IN4MATX 133: User Interface Software

Lecture:
Modeling human performance

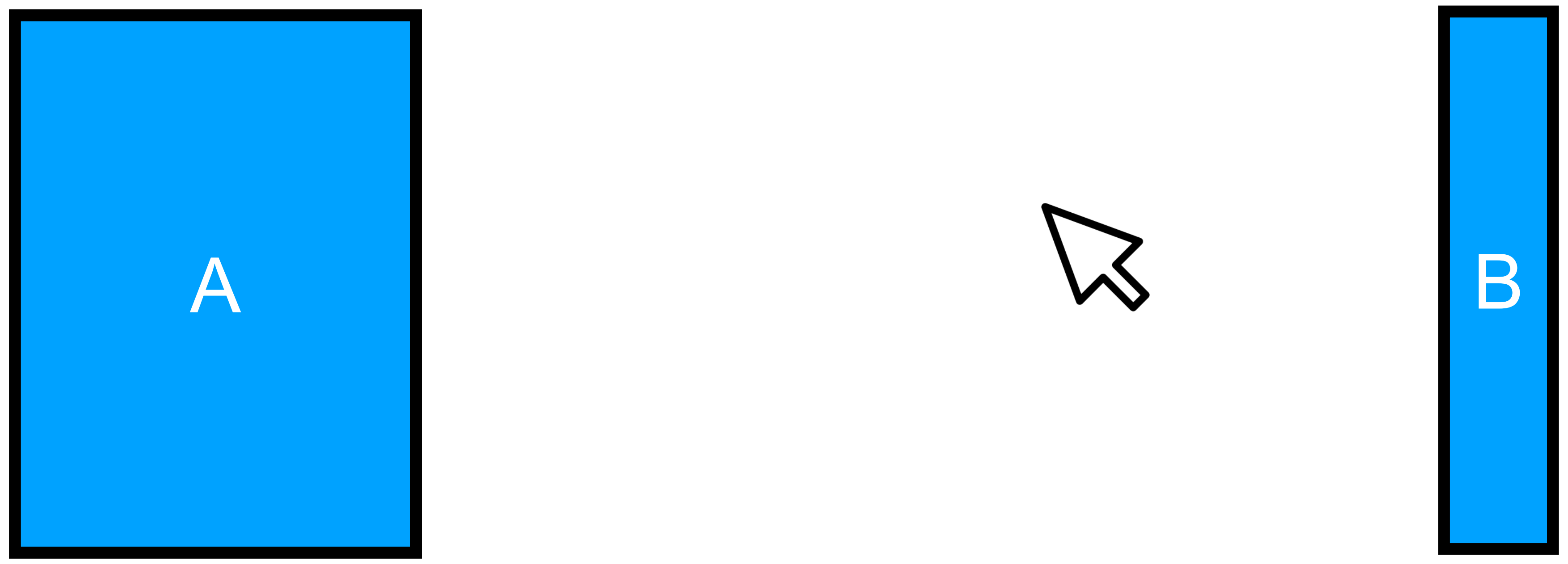
Today’s goals

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

Question

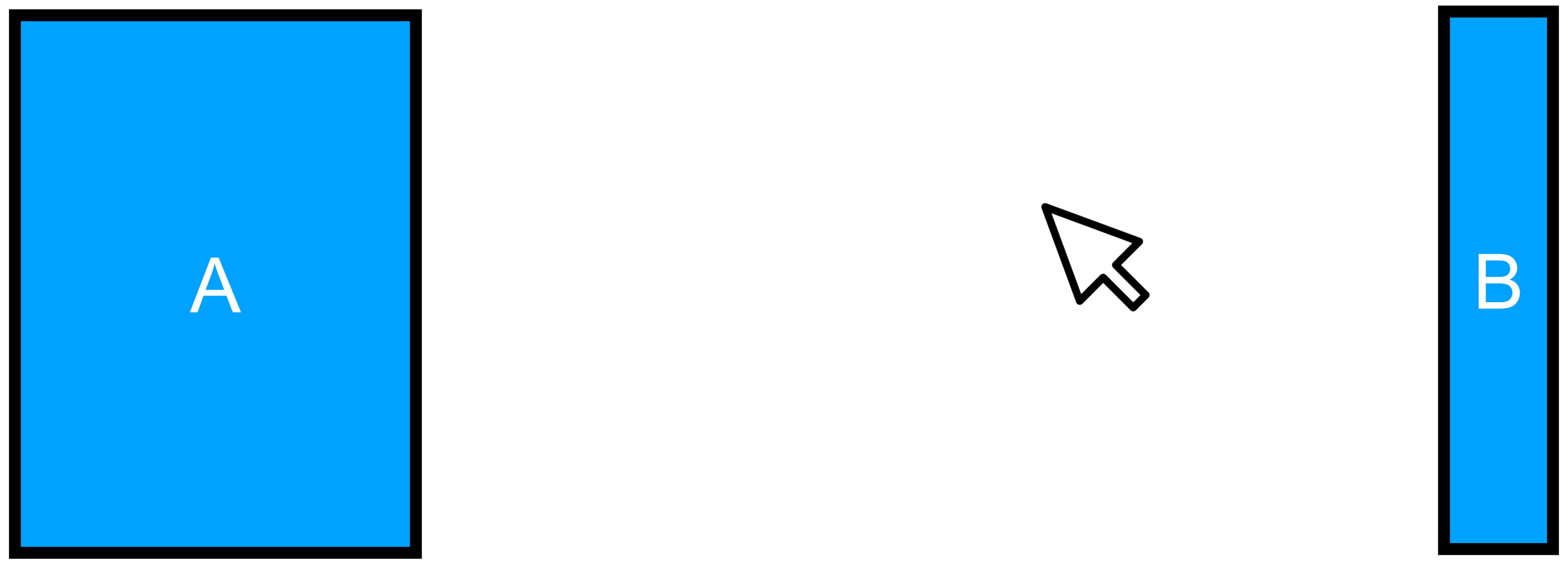
Which button would be faster to click on?



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

Question

Which button would be faster to click on?



- Ⓐ A
- Ⓑ B
- [✓ Ⓒ Roughly equal]
- Ⓓ
- Ⓔ

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

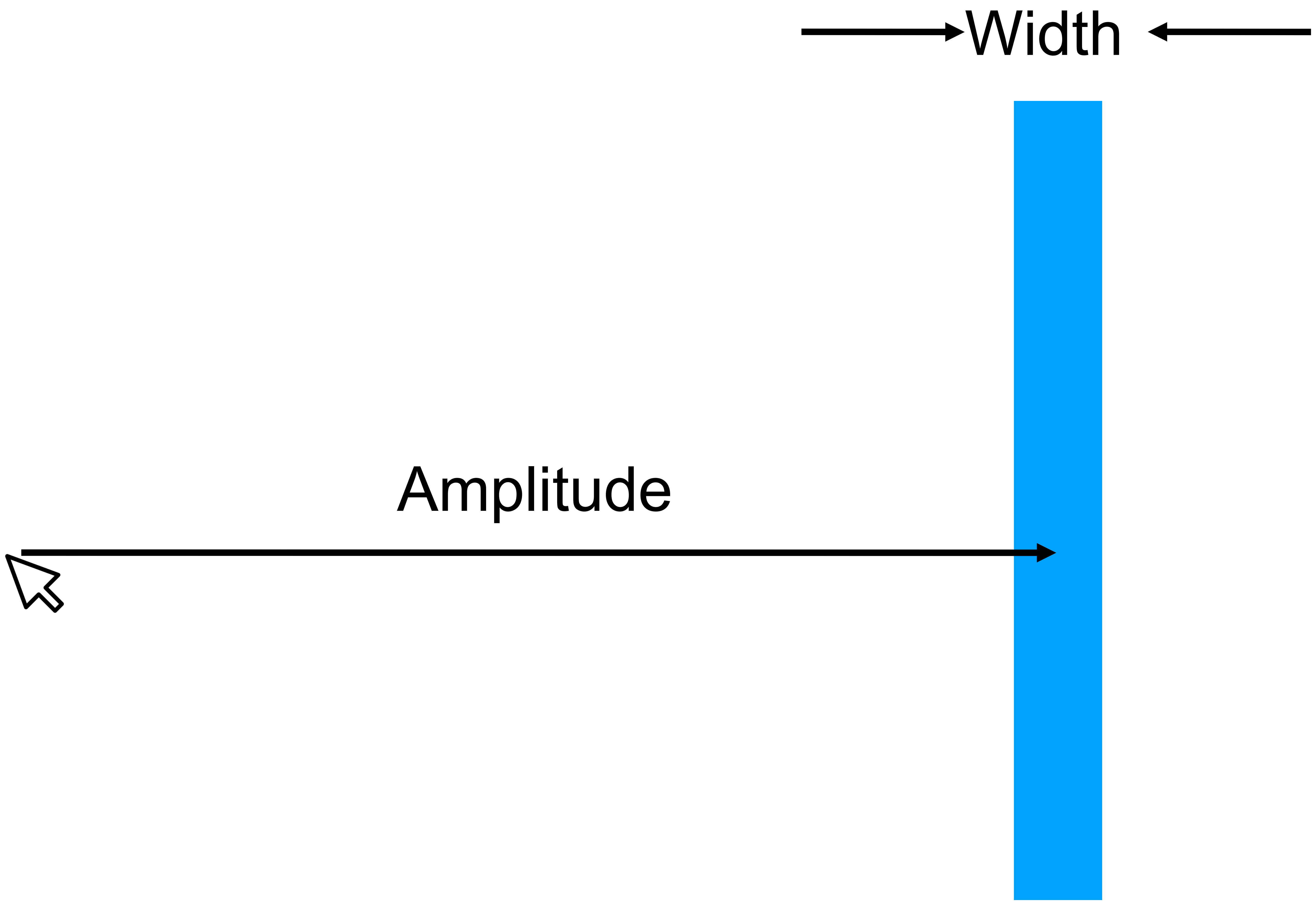
https://en.wikipedia.org/wiki/Fitts%27s_law

