Feel the touch

touchscreen interfaces for visually impaired users

617AA

Tecnologie assistive per la didattica

21 November 2016, Pisa

Text Entry on Touchscreen Mobiles

- Difficult for blind users due to lack of physical keys and layout references
- External keyboards (Qwerty or Braille) are not easily portable nor cheap
- Use of Automatic Speech Recognition (ASR) and Text-To-Speech (TTS)
  - Inconvenient in noisy environments
  - Privacy and etiquette concerns

Barbara Leporini

Barbara Leporini

- Blind since childhood
- President of the Italian Blind Association in Tuscany
- PhD and researcher on Human Computer Interaction and accessible interfaces
- **Uses digital technologies on a daily basis**

Barbara’s cellphones

Nokia N95

- No touchscreen
- Physical keypad
- TALKS screen reader
- Symbian OS

iPhone 4S

- Touchscreen
- No physical keyboard
- VoiceOver screen reader
- iOS 7

Why two cellphones?

Nokia N95

- Phone calls
- Text messages (SMS)
- Confortable audio feedback without earphones
- Longer battery life (no Internet access)

iPhone 4S

- Information and entertainment
- eBooks and news
- Music and podcast listening
- E-mail and online social networks

Text Entry on the iPhone 4S

- Mainly via the virtual keyboard
  - Lack of precision because of the small keys
  - Trouble with adjacent letters with similar sounds (e.g., *M* and *N*) on noisy environments
  - Difficult text navigation and revision
  - Complicated editing at the word or phrase level
- Siri's ASR is used when alone and in quite environments only

Accessible Mobile Text Entry

- **Software-only approaches**
  - TalkBack (Android) and VoiceOver (iOS)
- **Hardware-only approaches**
  - Plastic overlays (e.g., keyboard, maps)
- **Hybrid solutions**
  - Plastic overlays with NFC chips

Software-only Approaches

- **Multitouch Character Encoding**
  - BrailleTouch and DigiTaps
- **Character Drawing**
  - Graffiti and iOS Handwriting
- **Constructive Methods**
  - Virtual keyboard with TTS

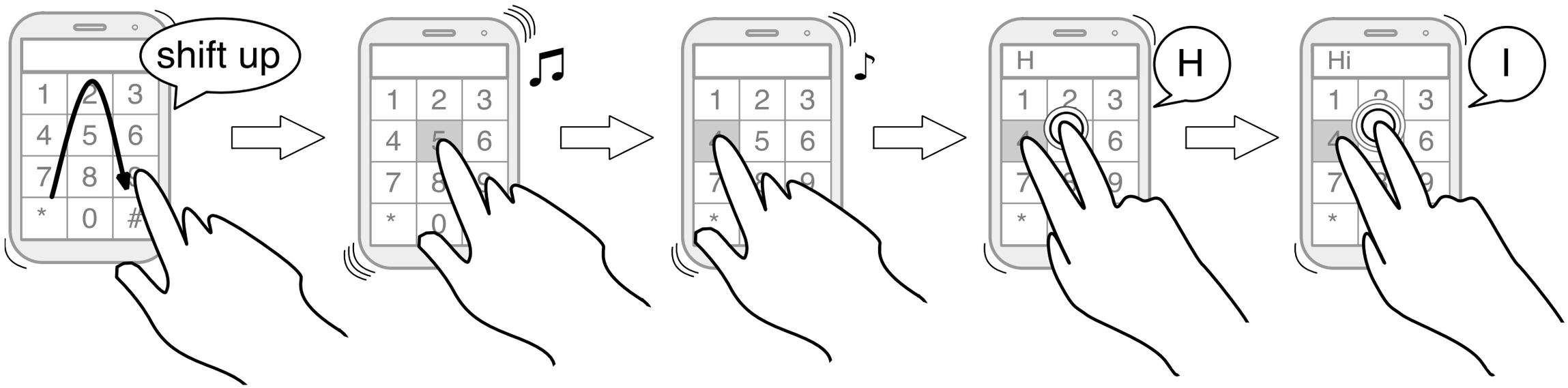
Our Approach: MTITK

Multimodal Text Input Touchscreen Keypad

- Software-only approach based on previous work on haptic differentiation of UI elements
- Use of the common 12-button telephone keypad layout
- Use of gestures for additional actions
- Simultaneous voice and haptic feedback

Haptic Keytap Prototype

An Android Input Method



Telephone Keypad

ITU E.161

ISO/IEC 9995.8

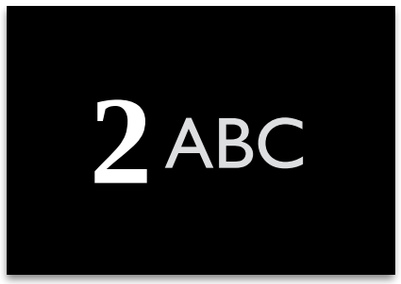
ETSI ES 202 130

Text Editor

Input Area

Global Actions

Input Method



Normal State

(press gesture)

Selected State

(initial haptic feedback)

