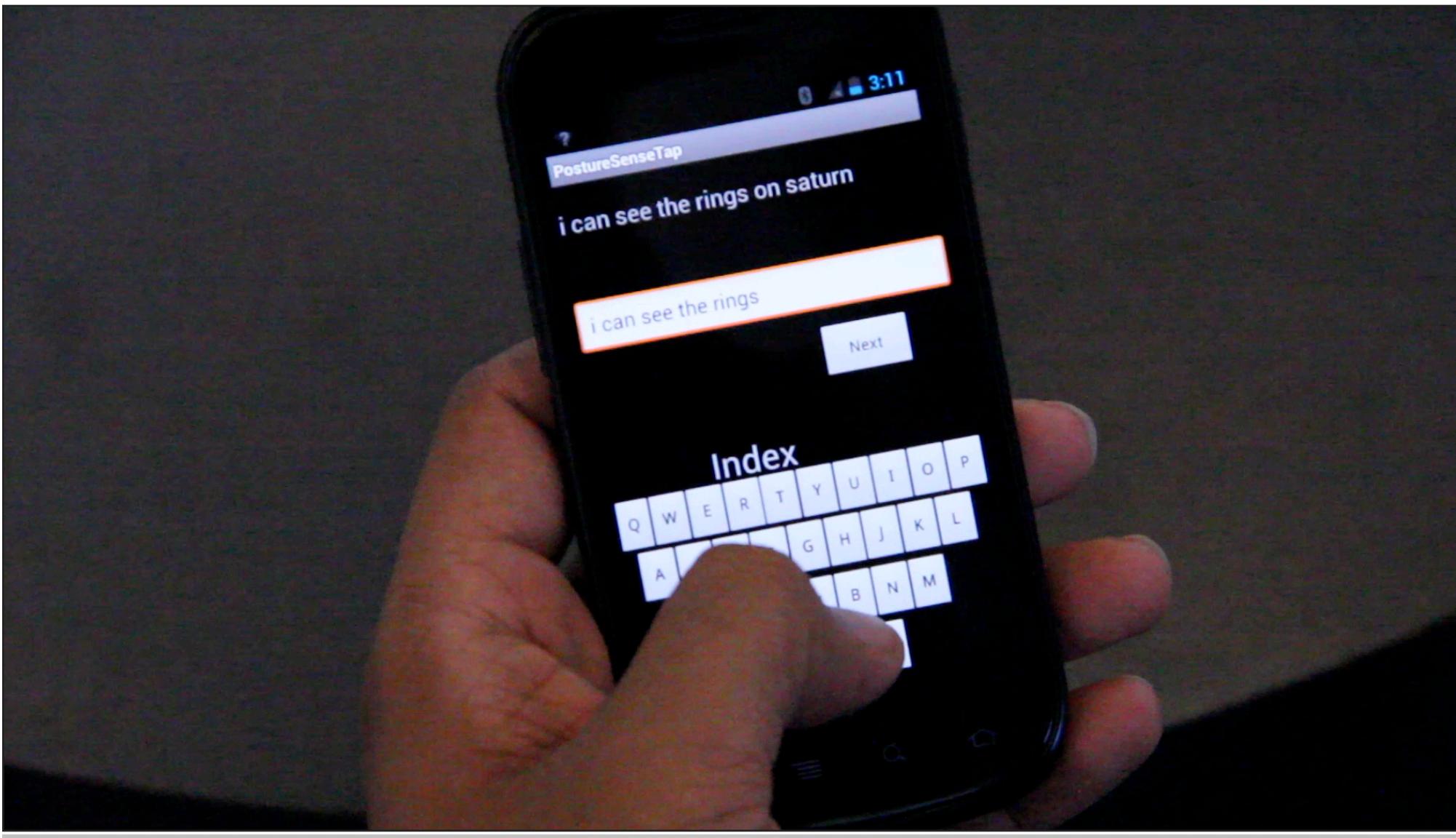
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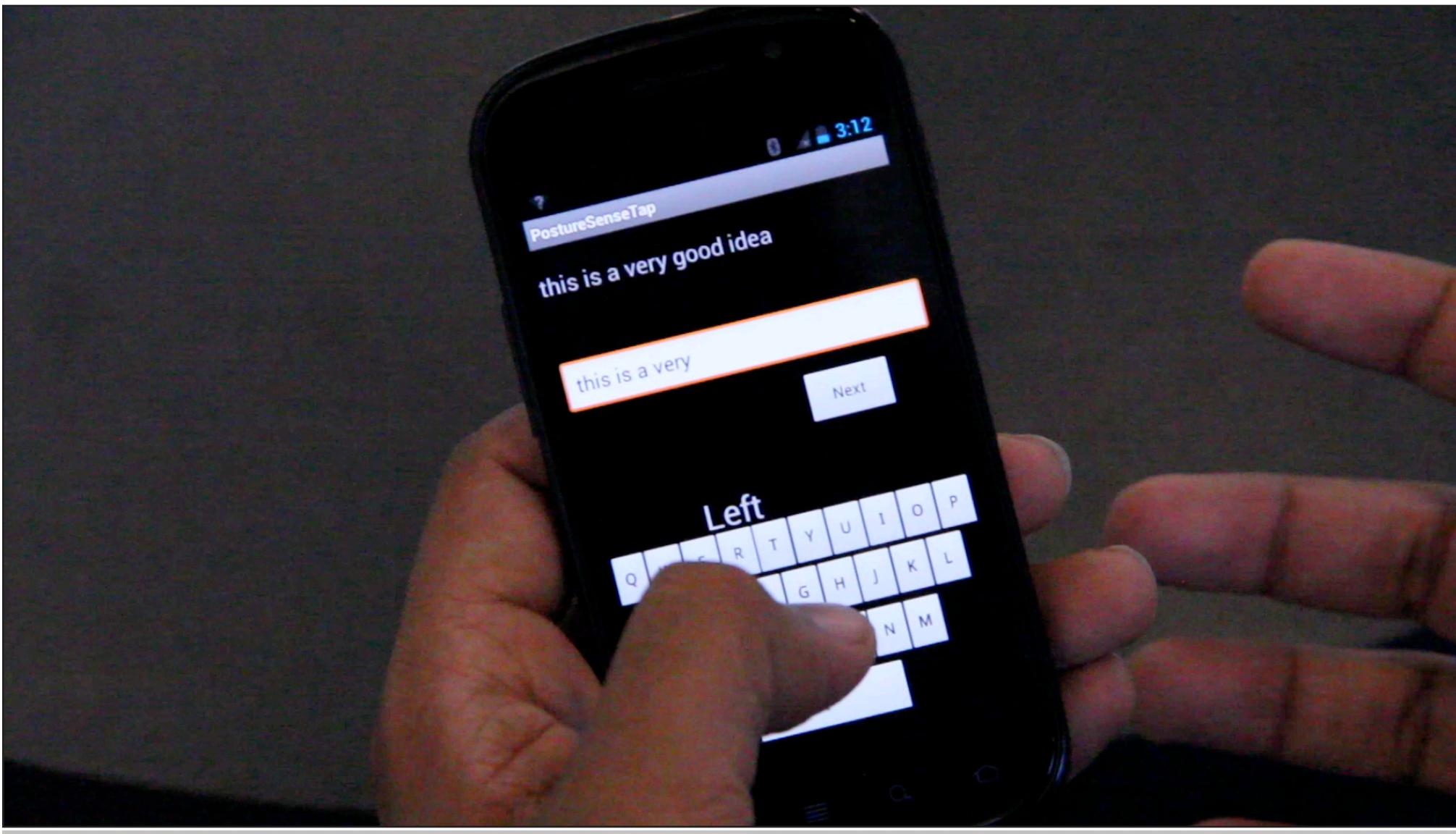
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