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 log2(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 demo]

http://simonwallner.at/ext/fitts/

“Beating” Fitts’s law

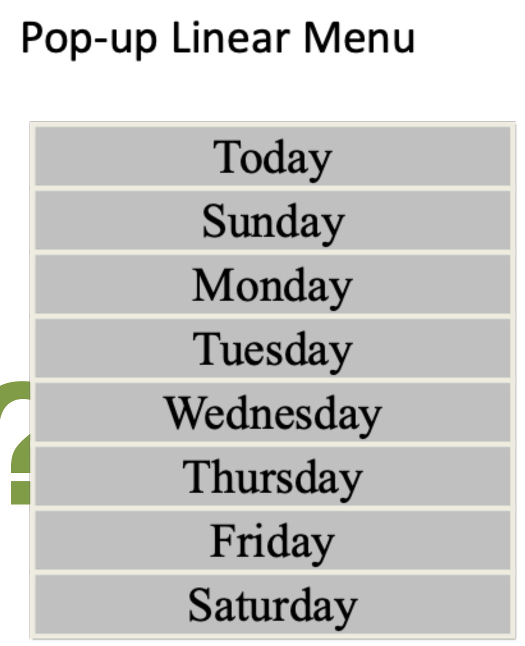
- It is the law, right?
  - MT = a + b log2(A/W + 1)
- So how can we reduce movement time?
  - Reduce amplitude (A)
  - Increase width (W)

“Beating” Fitts’s law

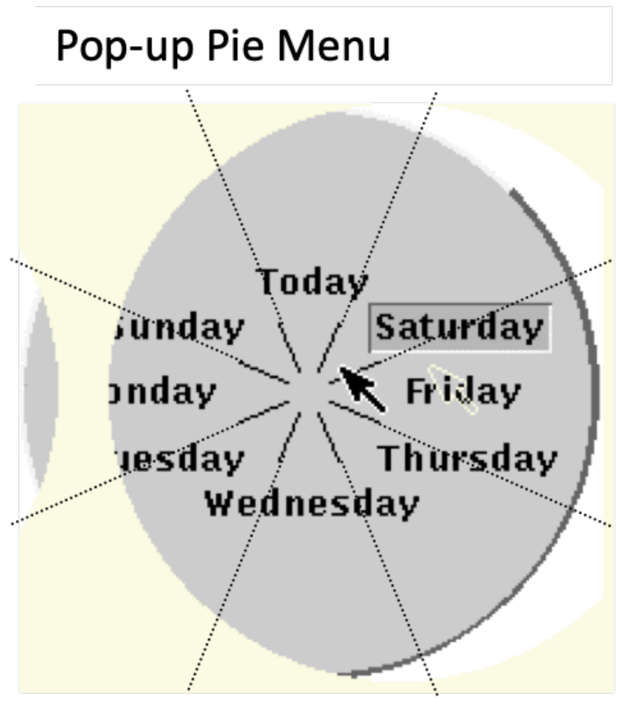
- Put targets closer together
- Make targets bigger
- Make cursor bigger
- Make impenetrable edges

Question

(A)


Pop-up Linear Menu

(B)


Pop-up Pie Menu

Which menu will be faster on average?

Ⓐ A

Ⓑ B

Ⓒ Roughly equal

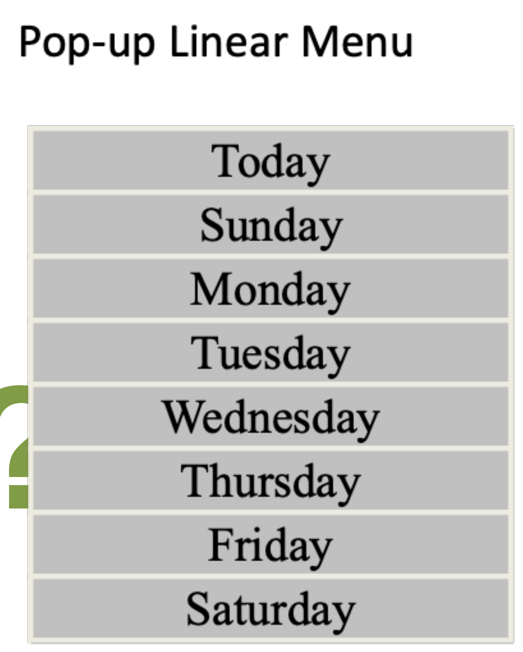
Ⓓ

Ⓔ

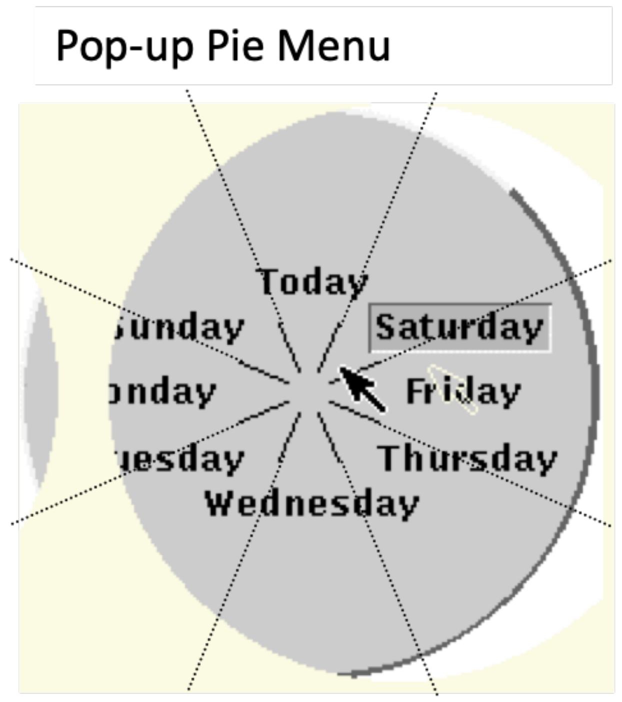
Question

Which menu will be faster on average?

(A)


Pop-up Linear Menu

(B)