2 ABC

press gesture + 1 tap

A

2 ABC

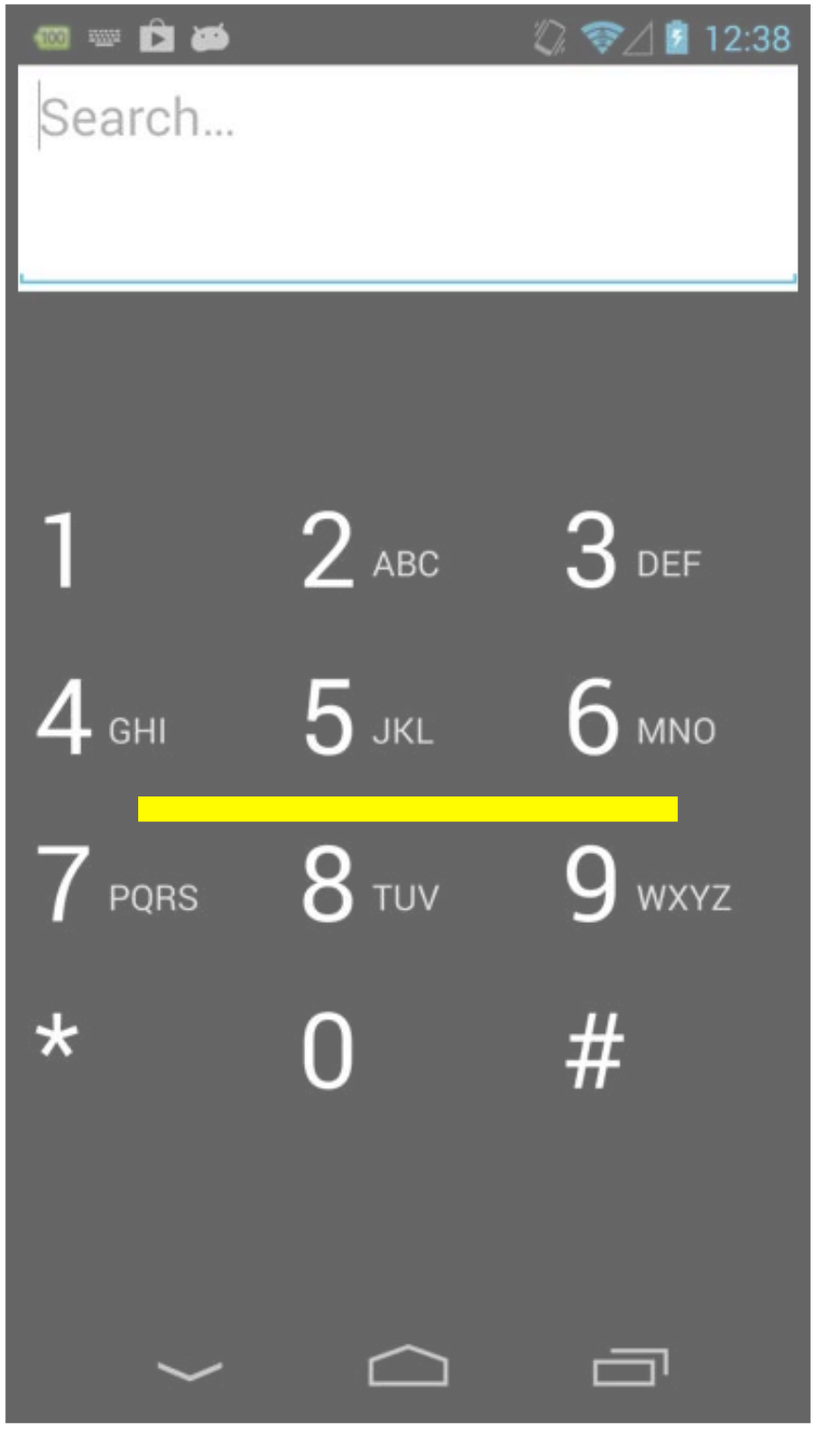
press gesture + 2 taps

B

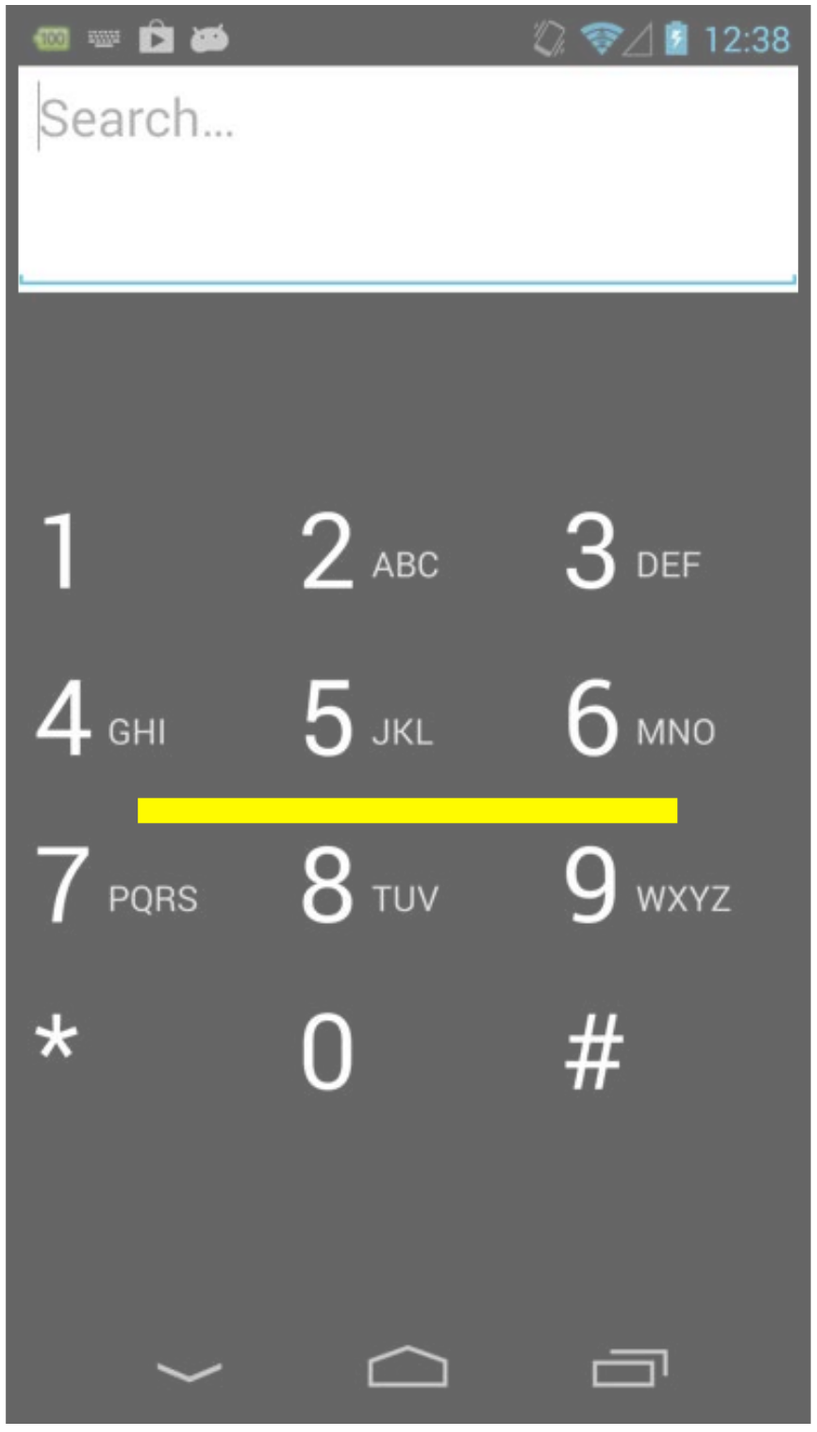
2 ABC

press gesture + 3 taps

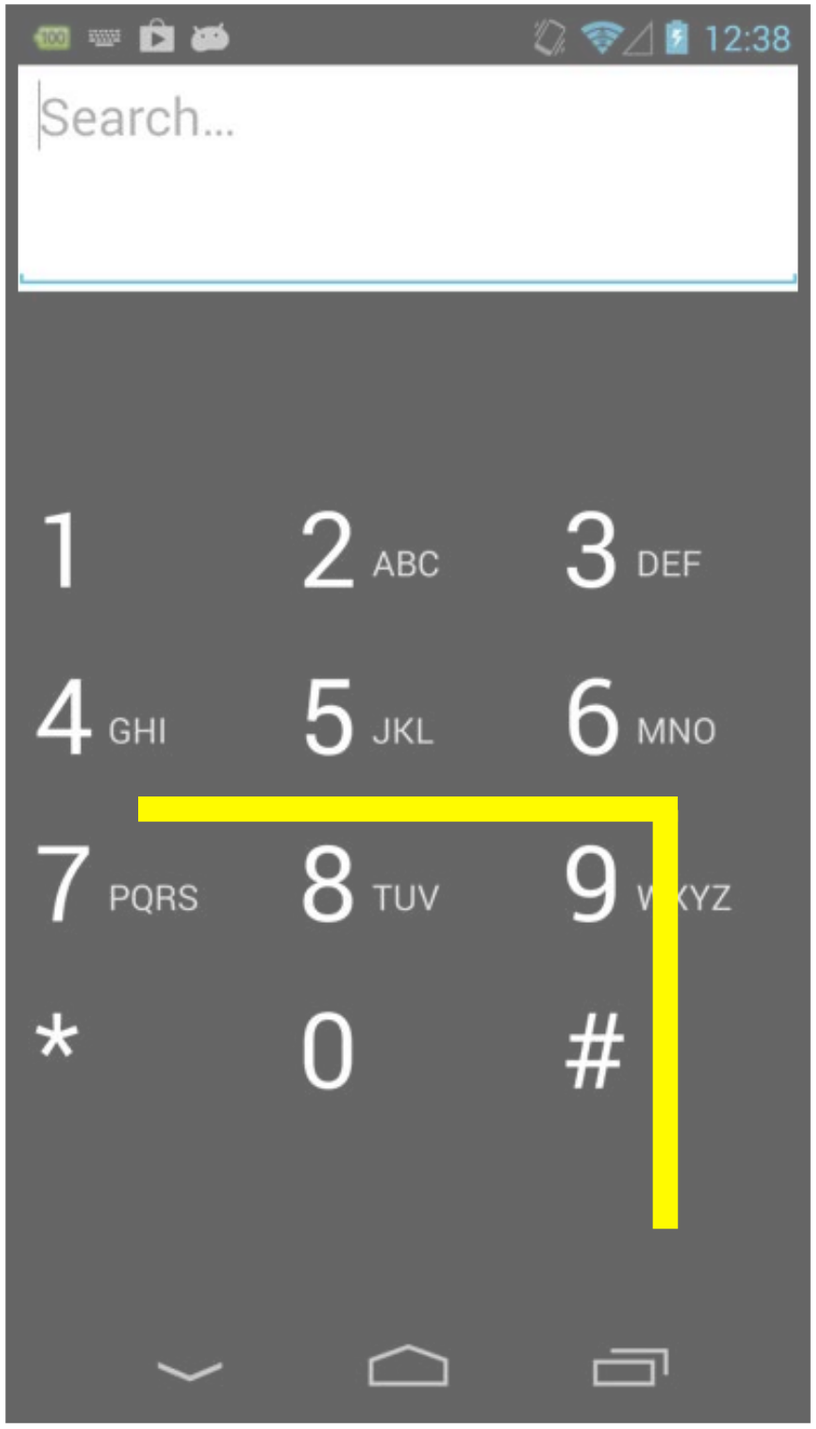
C



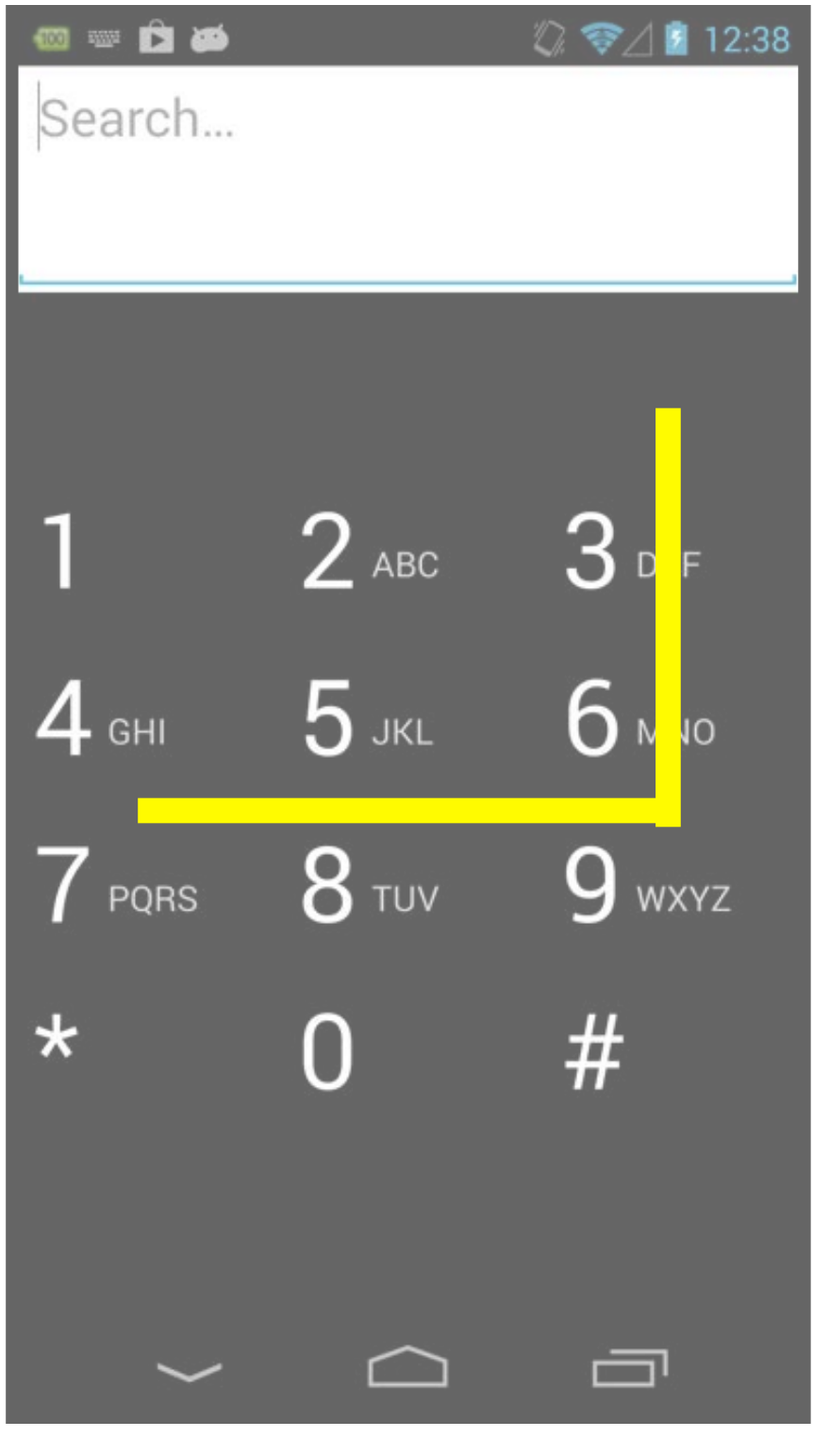
Backspace



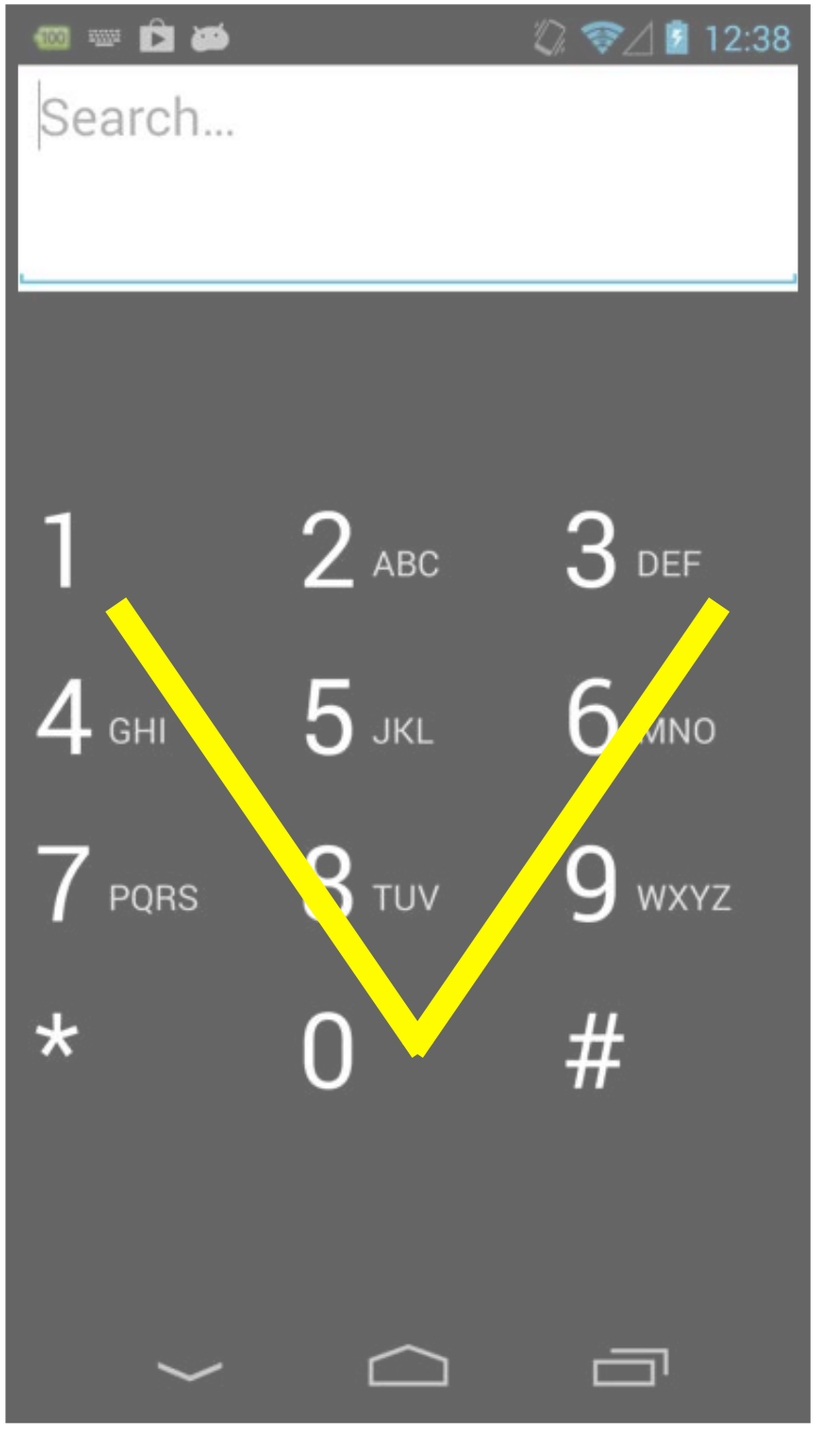
Read last char



Shift Down



Shift Up



Block Shift Down

Block Shift Up

Keyboard Layout

I tap

1	2	3
4	5	6
7	8	9
*	0	#

Shift down

1	2	3
4	5	6
7	8	9
*	0	#

Shift up

l tap

@	a	d
g	j	m
p	t	w
(	⌓	)

Shift down

-	A	D
G	J	M
P	T	W
/	⌓	\

Shift up

2 taps

'	b	e
h	k	n
q	u	x
¿	.	?

Shift down

_	B	E
H	K	N
Q	U	X
[	+	]

Shift up

3 taps

"	c	f
i	l	o
r	v	y
¿	,	?

Shift down

:	C	F
I	L	O
R	V	Y
£	€	$

Shift up

4 taps

&	2	3
4	5	6
s	8	z
<	=	>

Shift down

;	2	3
4	5	6
S	8	Z
^	%	¥

Shift up

5 taps

1		
7		9
{	0	}

Shift down

1		
7		9
~	0	¤

Shift up

6 taps

*		#

Shift down

		§

Shift up

Localization

Keypad Layout and
default Text To Speech engine

- US English (en_US) *android default*
- Spanish of Spain (es_ES)
- French of France (fr_FR)
- Italian of Italy (it_IT)

KEYPAD LAYOUT AND KEY GROUPS

1	2	3
4	5	6
7	8	9
*	0	#

KEYPAD LAYOUT AND KEY GROUPS

Intercardinal point

1	2	3
4	5	6
7	8	9
*	0	#

KEYPAD LAYOUT AND KEY GROUPS

Cardinal point

1	2	3
4	5	6
7	8	9
*	0	#

KEYPAD LAYOUT AND KEY GROUPS

Center

1	2	3
4	5	6
7	8	9
*	0	#

KEYPAD LAYOUT AND KEY GROUPS

1	2	3
4	5	6
7	8	9
*	0	#

Zero

KEYPAD LAYOUT AND KEY GROUPS

1	2	3
4	5	6
7	8	9
*	0	#

Symbol

KEYPAD LAYOUT AND KEY GROUPS

- Intercardinal point
- Cardinal point
- Center
- Zero
- Symbol

1	2	3
4	5	6
7	8	9
*	0	#

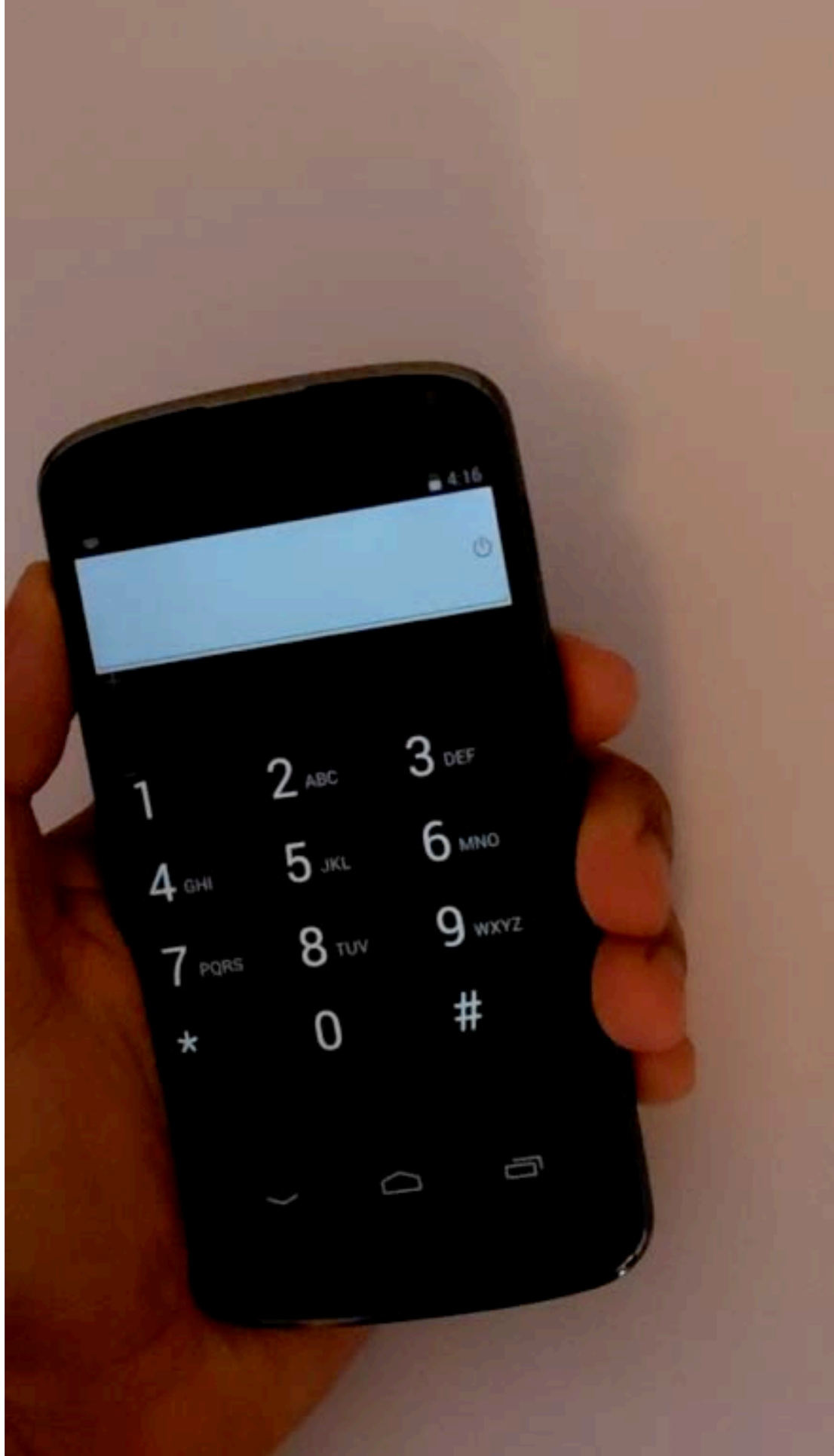
MTITK PROTOTYPE DEMO

on

Nexus 4

(Android 4.4)