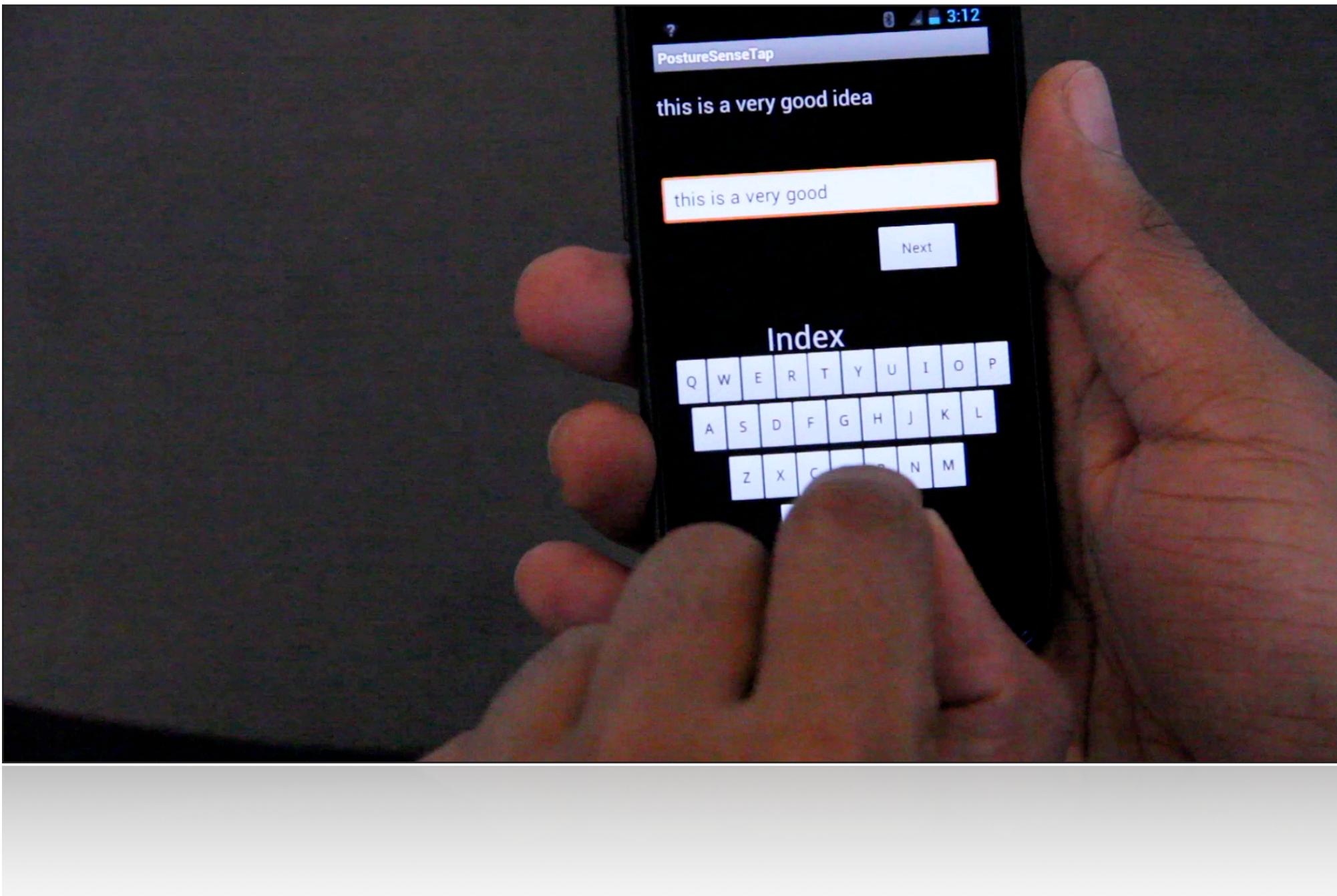
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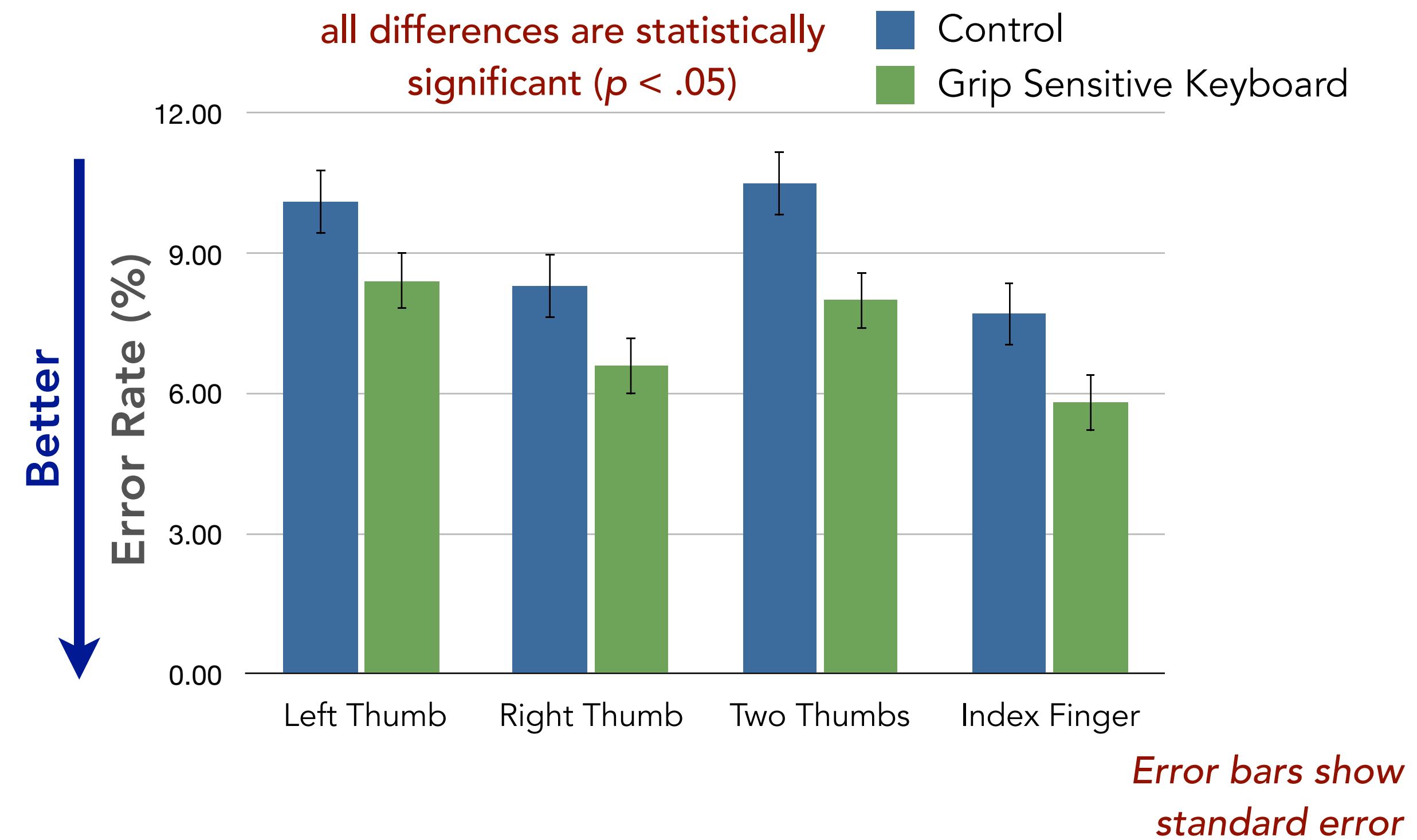
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Summary

- 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

Today's goals

By the end of today, you should be able to...

- Describe what Fitts's Law says we trade off
- Explain the Fat Finger problem in touchscreens
- Describe how we can correct systematic errors in touch performance

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