Pop-up Pie Menu

A A

[✓ B] B

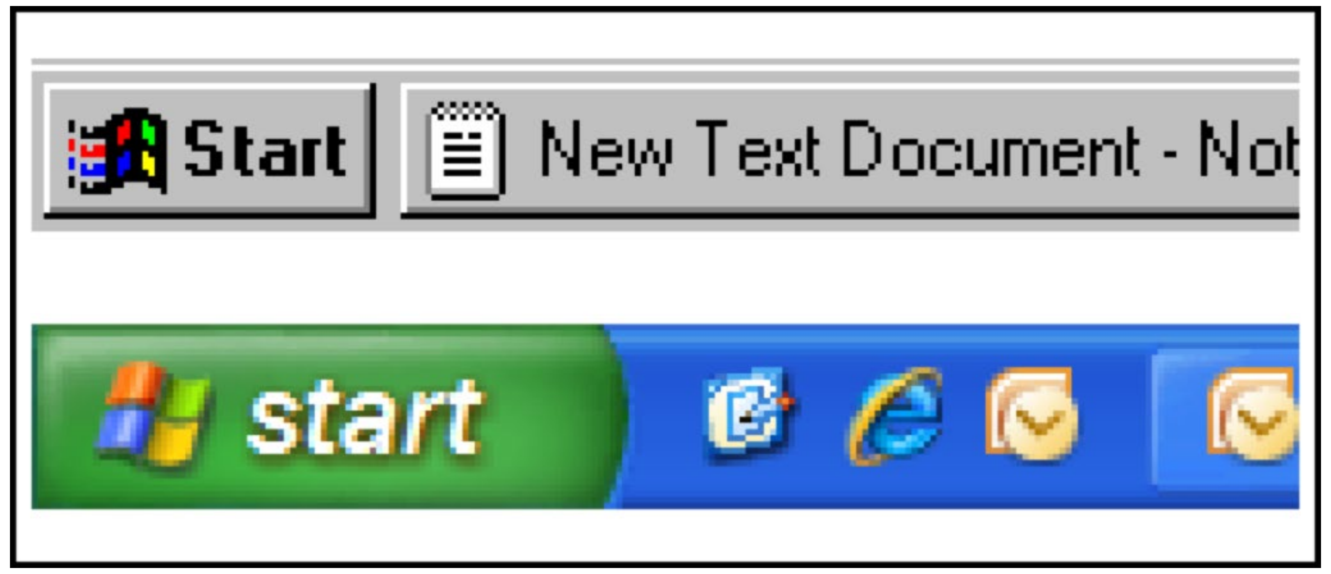
C Roughly equal

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

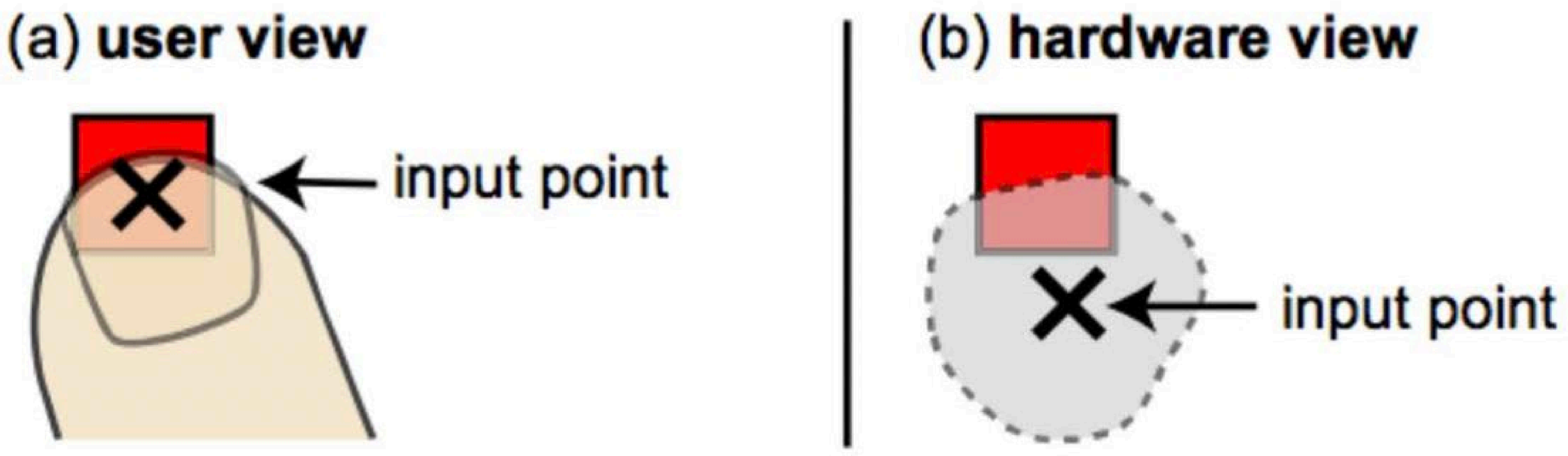
- But in practice, touchscreens on mobile tend not to be much faster
  - Buttons are smaller
  - People tend to be slower near the edges of touchscreens

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



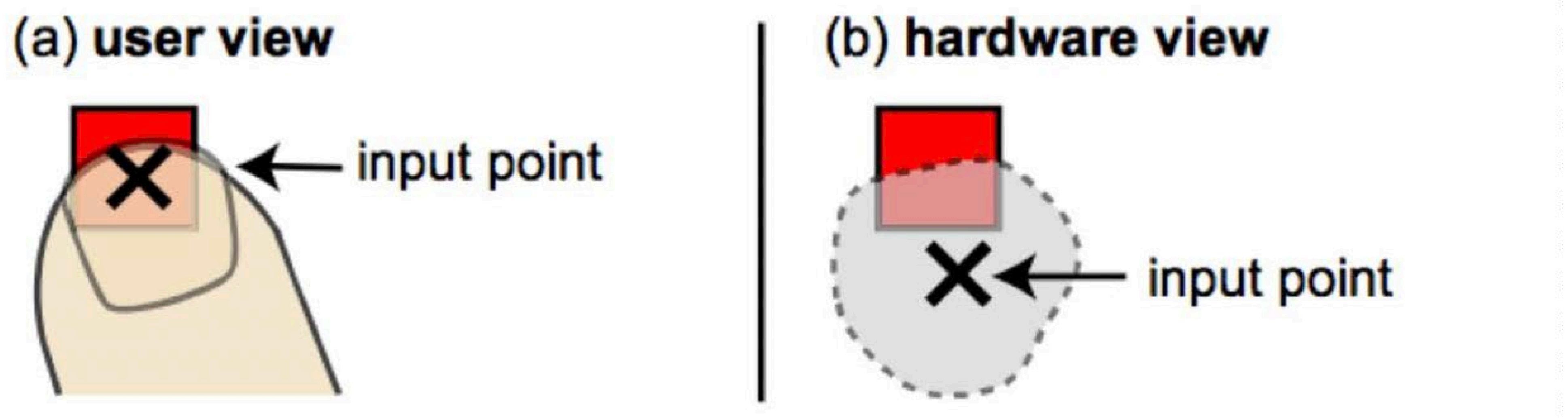
Daniel Vogel and Patrick Baudisch. 2007. Shift: a technique for operating pen-based interfaces using touch. CHI 2007. https://doi.org/10.1145/1240624.1240727

Modeling touch position

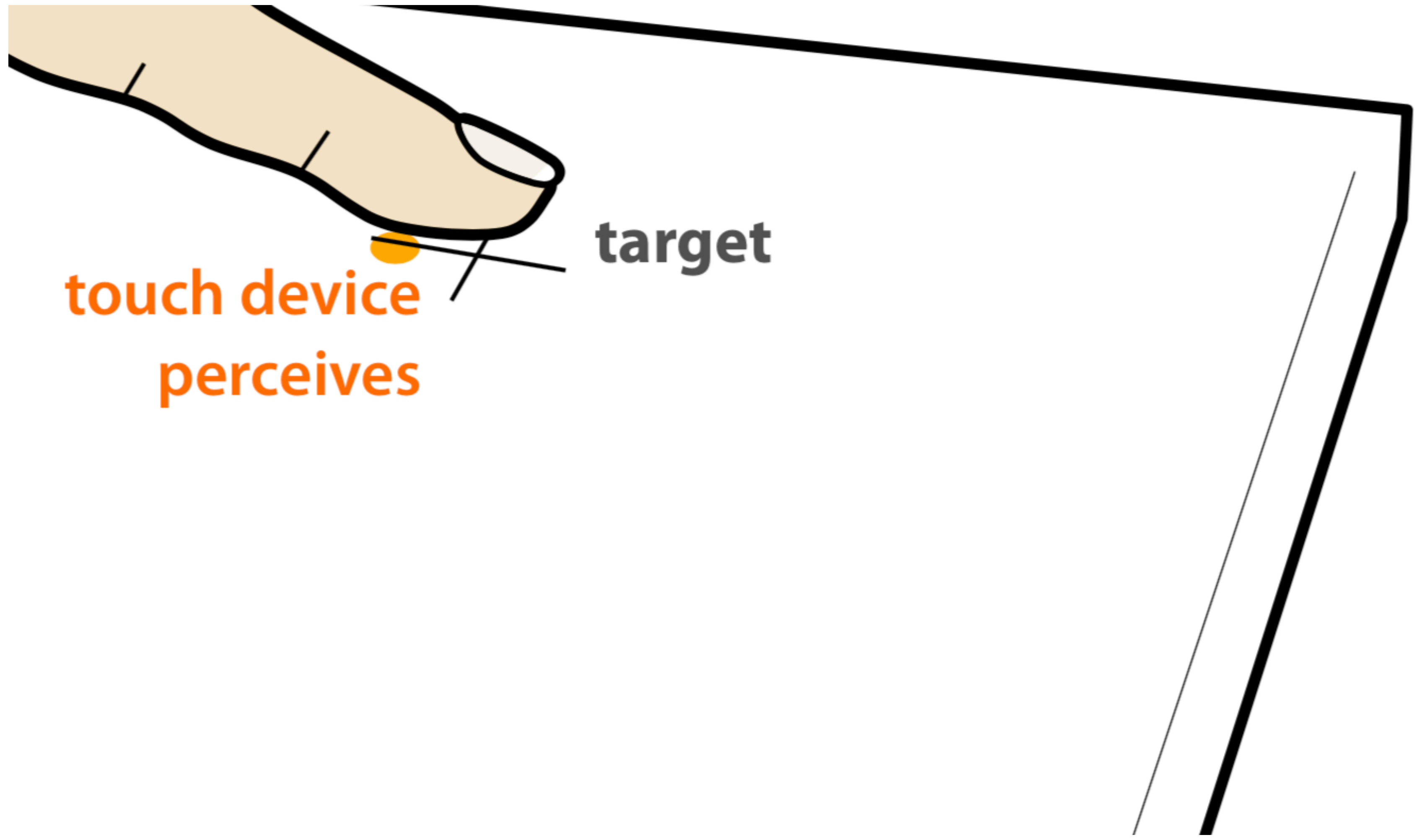
- One interpretation of the problem: *our fingers are fat*
  - We should use tiny styluses to make our our selection more accurate
- Another interpretation: *our model of touch position is inaccurate*
  - We should make our model better