SIMPLE TEXT ENTRY



REVIEW GESTURES

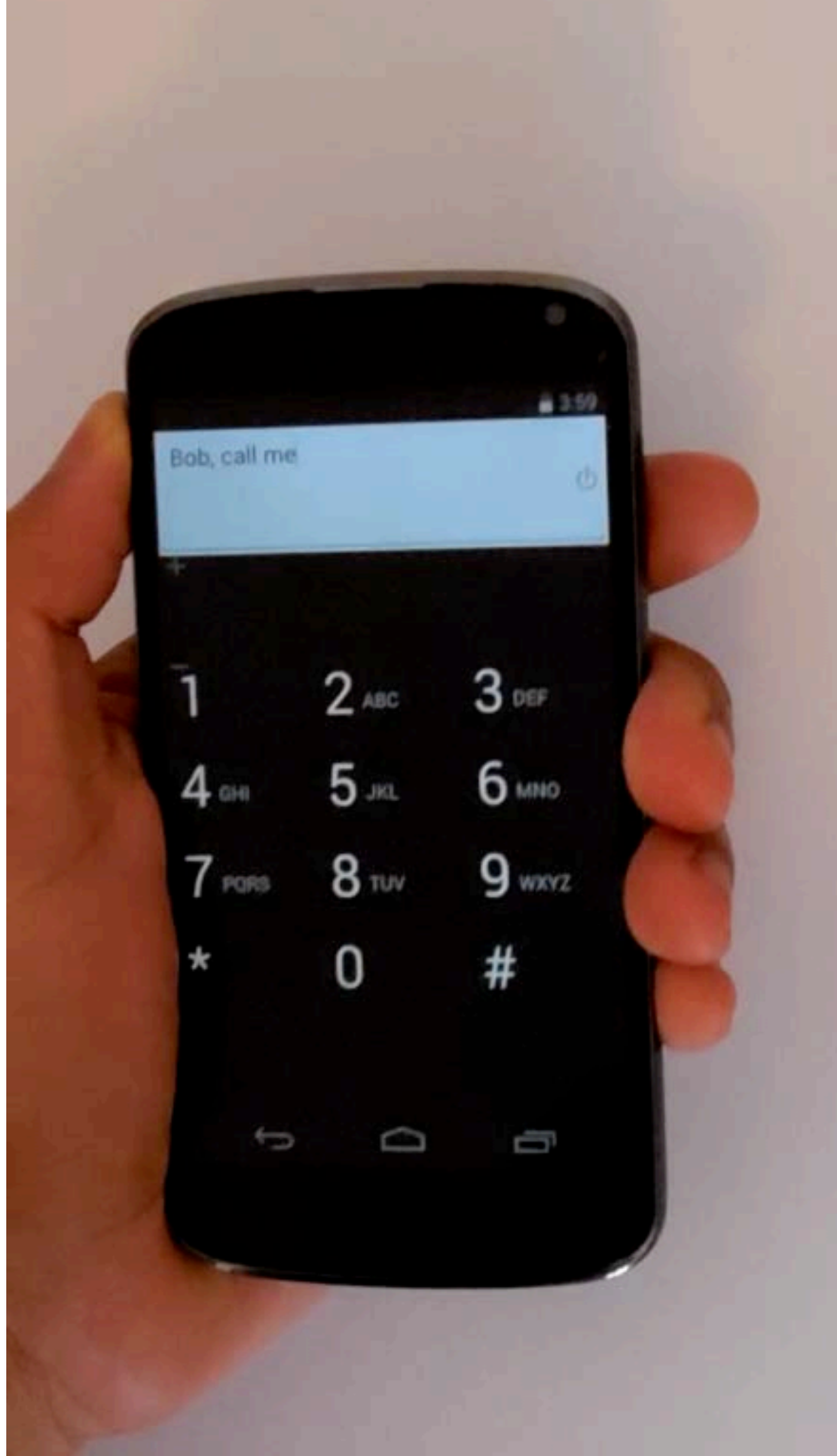
Read / Delete :

last character

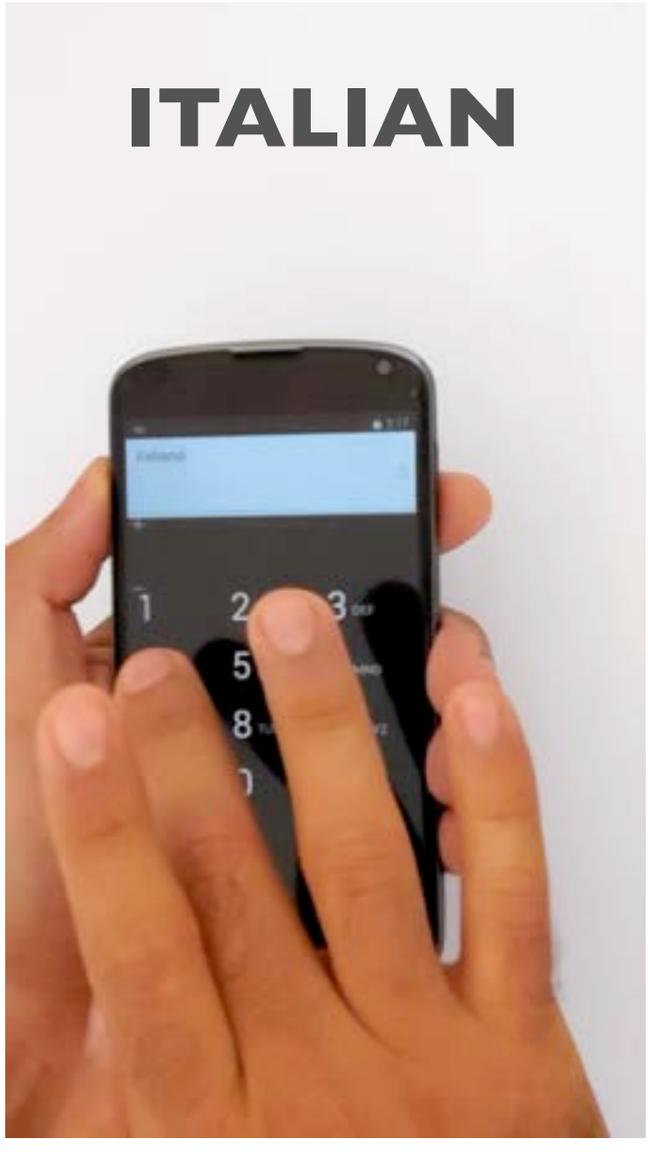
last word

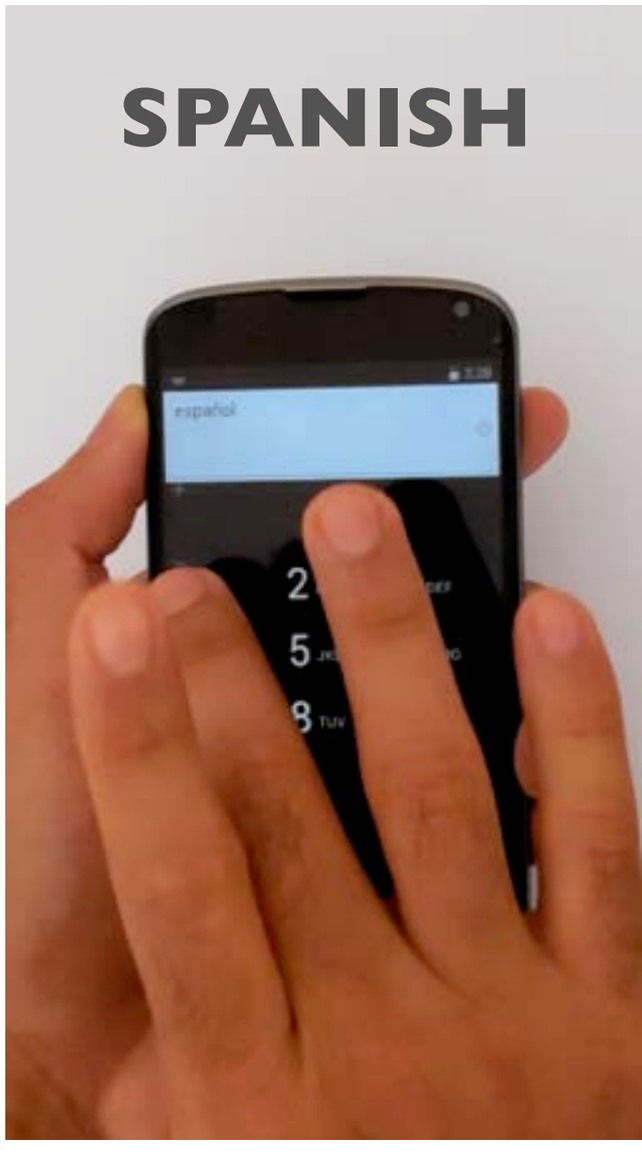
last sentence

all text



MULTI-LANGUAGE





Pilot Test

- 14 participants: 6 females, 8 males, median age of 44
- Self-reported most difficult text entry and editing tasks on the Qwerty virtual keyboard: autocomplete, select text and delete one or more words
- Difficulties to remember the keypad's character mapping despite having declared familiarity
- Some participants could not accurately differentiate the key groups' vibration patterns
- Difficulties with right-angle gestures

Lessons and Observations (1)

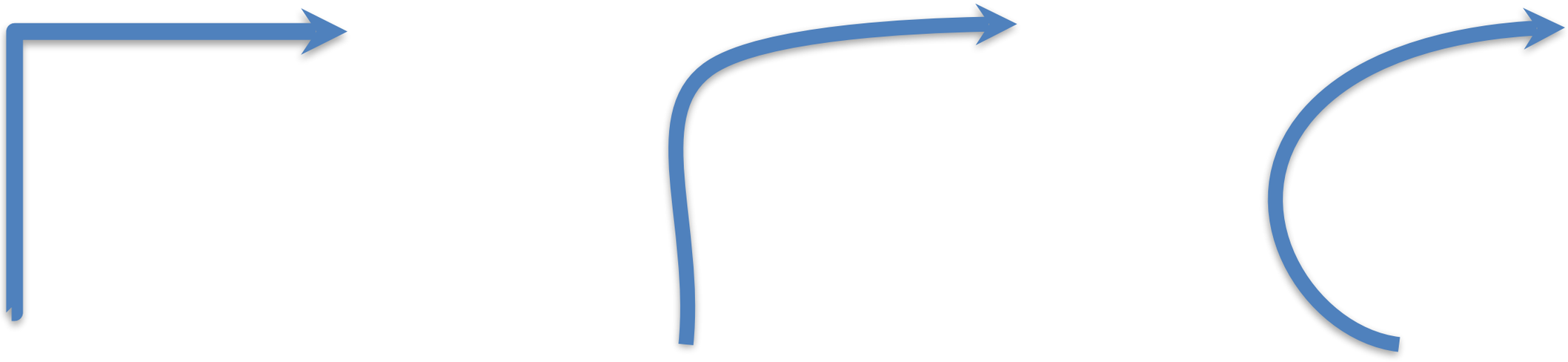
- iOS is the most popular among blind users
  - More accessible features
  - VoiceOver maturity
- Android is better suited for research
  - Open nature and lower device cost
  - But significant device fragmentation

Lessons and Observations (2)

- Some blind users don’t know their devices
  - Unaware of most accessibility features
  - Knowledge transfer among blind users
- Research participation motivates blind users
  - Some participants bought smartphones after experiencing current solutions

Lessons and Observations (3)

- Many participants had problems performing the prototype input gestures.
- Lack of knowledge on how blind users perform gestures on mobile phones' touchscreens



How do visually impaired people perform touch gestures and what are their preferences?

Motivation

Touch-based and screen reader interaction may be hampered by non-accessible design choices or the user’s environment.