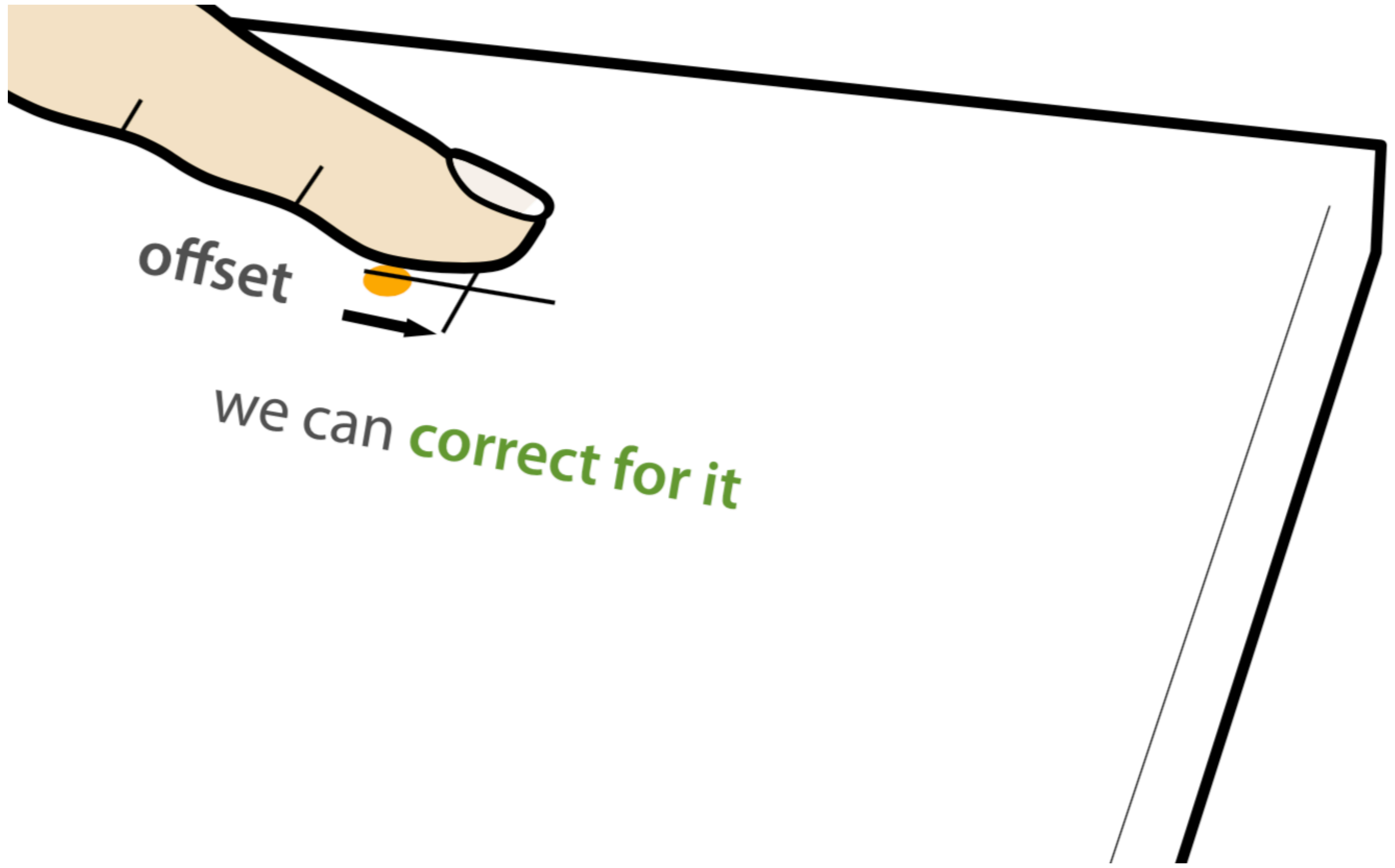
Modeling touch position

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



Modeling touch position

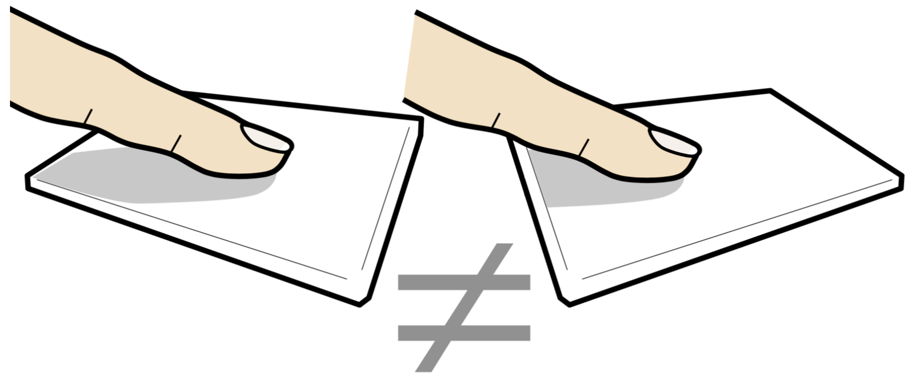




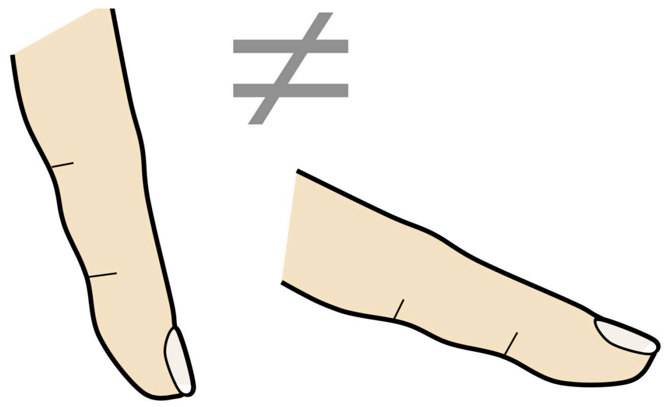
Christian Holz and Patrick Baudisch. 2011. Understanding touch. CHI 2011. https://doi.org/10.1145/1978942.1979308