- No physical references
- Limited haptic feedback
- Noisy surroundings
- Privacy concerns
- Gesture performance

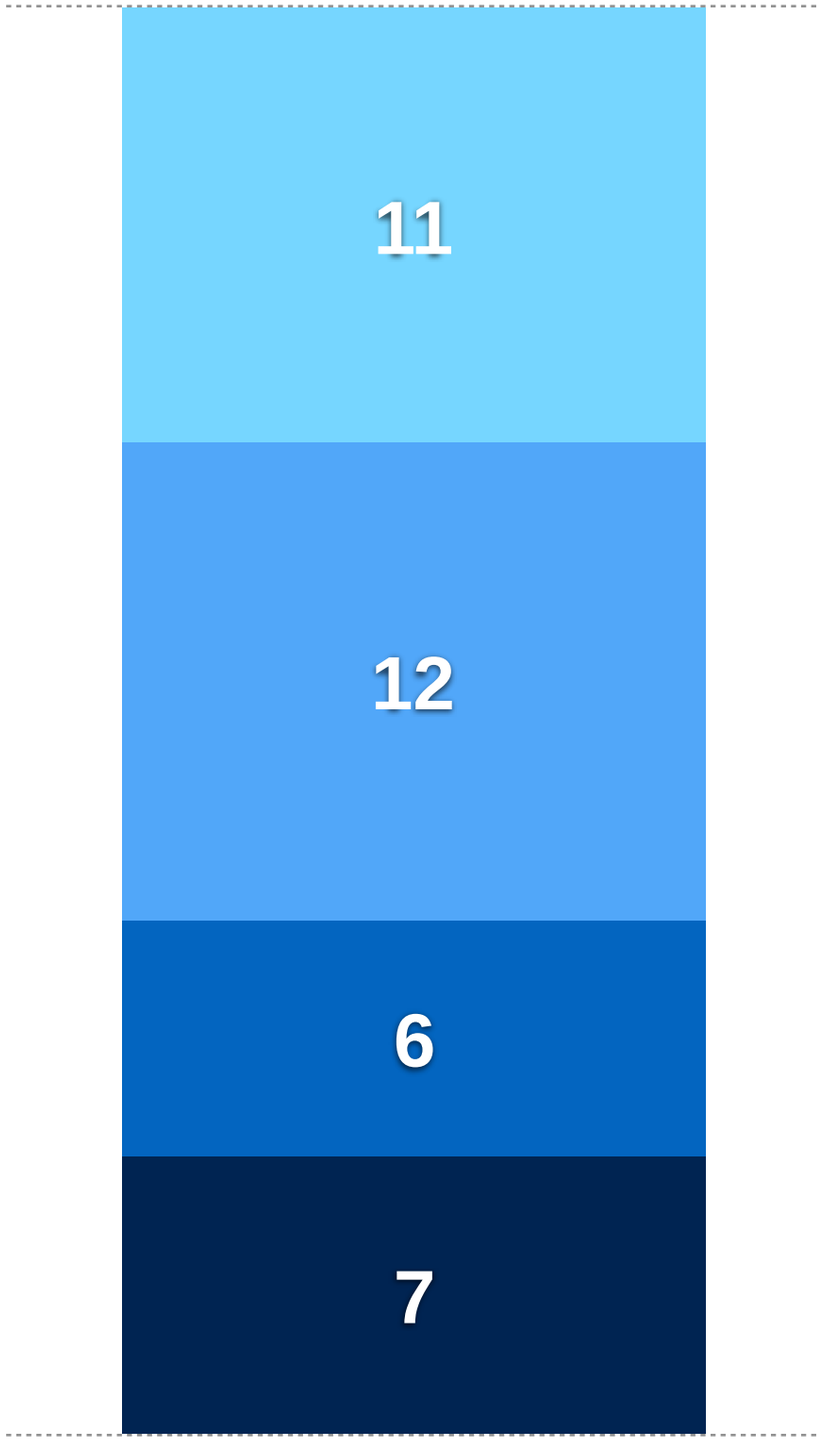
Participants

36 participants

14 women
22 men

Mean age: 48 years
Std Dev: 15 years

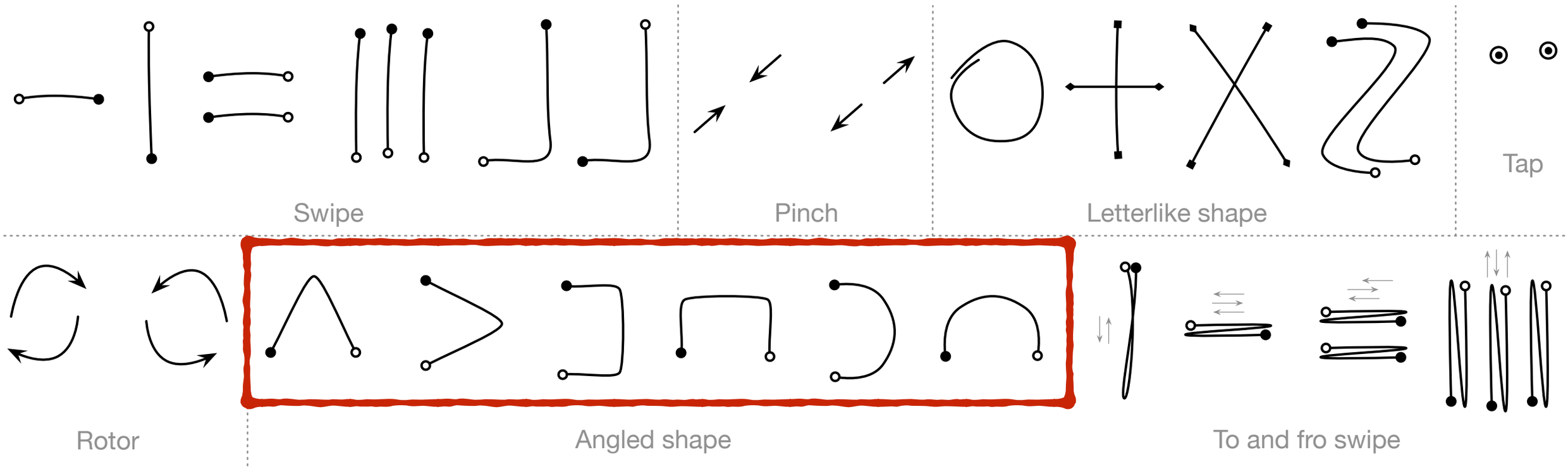
- Severe low vision
- Blind in adulthood
- Blind from adolescence
- Blind from birth



Participants' use of touchscreen devices

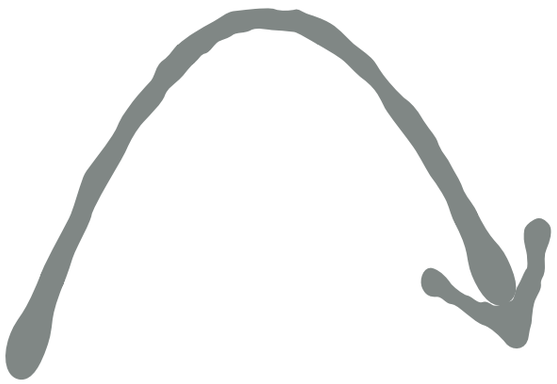
Group	*iOS*		*Android*		*Other*
	iPhone iPod	iPad	Phone	Tablet	Phone MP3
Low-vision	45%	18%	55%	9%	18%
Blind since birth	57%	14%	29%	14%	0%
Blind since adolescence	83%	0%	17%	17%	0%
Blind in adulthood	58%	25%	8%	0%	8%
All of the participants	*57%*	*17%*	*28%*	*8%*	*8%*