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



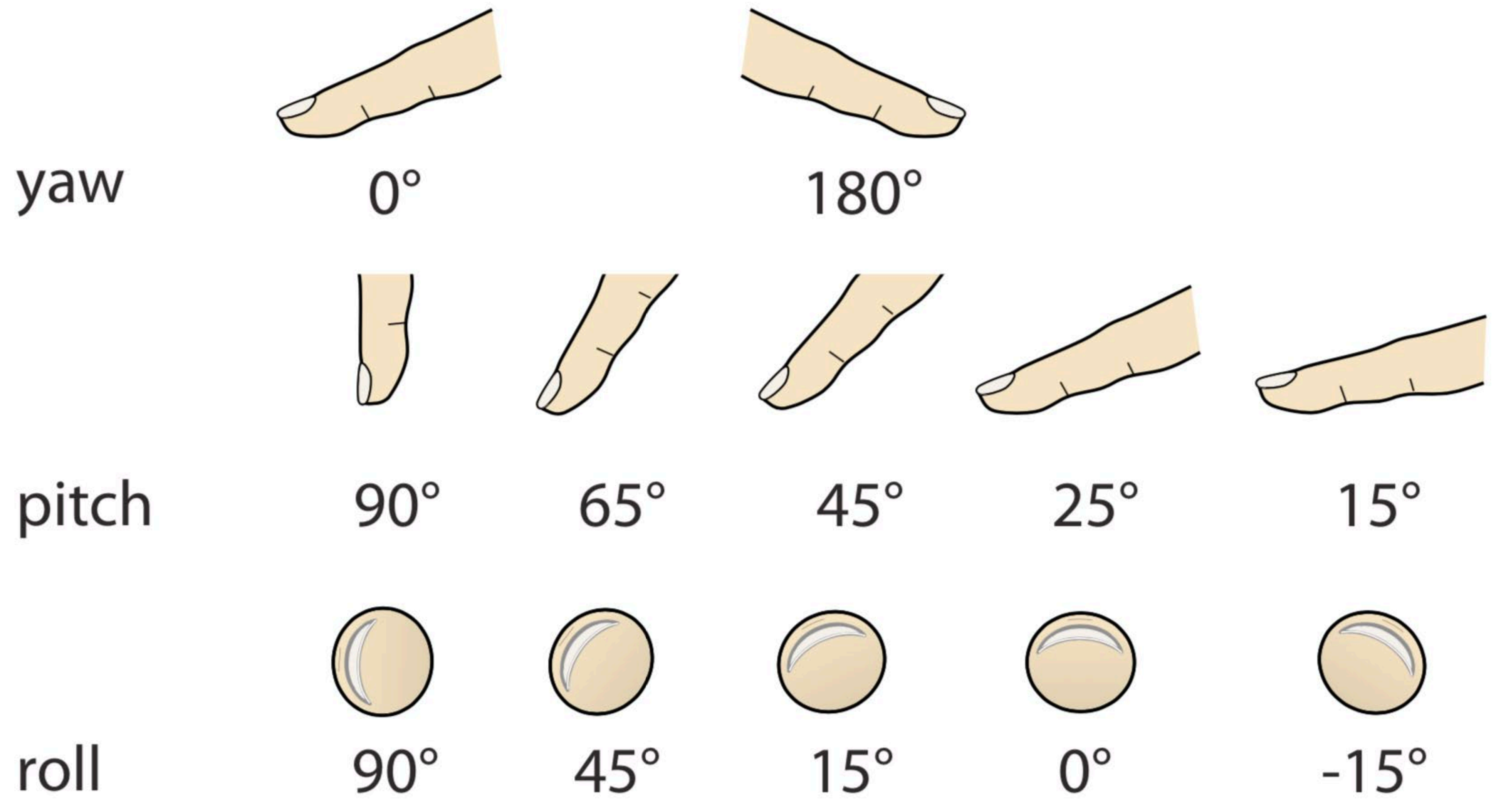
Pitch: angle of finger

Roll: rotation of finger

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

Modeling touch position

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



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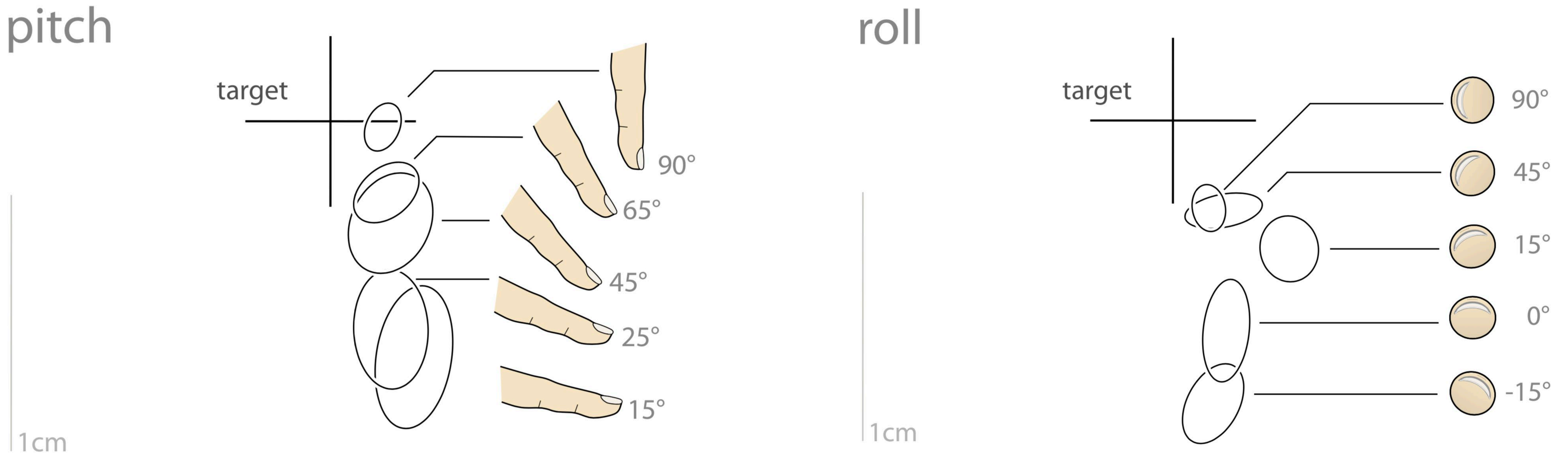
Modeling touch position



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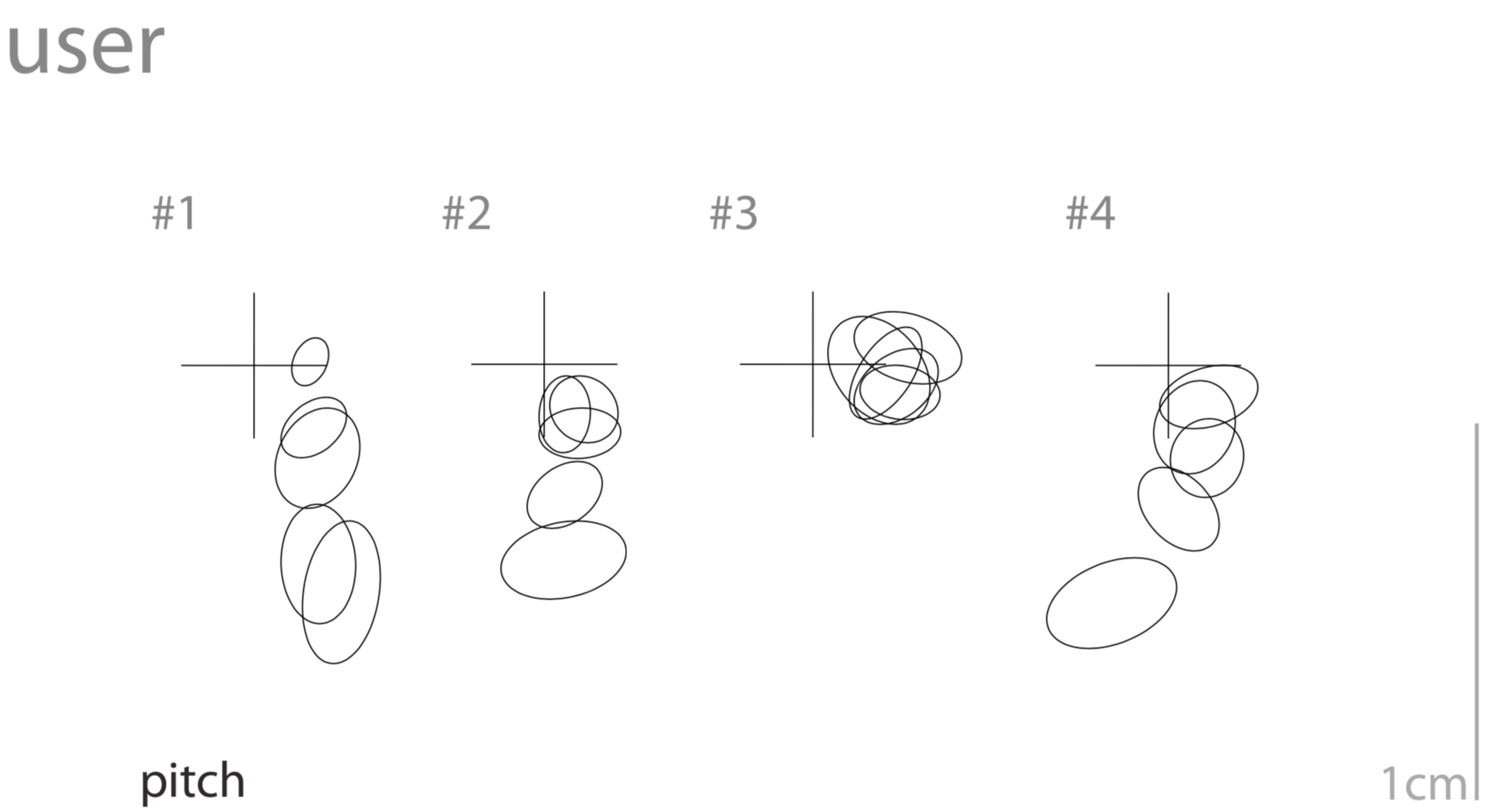
Modeling touch position



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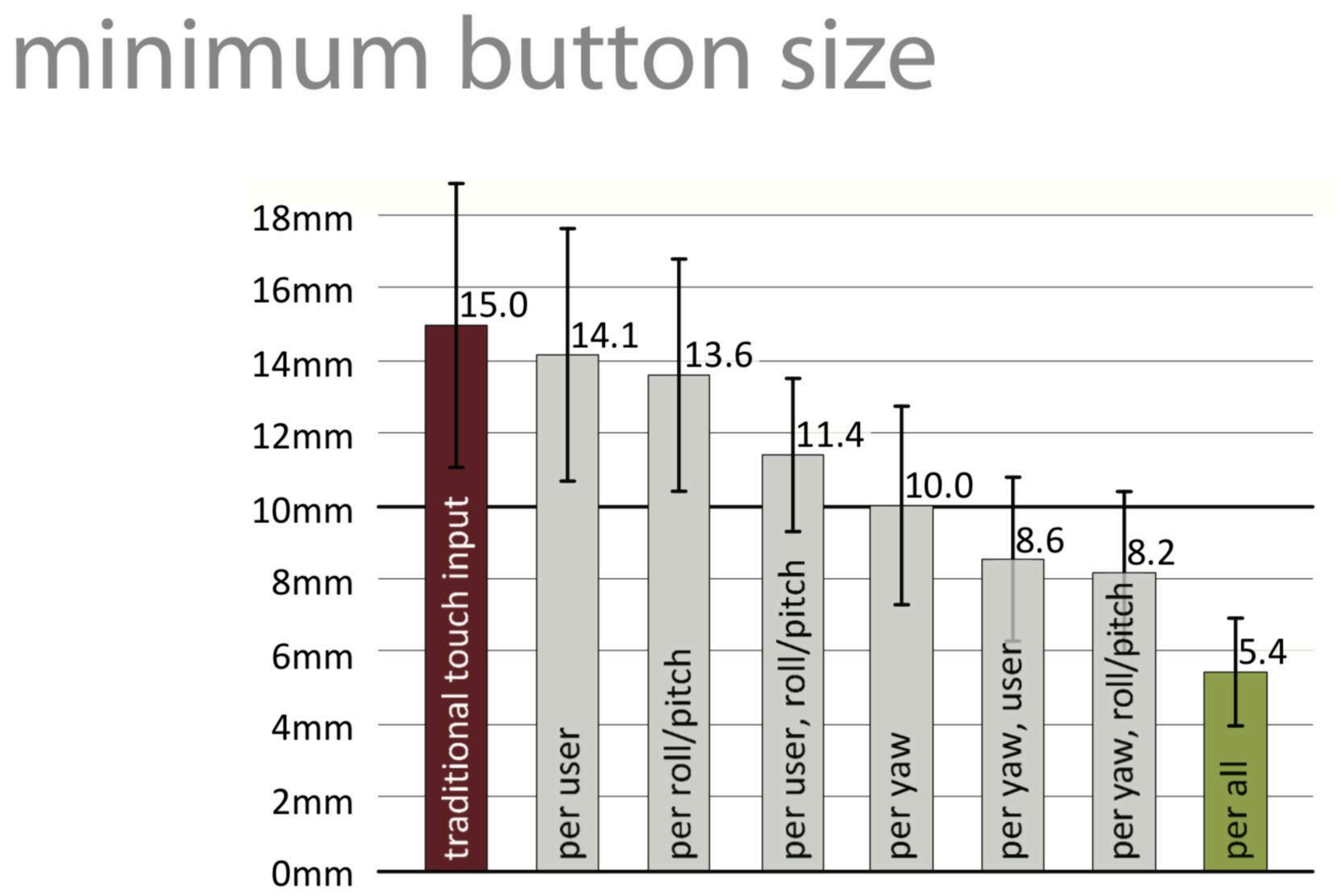
Modeling touch position