Gesture Patterns



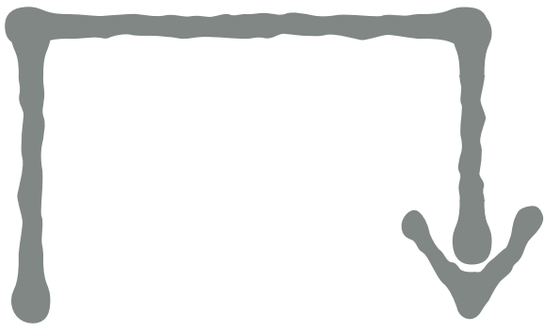
25 gesture patterns, 7 groups

Gesture Angle



Curved

Steep

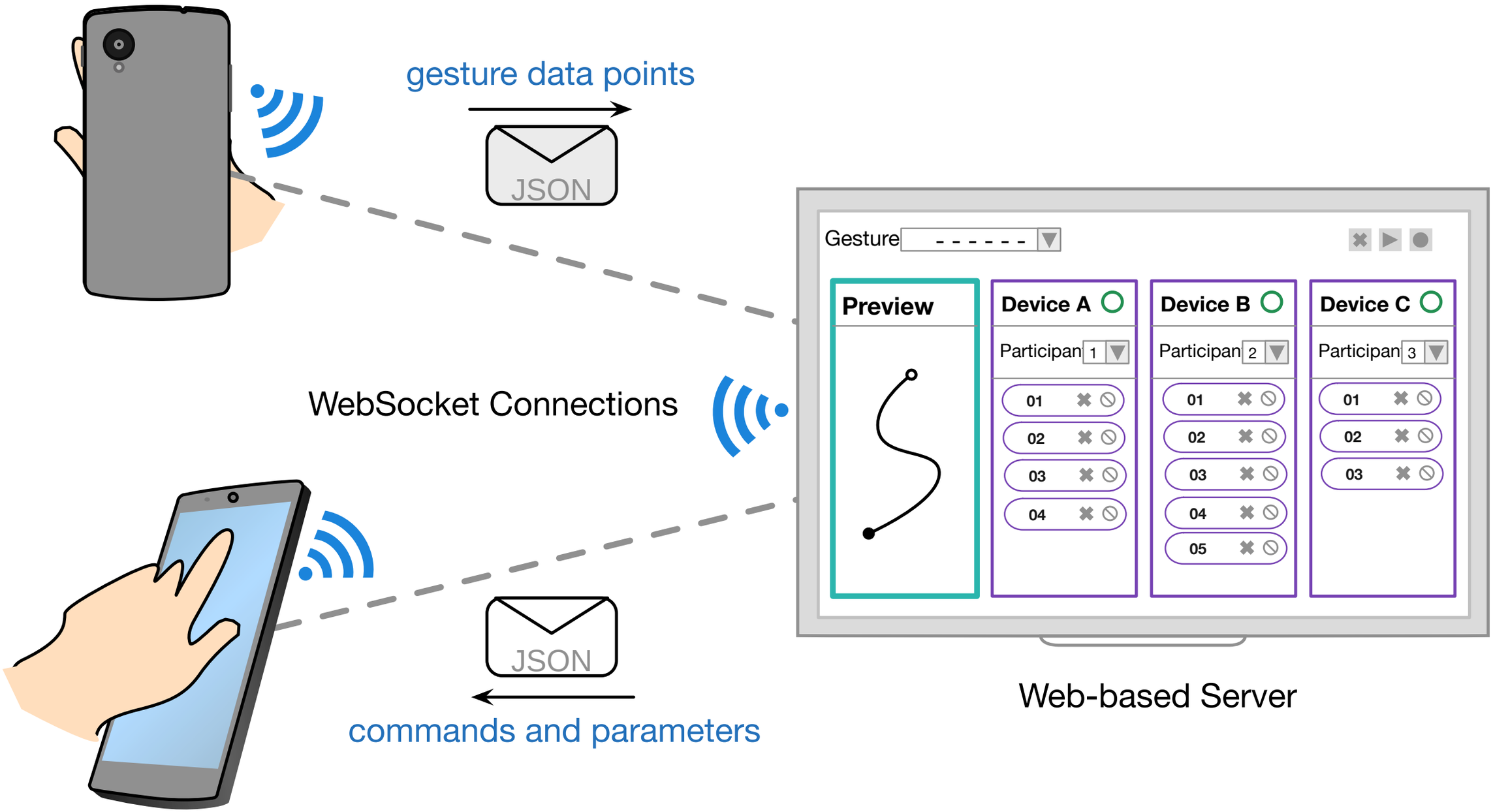


Right-angled

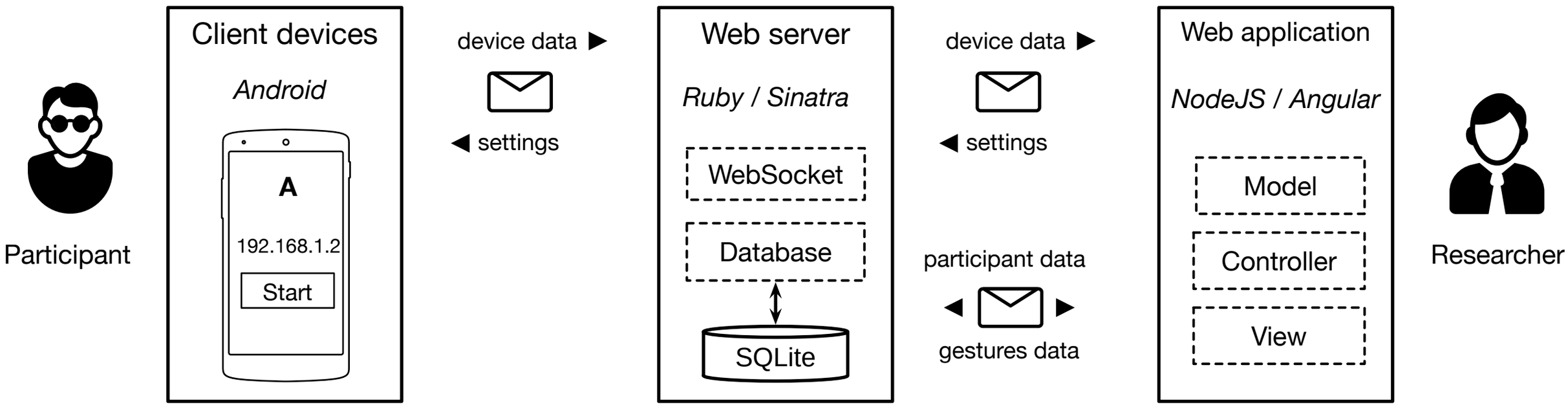
Gesture capture system

Nexus 5 Smartphone

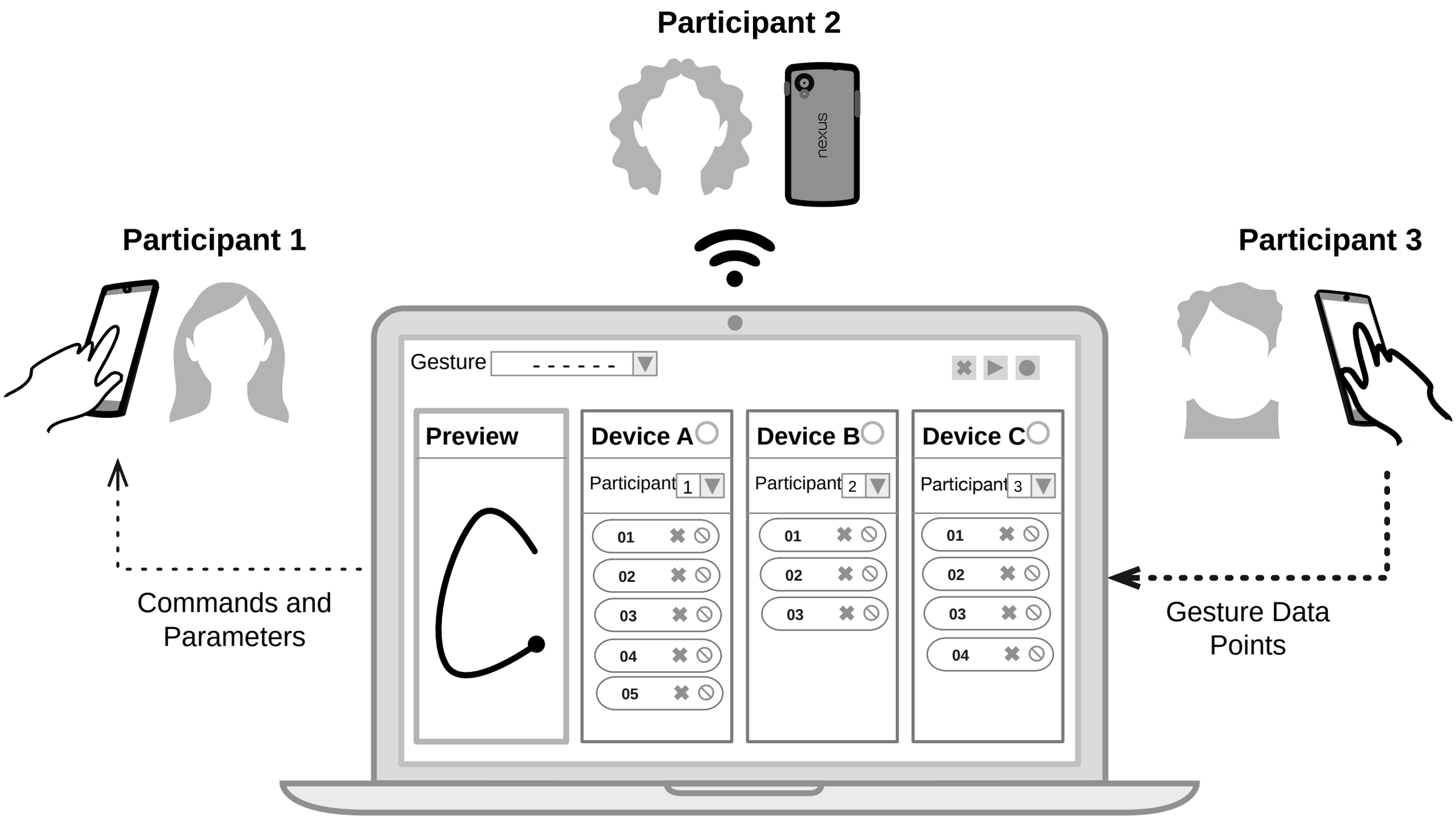
Conceptual model



Architecture



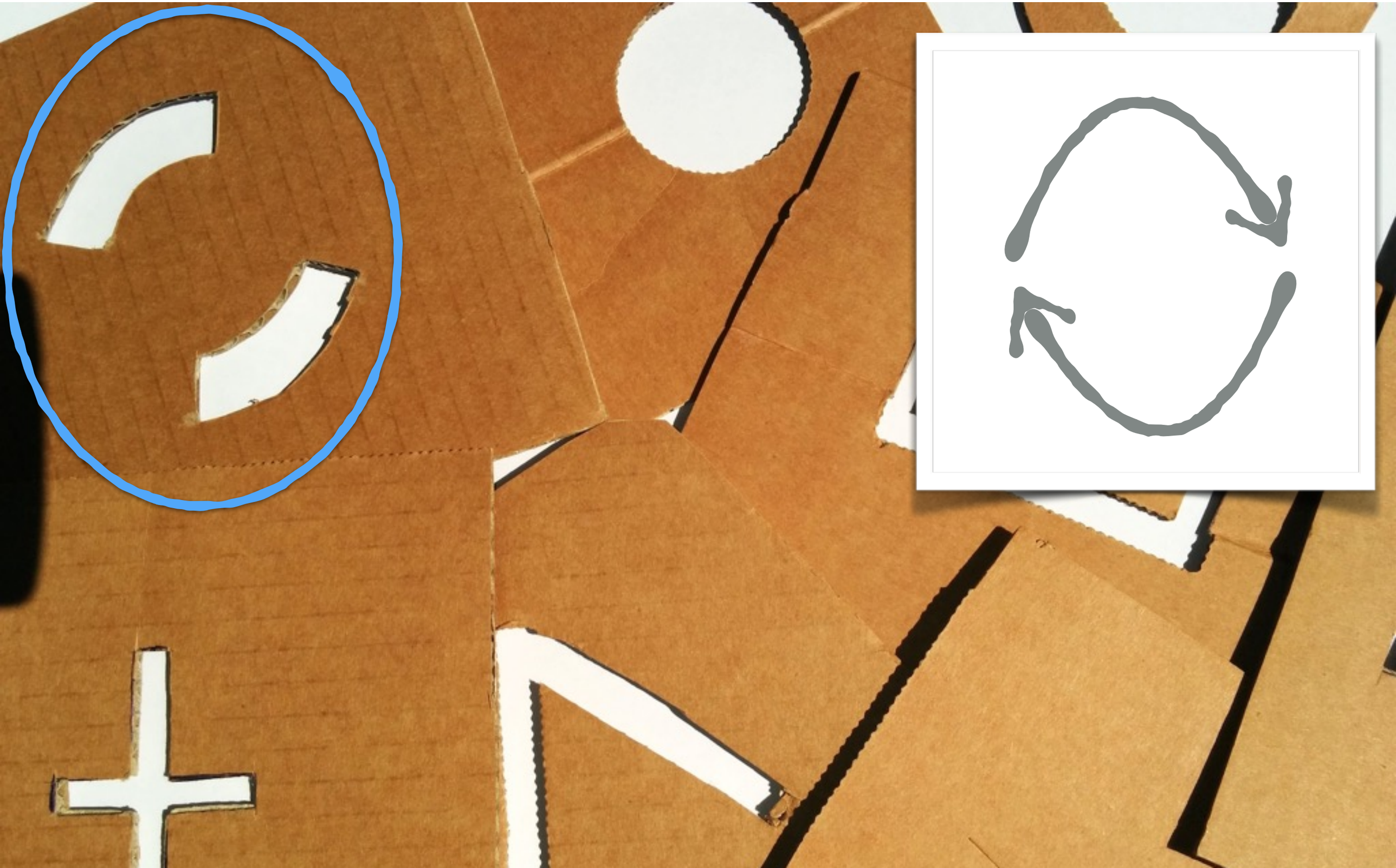
Multi-Participant



How to explain gestures?

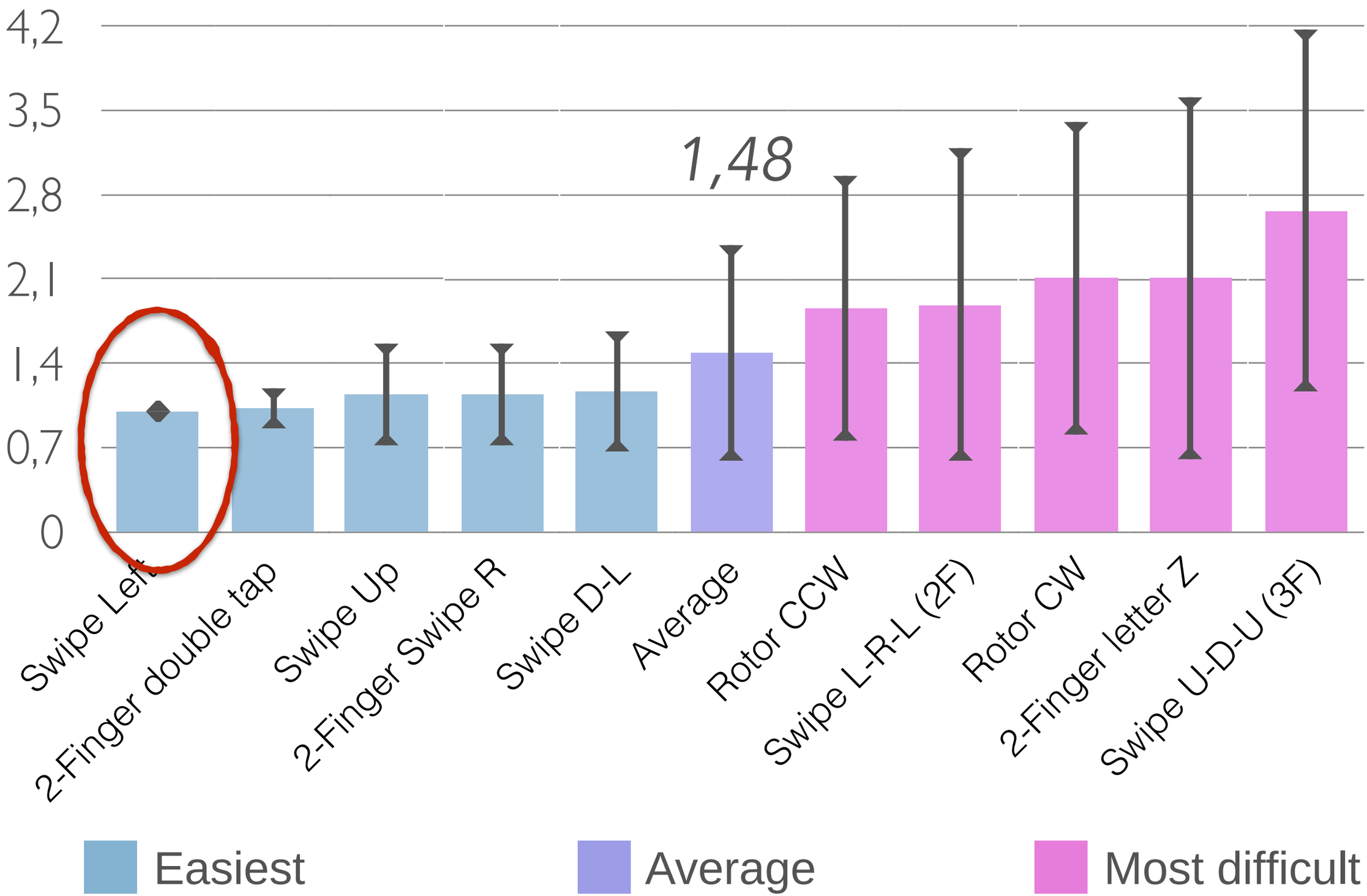
Analogies

Cardboard Cut-outs

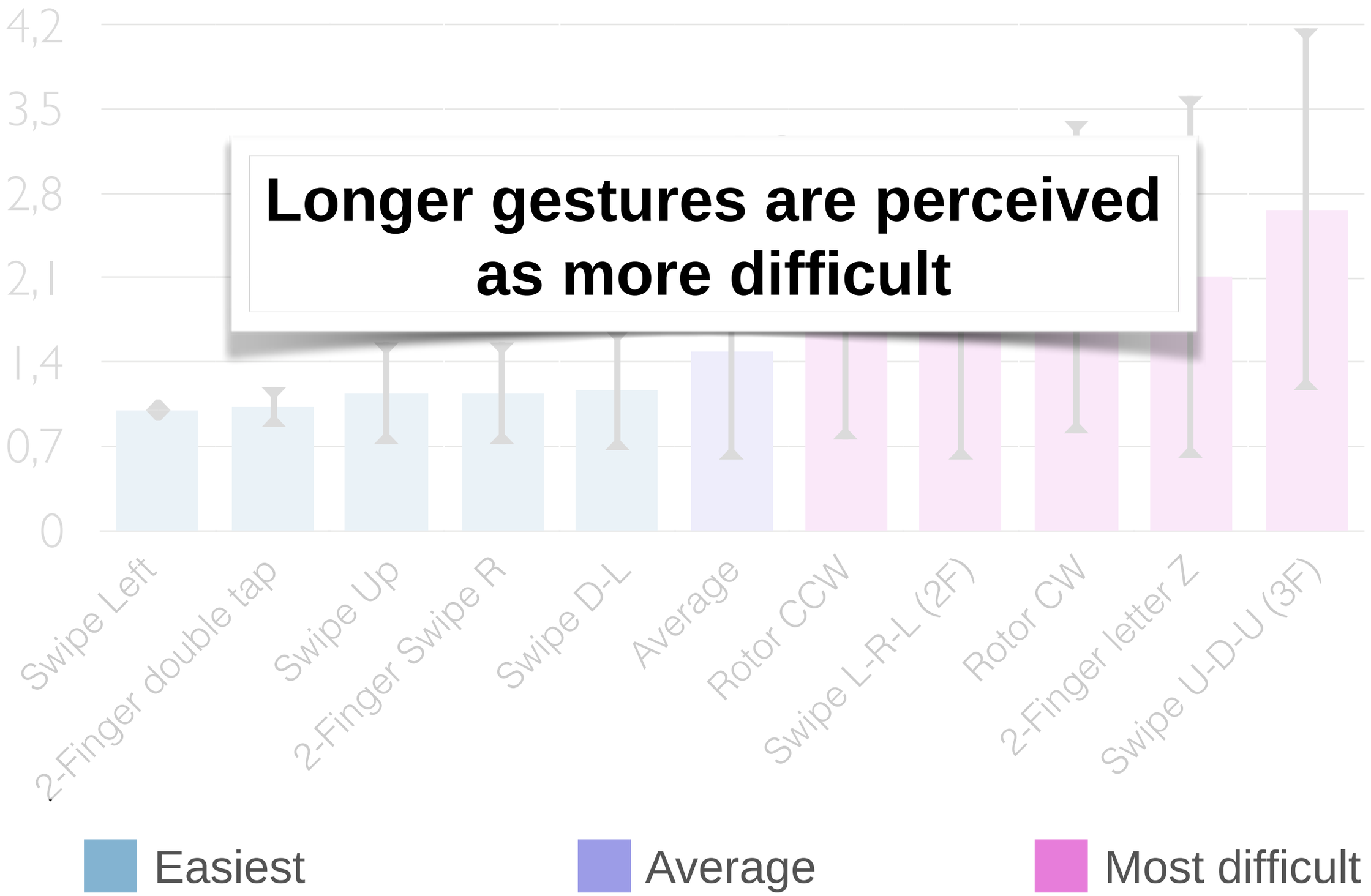


Preferences

Perceived Gesture Difficulty

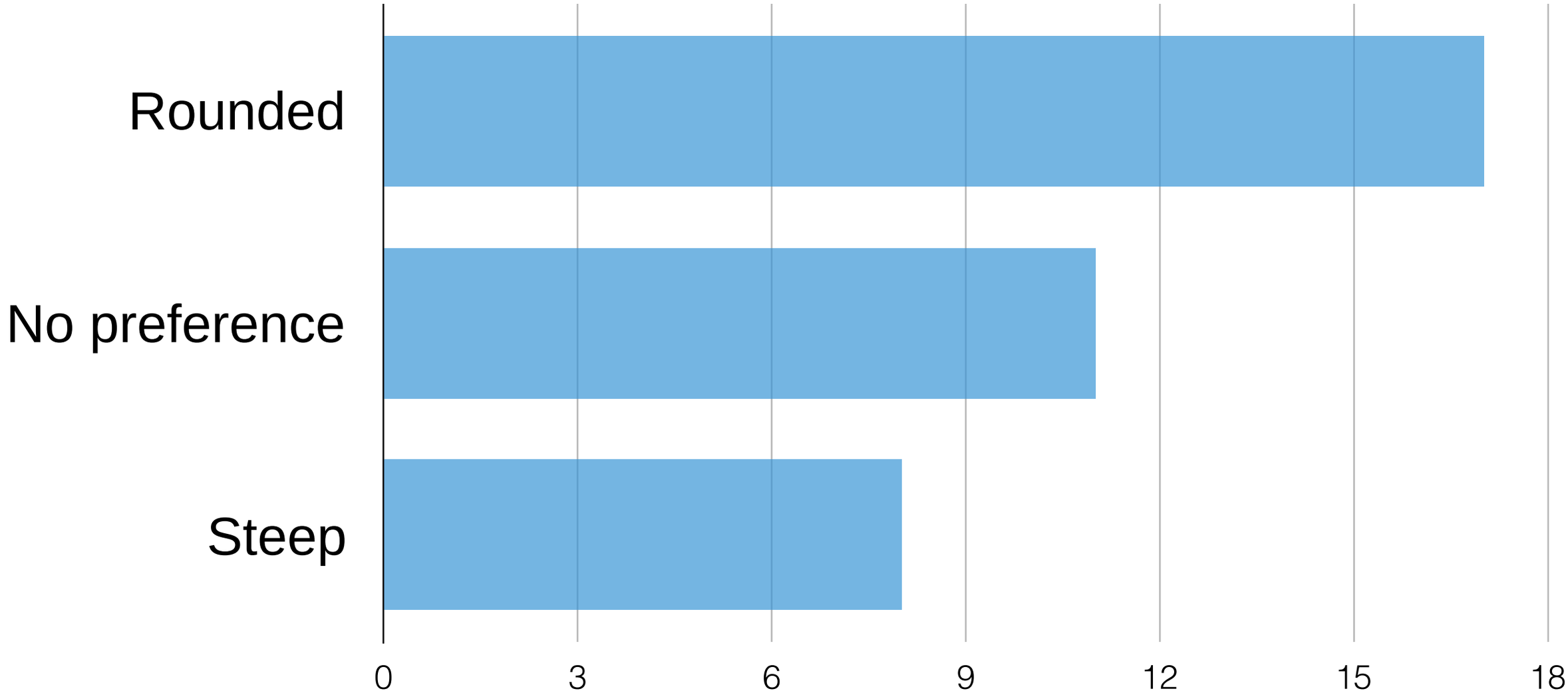


Perceived Gesture Difficulty



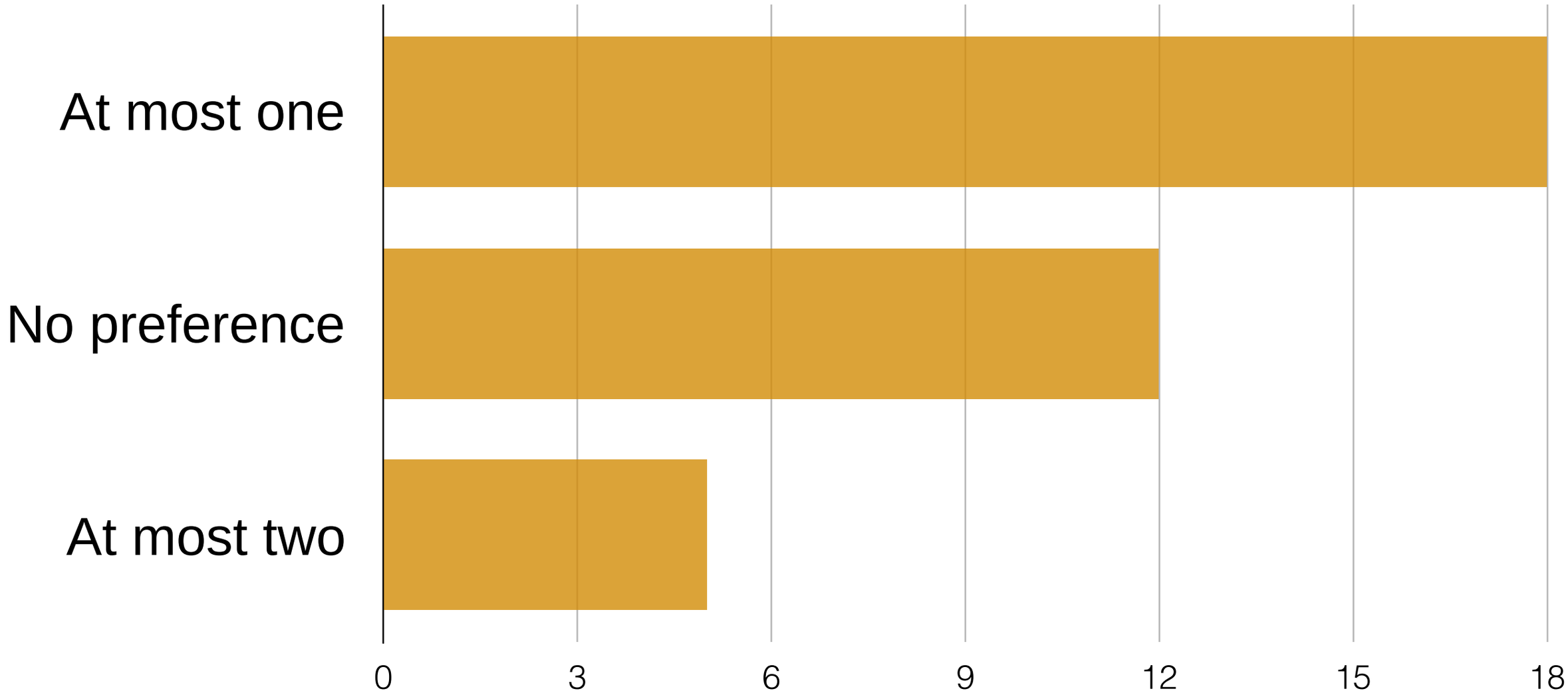
Longer gestures are perceived as more difficult