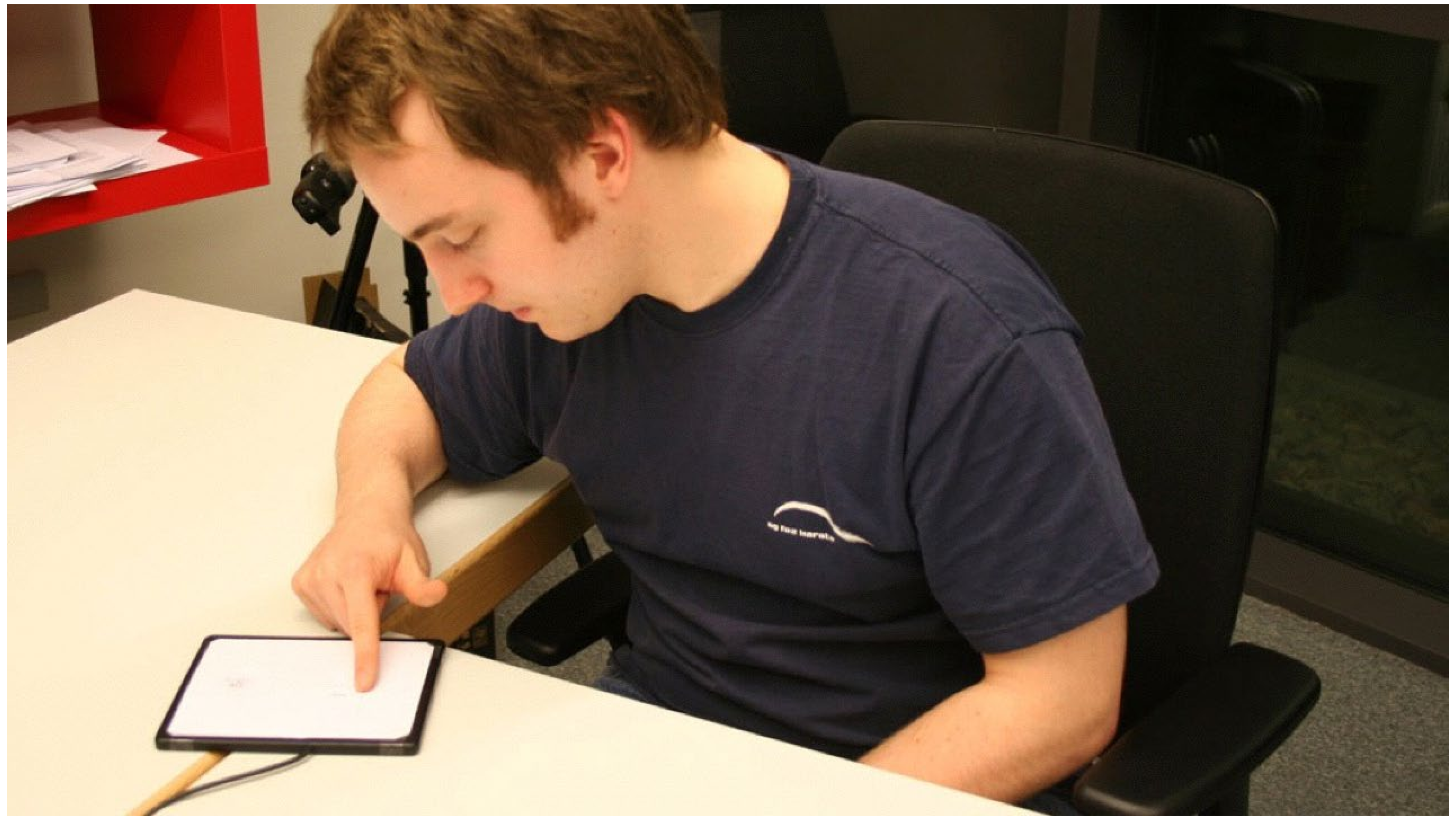


Improving the model means that buttons can be **3x** smaller and not be any harder to click

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

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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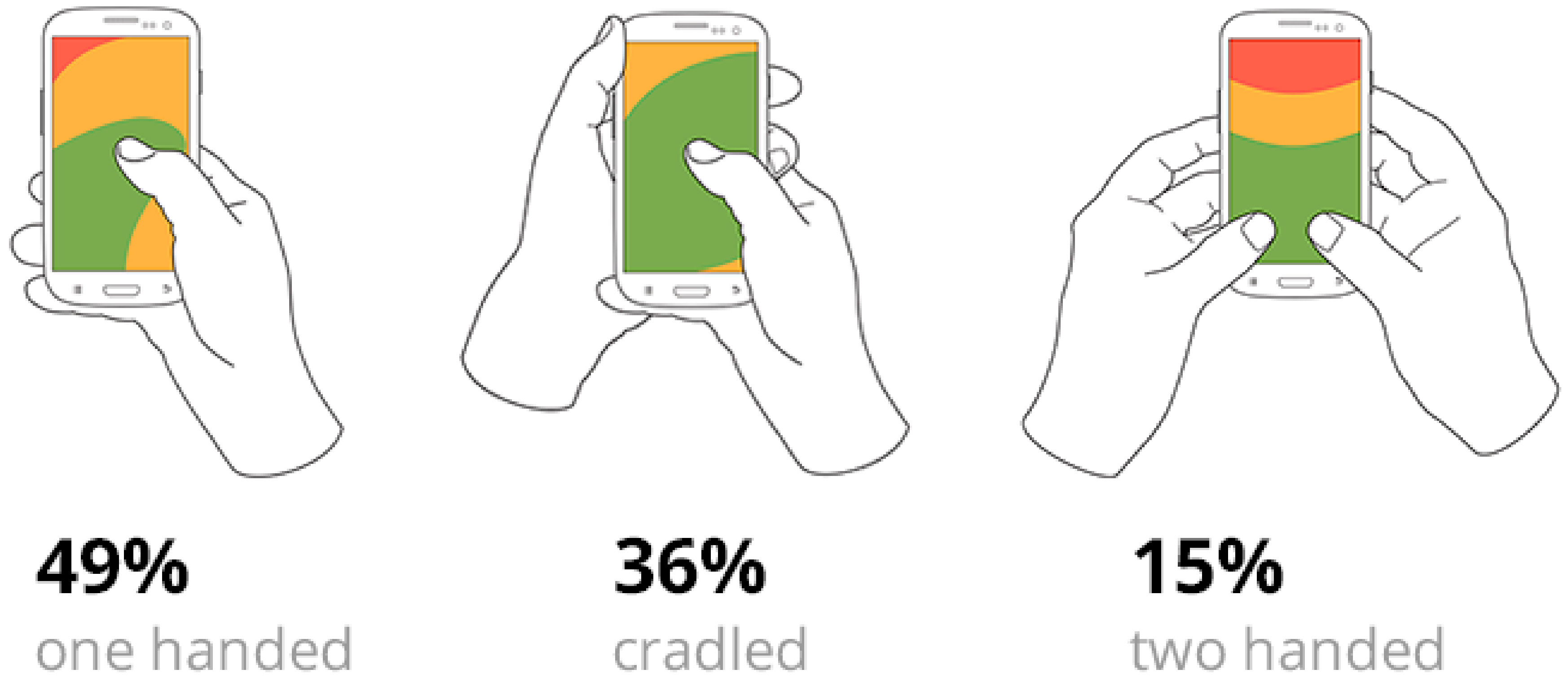
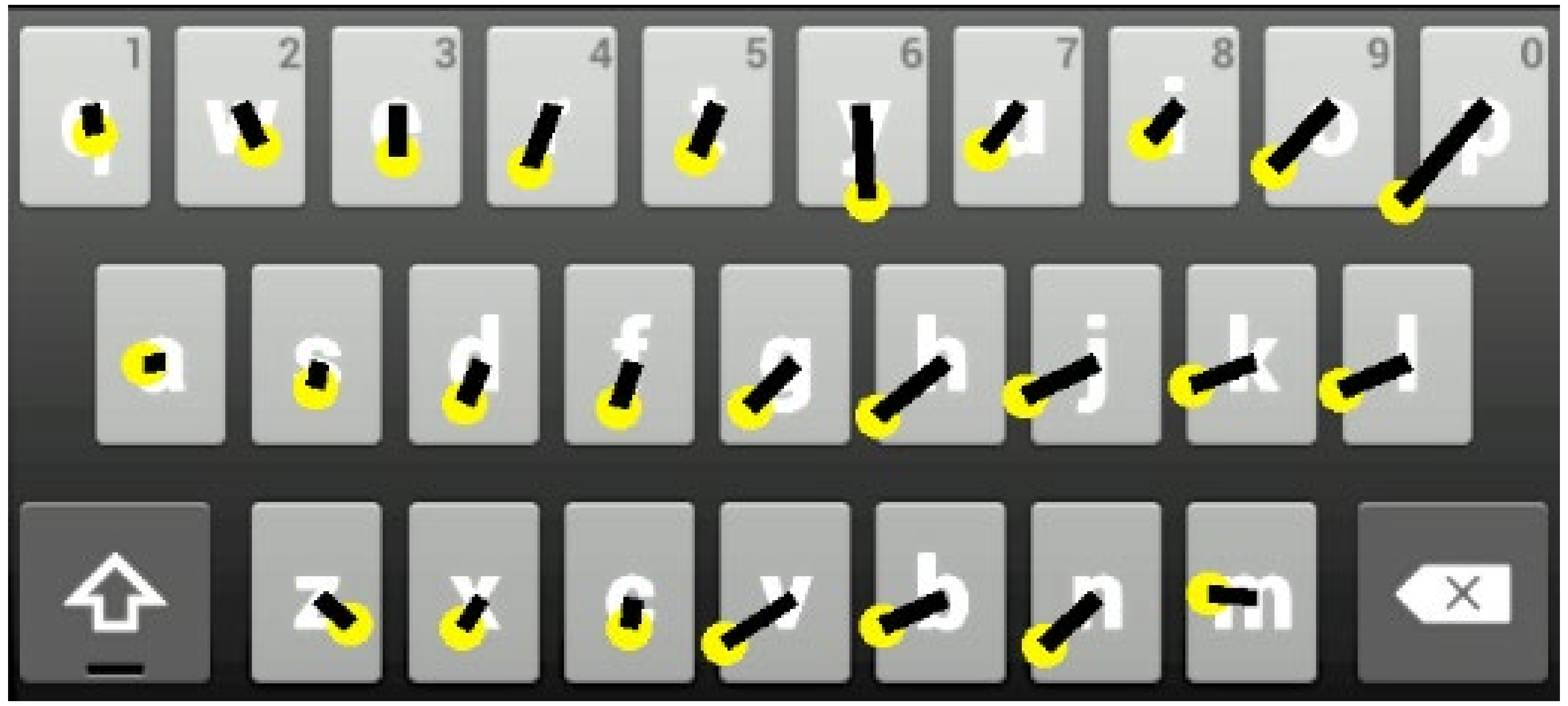
Modeling phone grip