Gesture Preferences



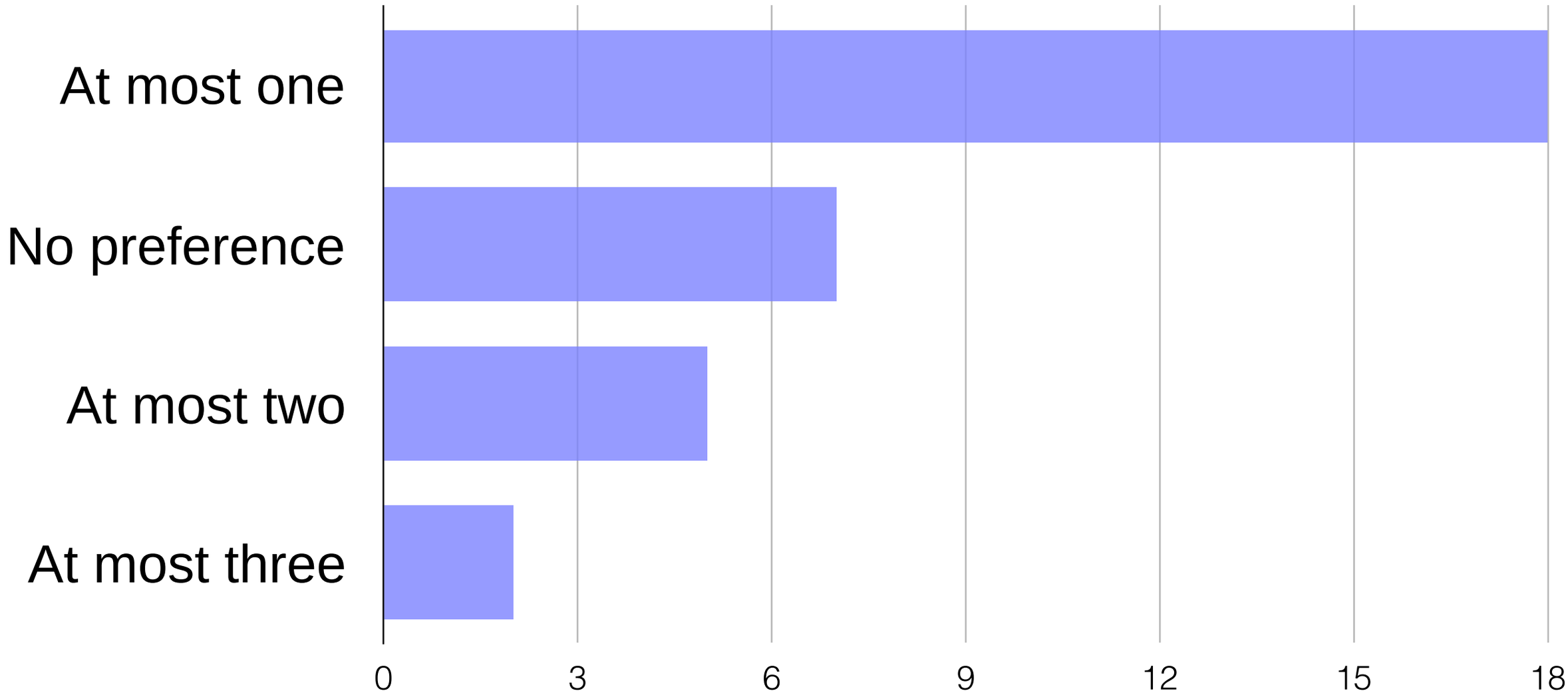
Gesture Preferences

Number of Strokes



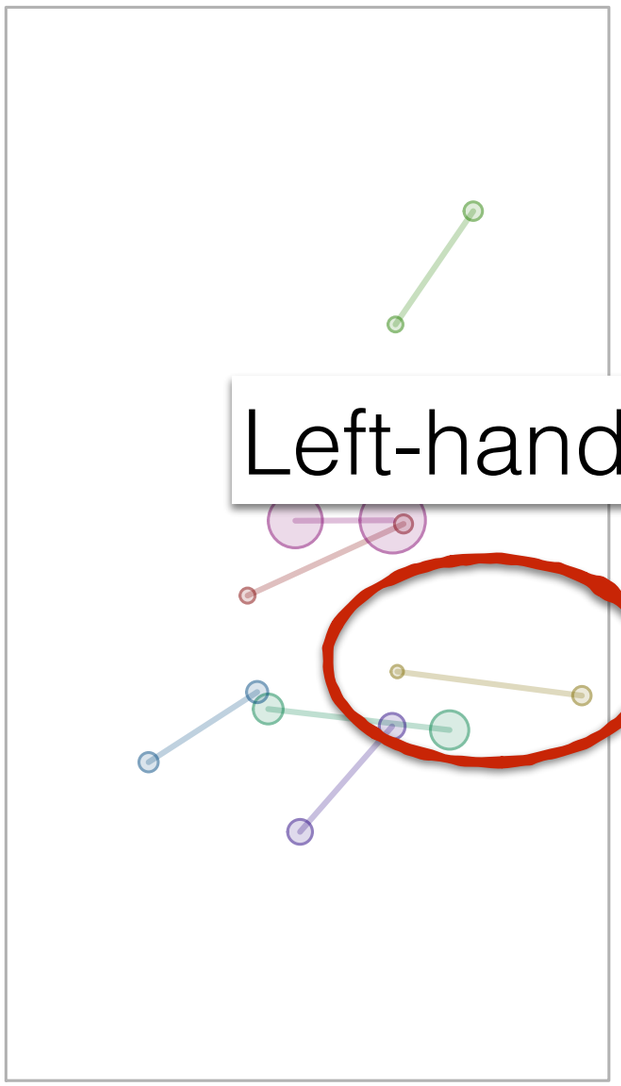
Gesture Preferences

Number of Fingers

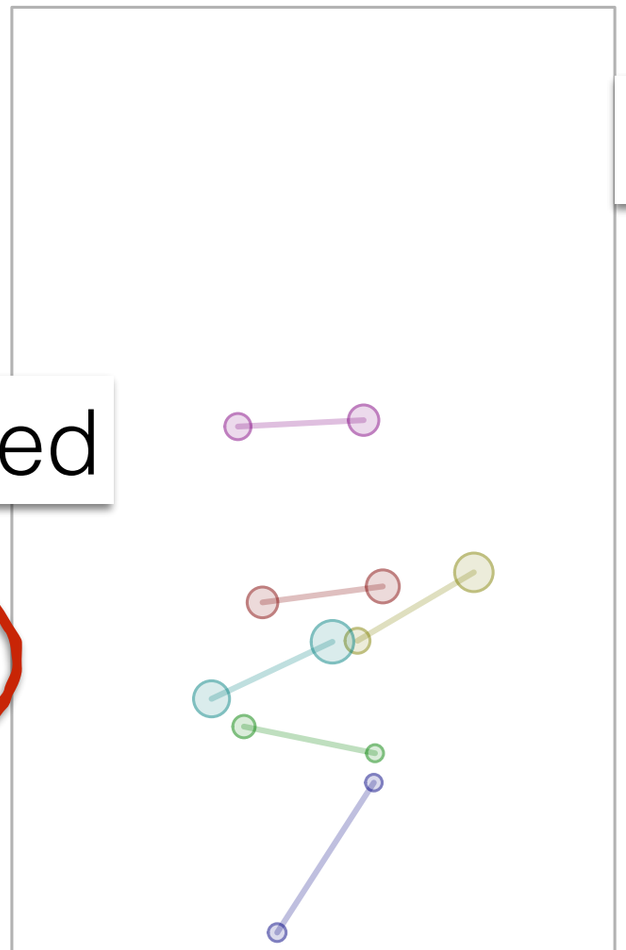


Analysis examples

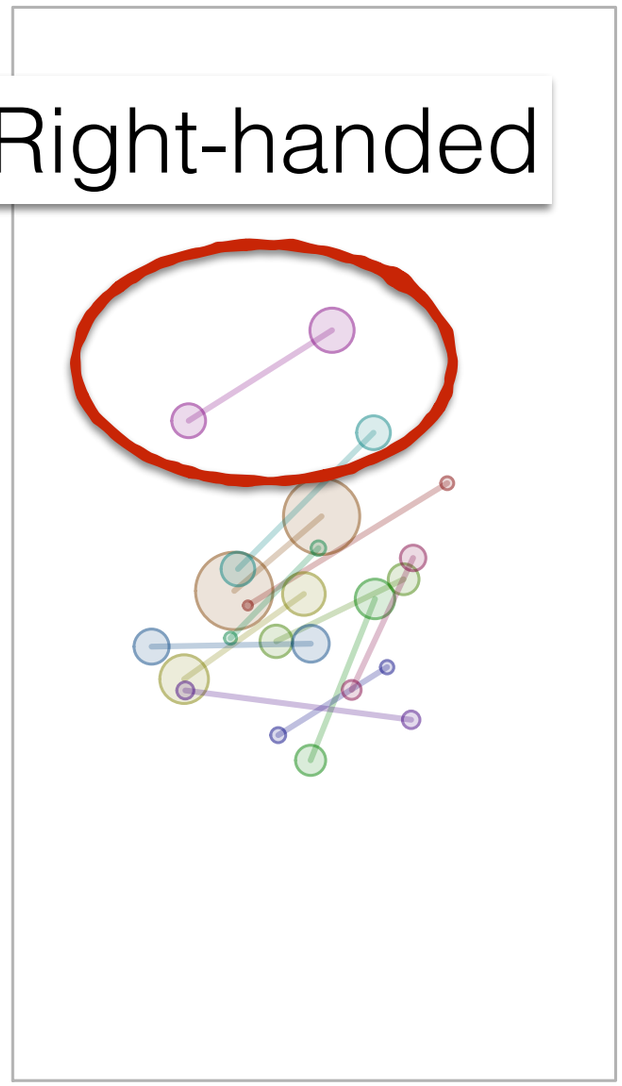
Two-finger double tap



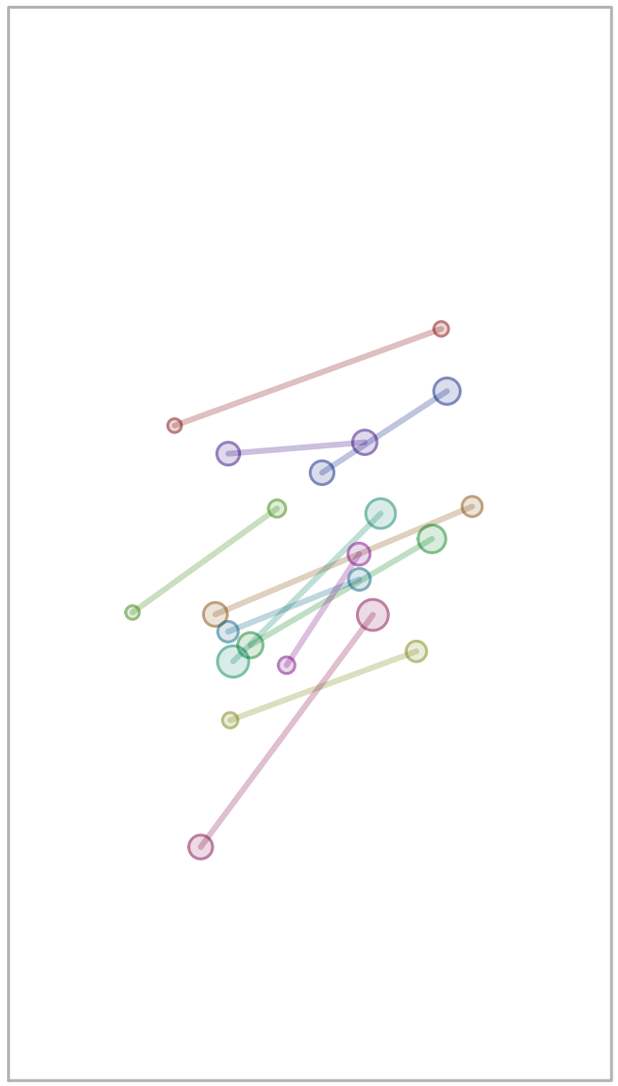
Blind since birth



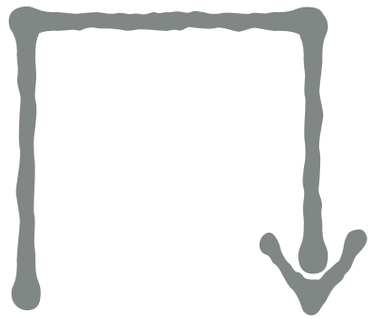
Blind since adolescence

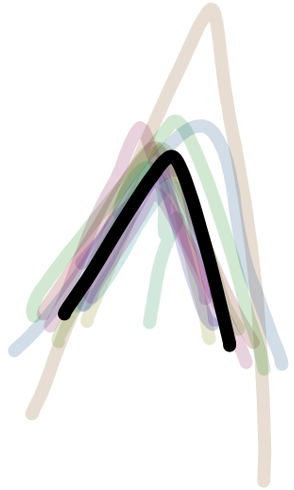


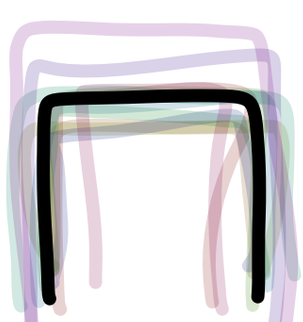
Became blind in adulthood



Severe low vision







Severe low vision

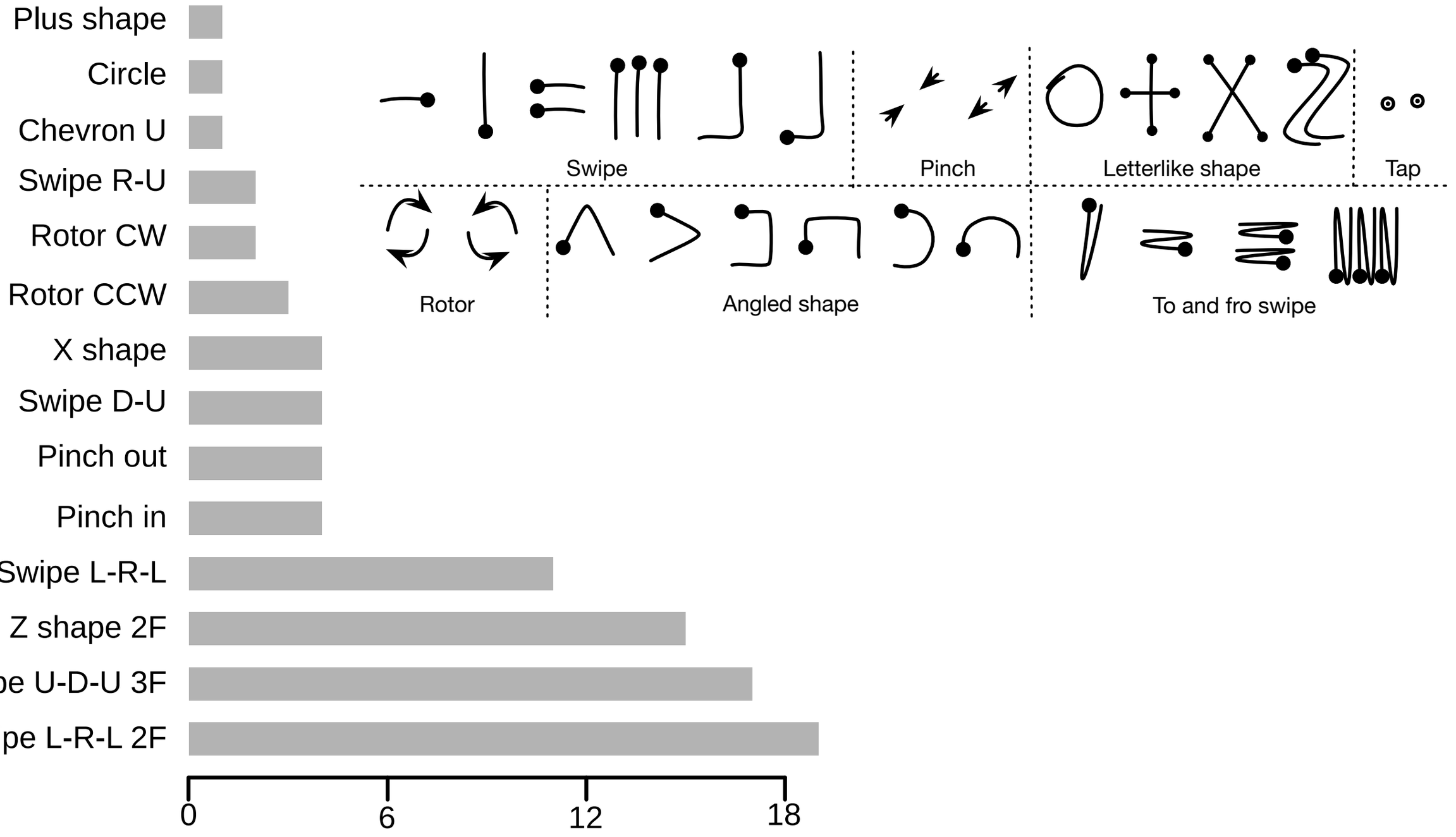
Blind in adulthood

Blind f. adolescence

Blind f. birth

All groups

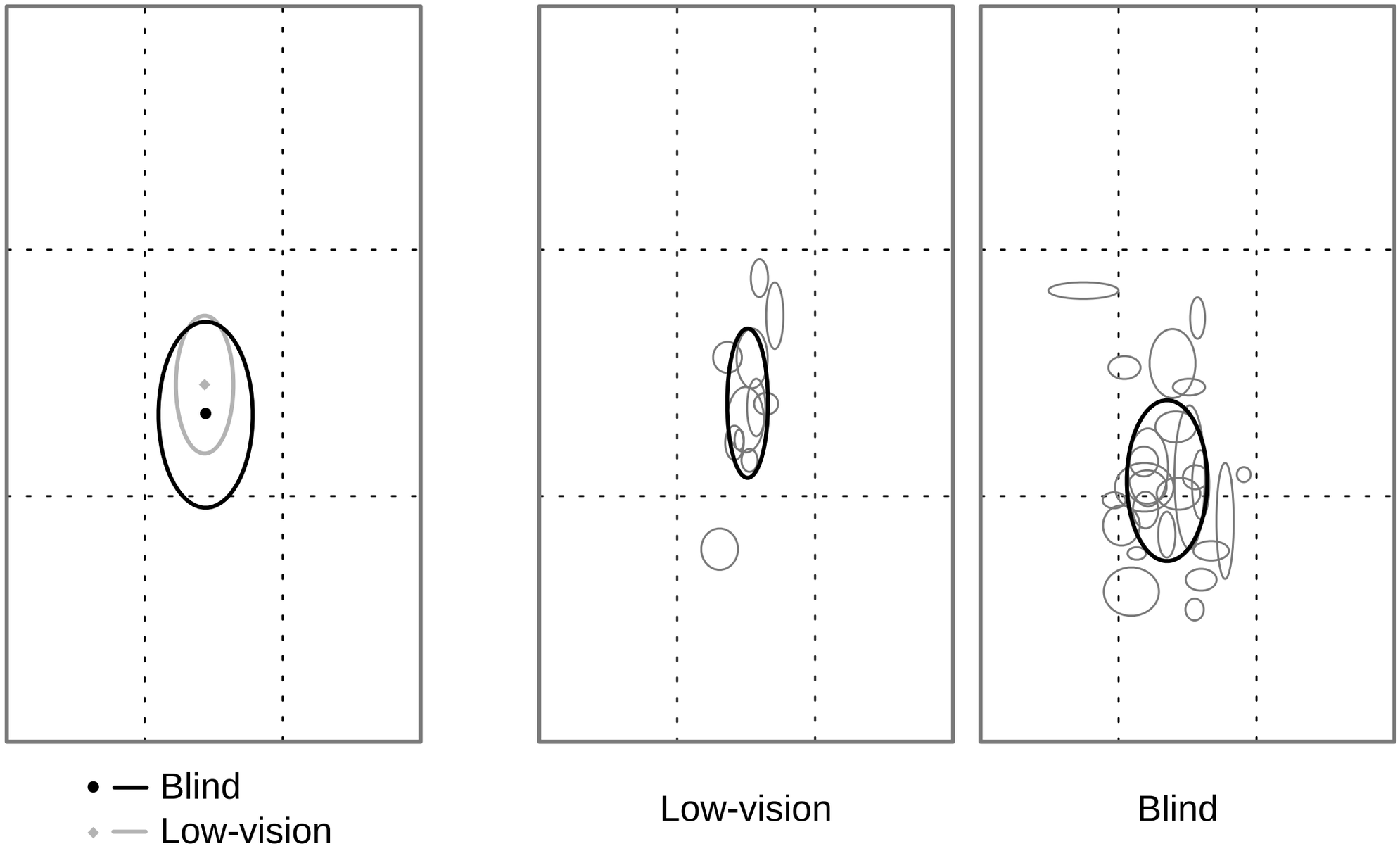
Invalid Captures Per Gesture



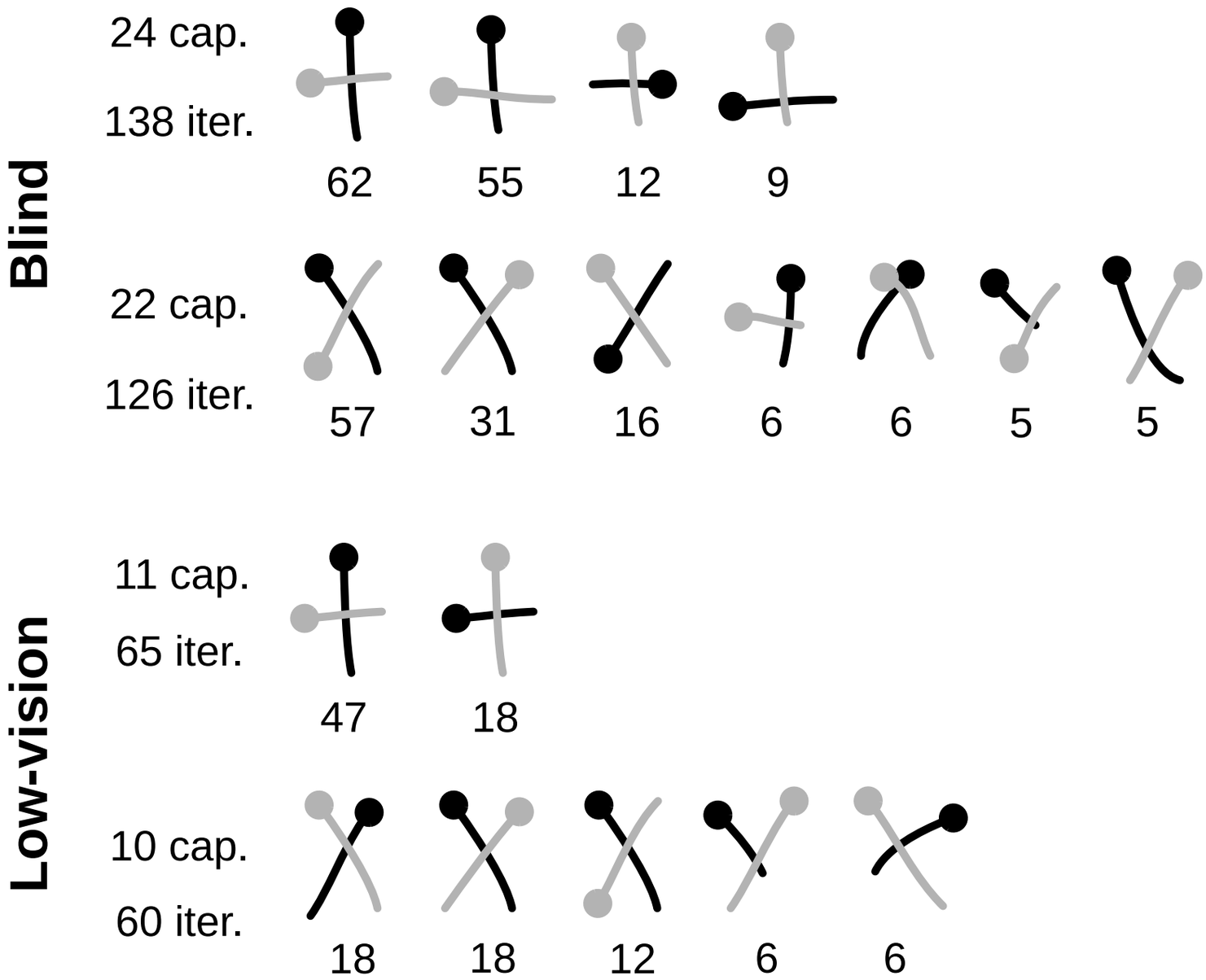
Bounding Box Centers

a) All bounding box centers