- 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?



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

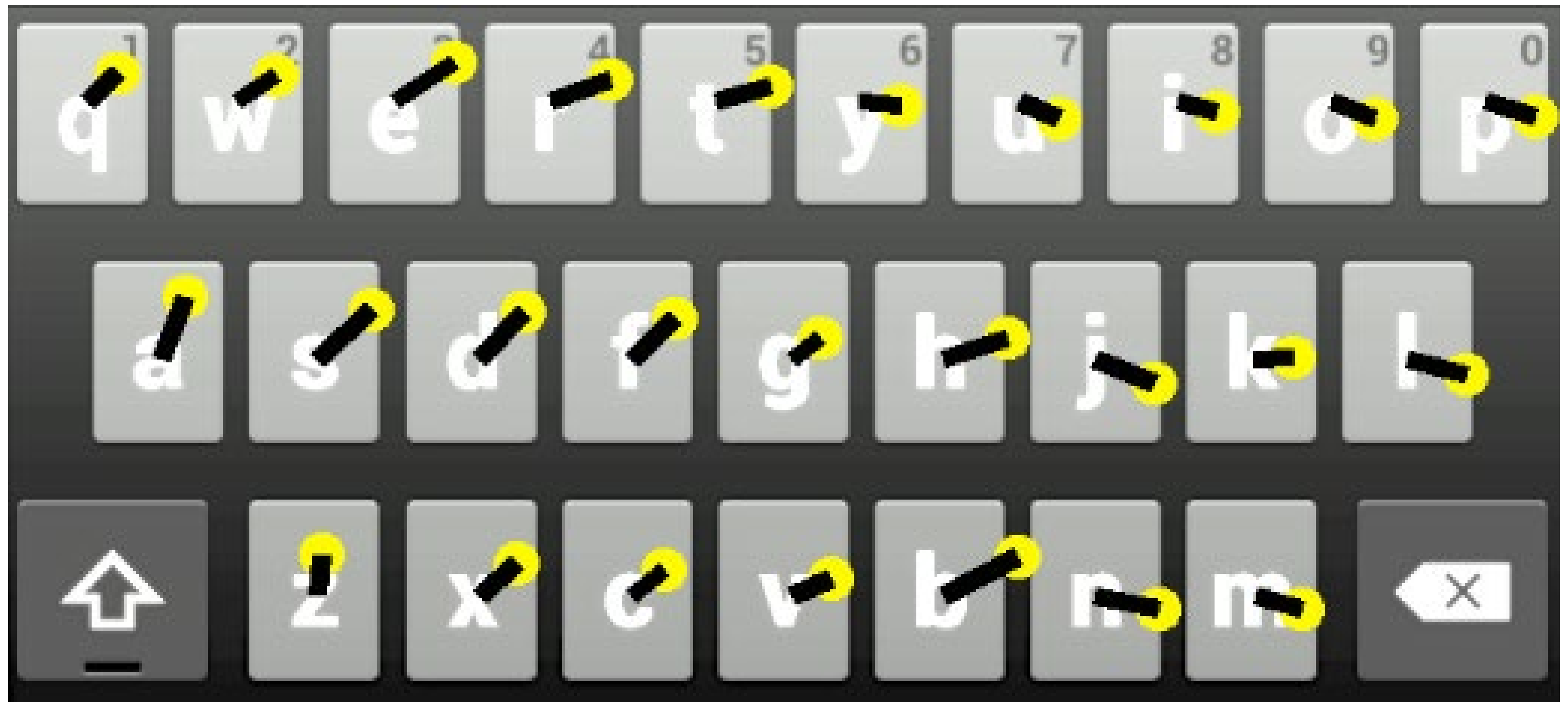
Modeling phone grip



Left Thumb

Mayank Goel, Alex Jansen, Travis Mandel, Shwetak N. Patel, and Jacob O. Wobbrock. 2013. ContextType: using hand posture information to improve mobile touch screen text entry. CHI 2013. https://doi.org/10.1145/2470654.2481386

Modeling phone grip



Right Thumb

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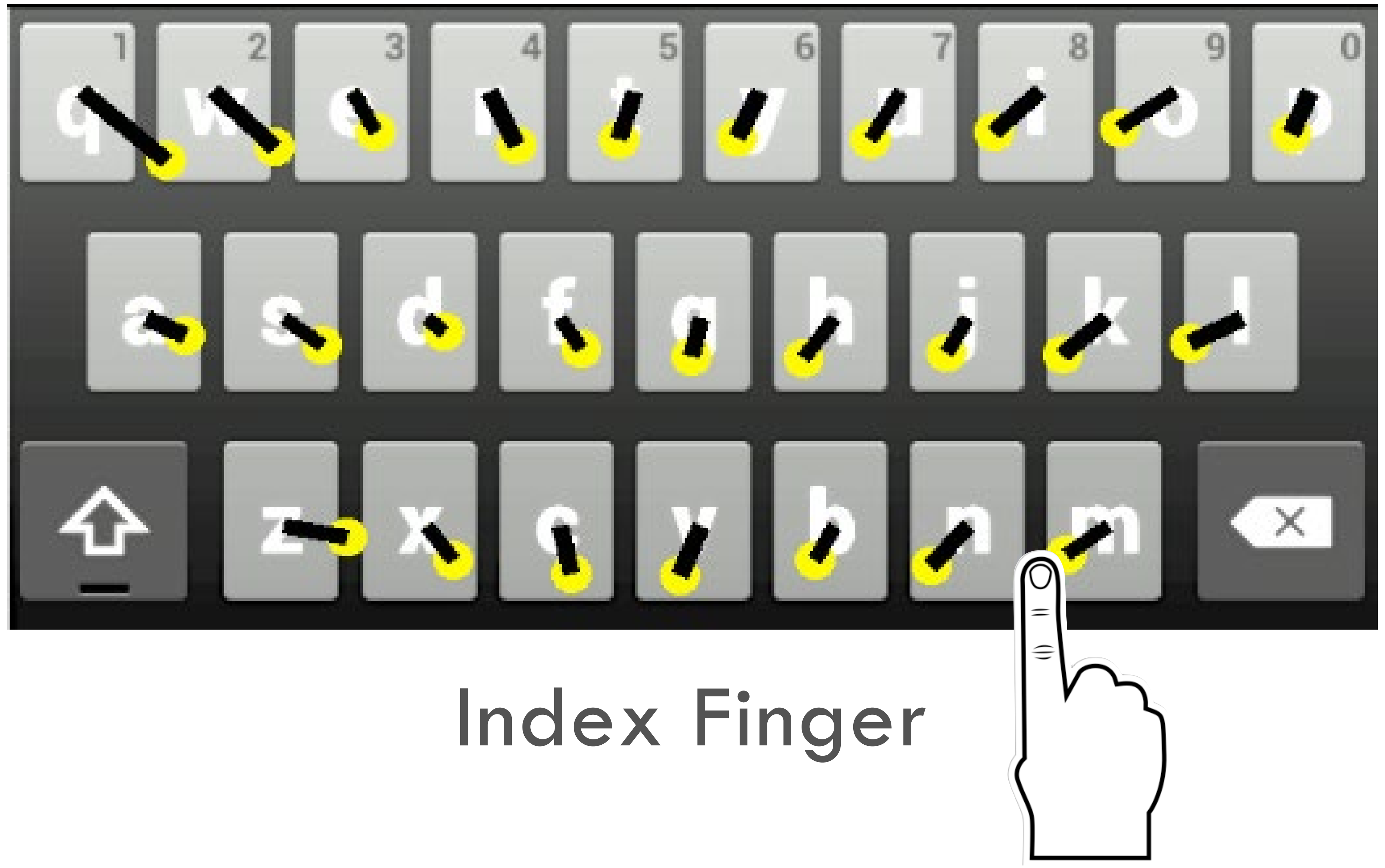
Modeling phone grip