b) Bounding box centers of the gesture *Bracket U*



Multistroke clusters

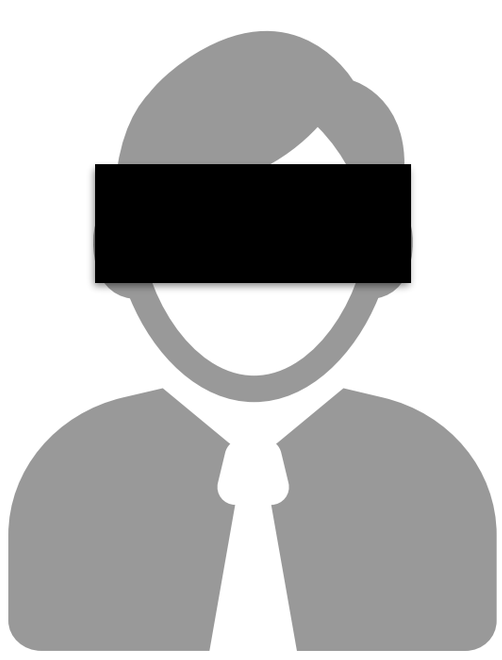


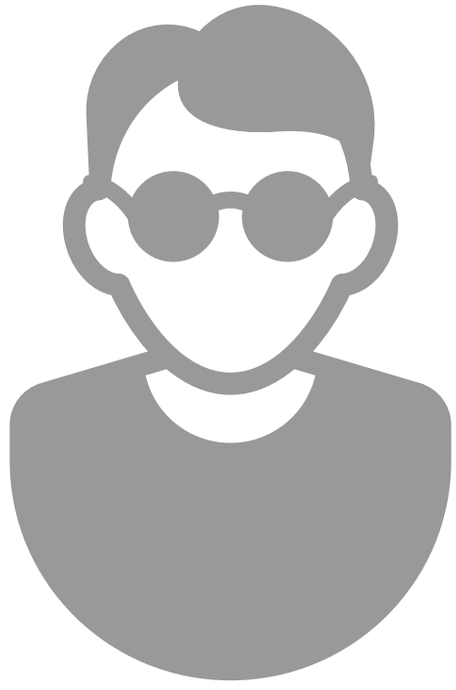
Study Limitations

- Difficulties in recruiting blind participants
- Under-representation of the younger generation
    - Mean age of 48 (s.d.=15.8)
- No prior training sessions
    - Some participants had limited used of touchscreen devices

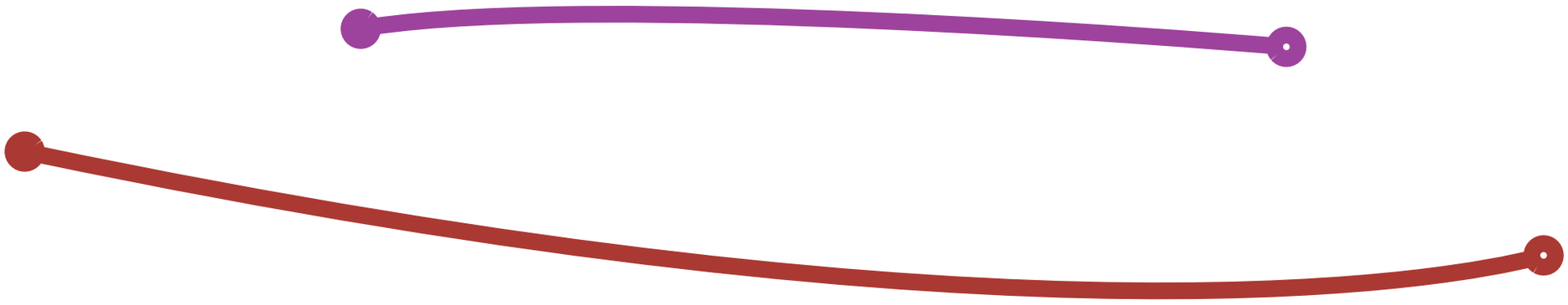
Take-away recommendations

Recruit participants with the target disability

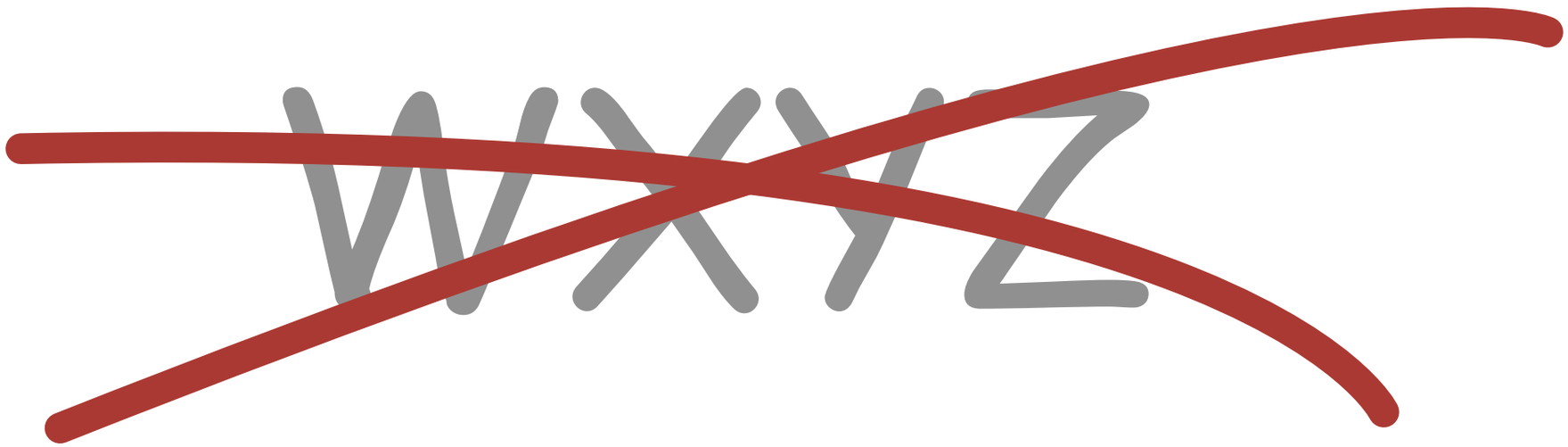




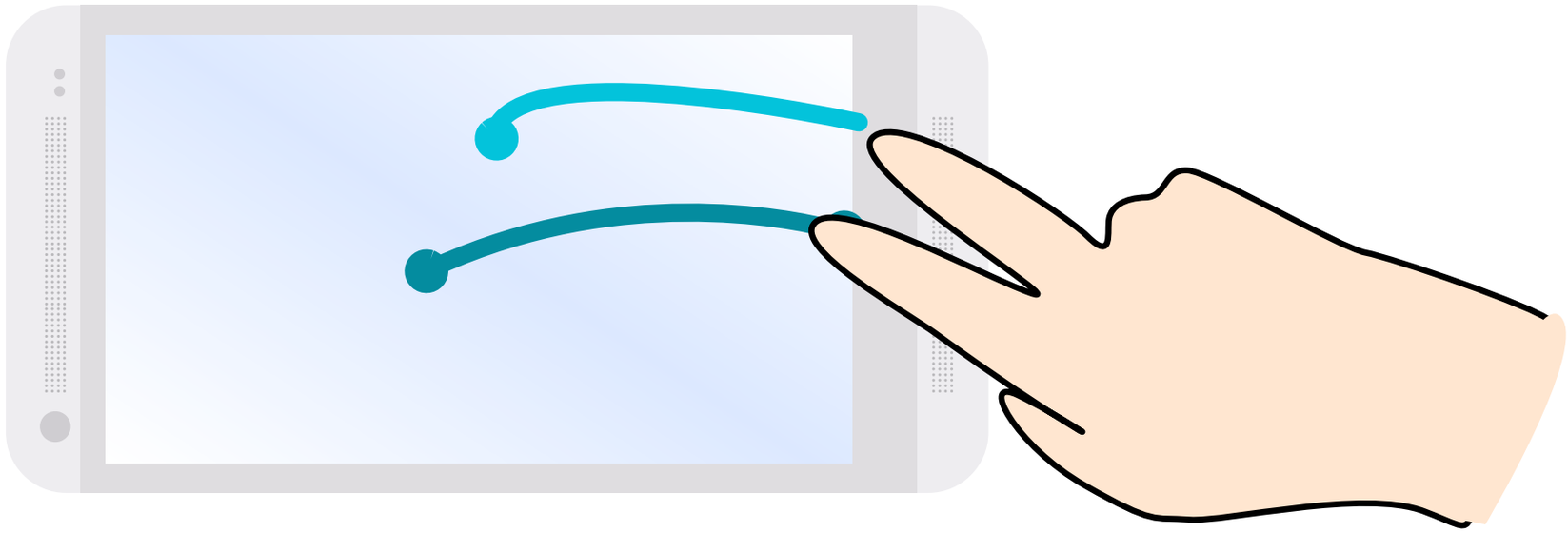
Longer gestures are curvier and perceived as more difficult



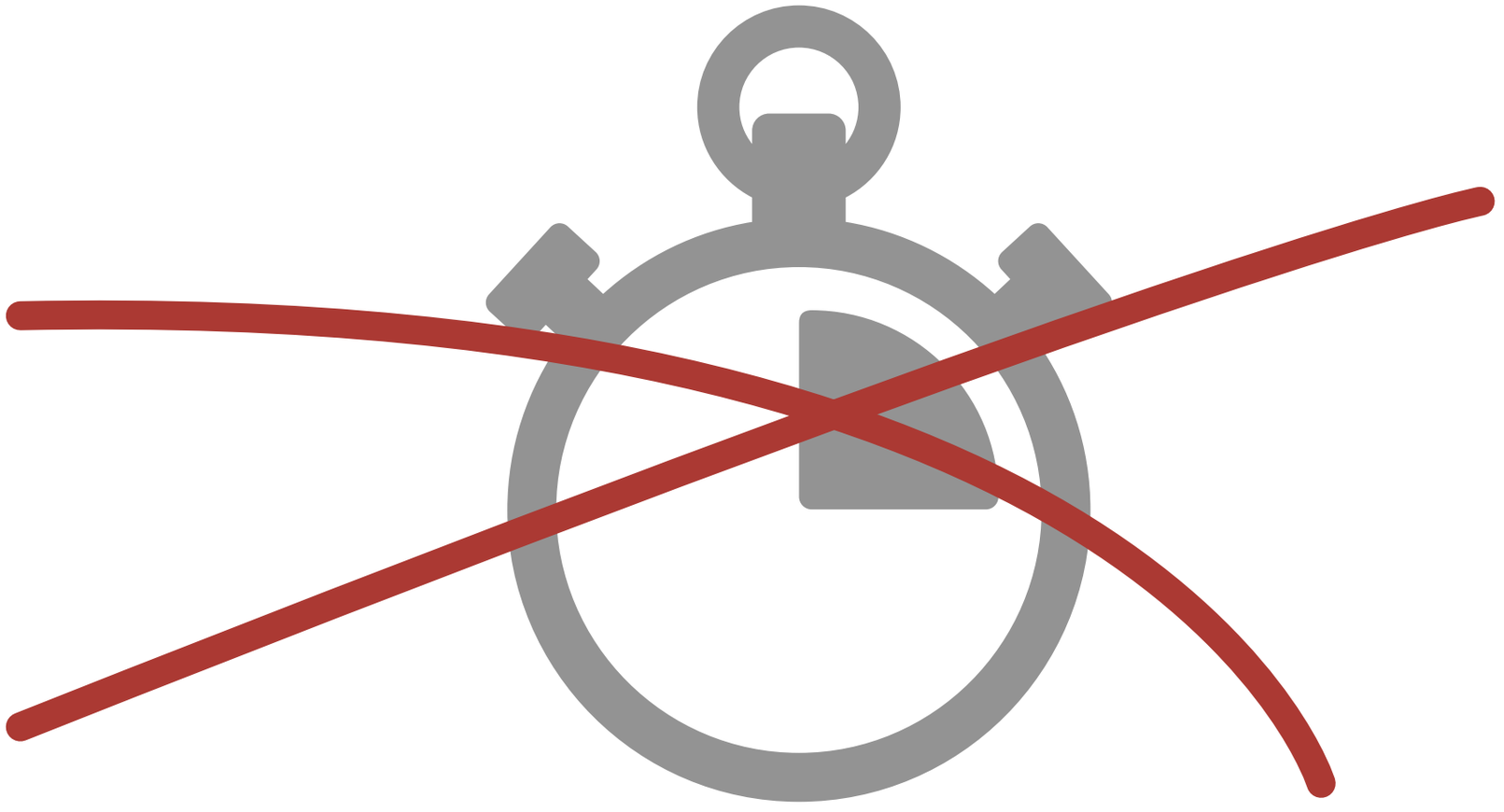
Avoid letter like figures



Multi-finger gestures are more likely to go offscreen



Try to avoid time-based recognition



Use web technologies
for multiplatform compatibility

Thank you.

Any questions?