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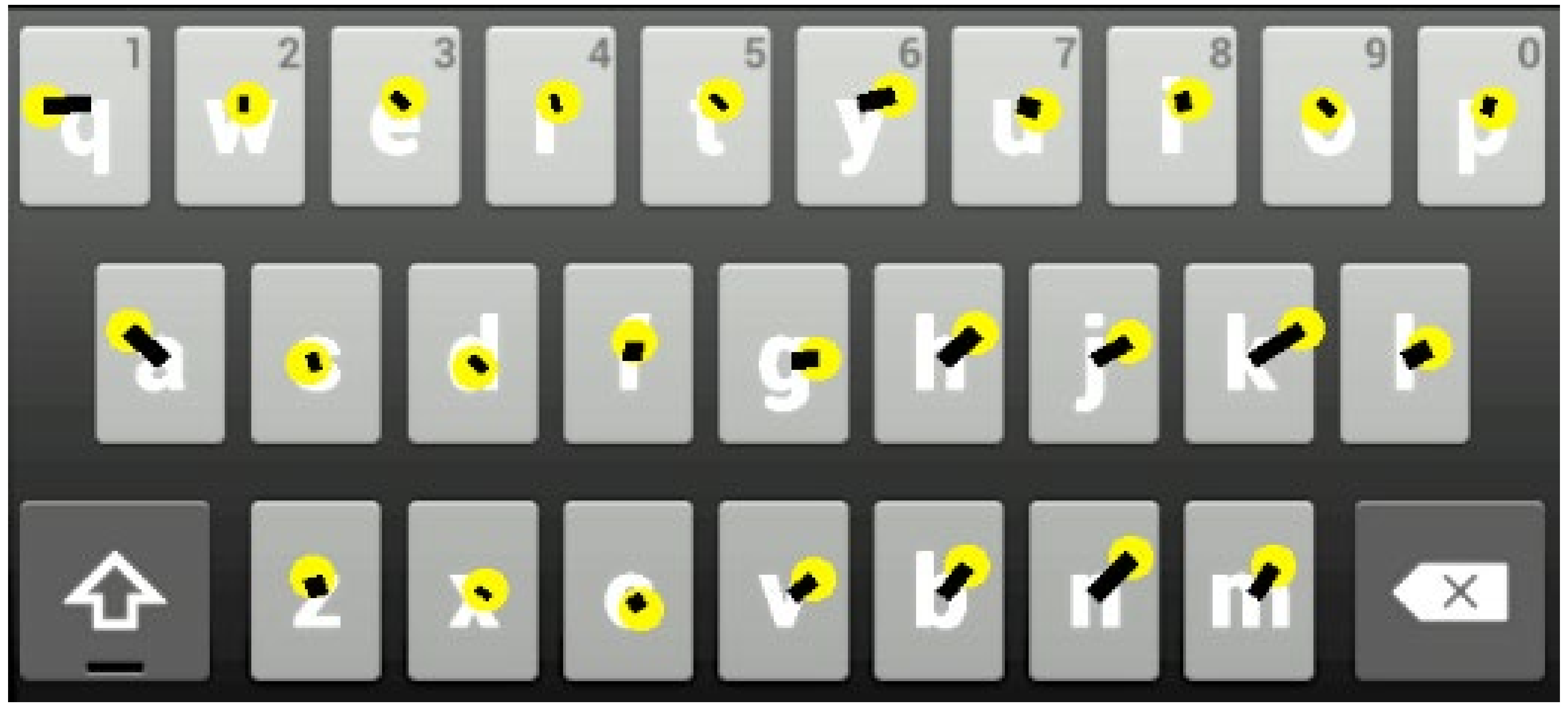
Modeling phone grip



Two Thumbs

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Detecting phone grip with sensors

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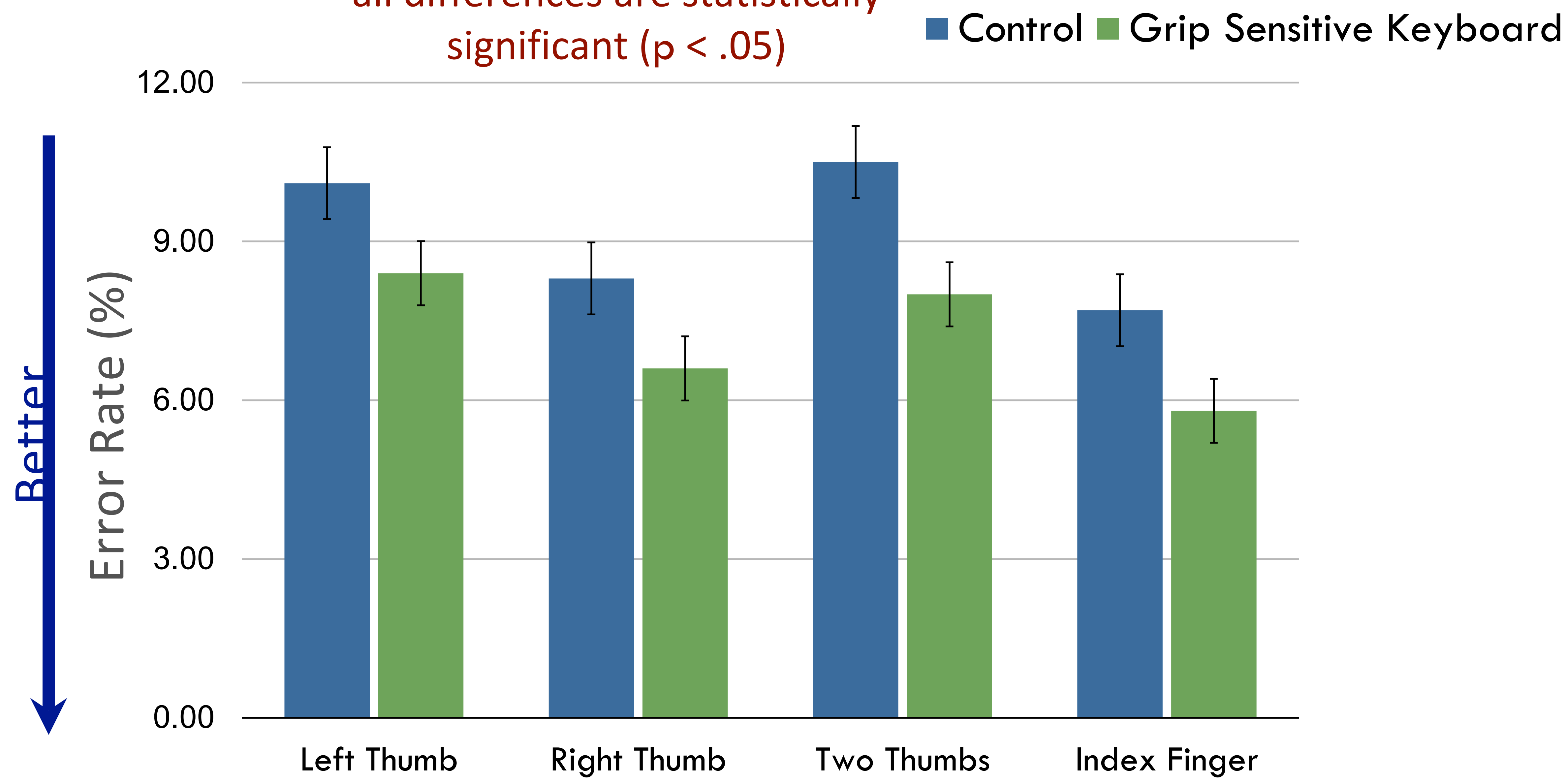
Detecting phone grip with sensors

all differences are statistically significant (p < .05)



Error bars show standard error

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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

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- Describe approaches for correcting systematic errors in touch performance