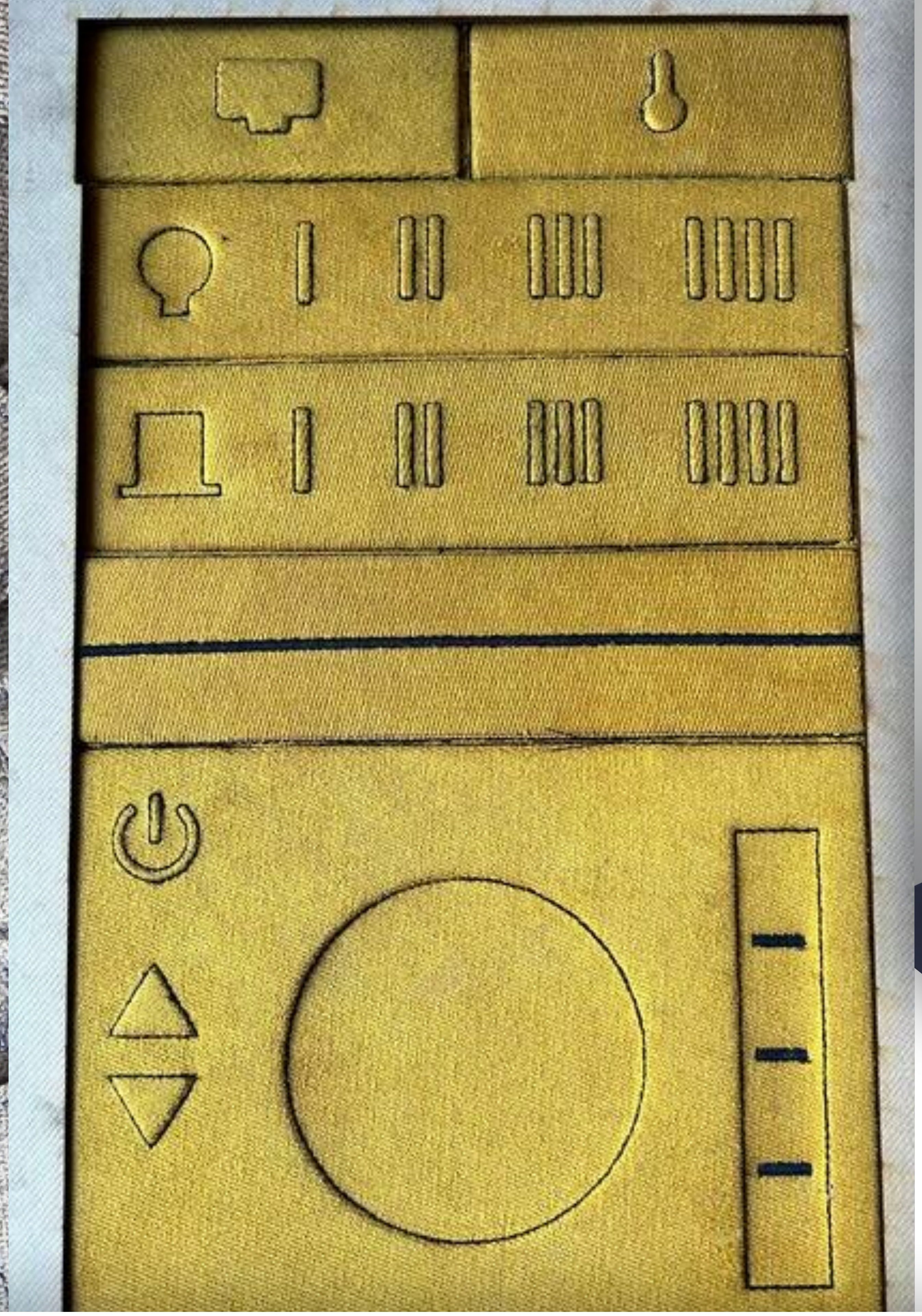





# Design Guidelines for Textile Interfaces (in the Home)

CTHCI ’24 — Oliver Nowak

RWTH AACHEN UNIVERSITY



RWTH AACHEN UNIVERSITY

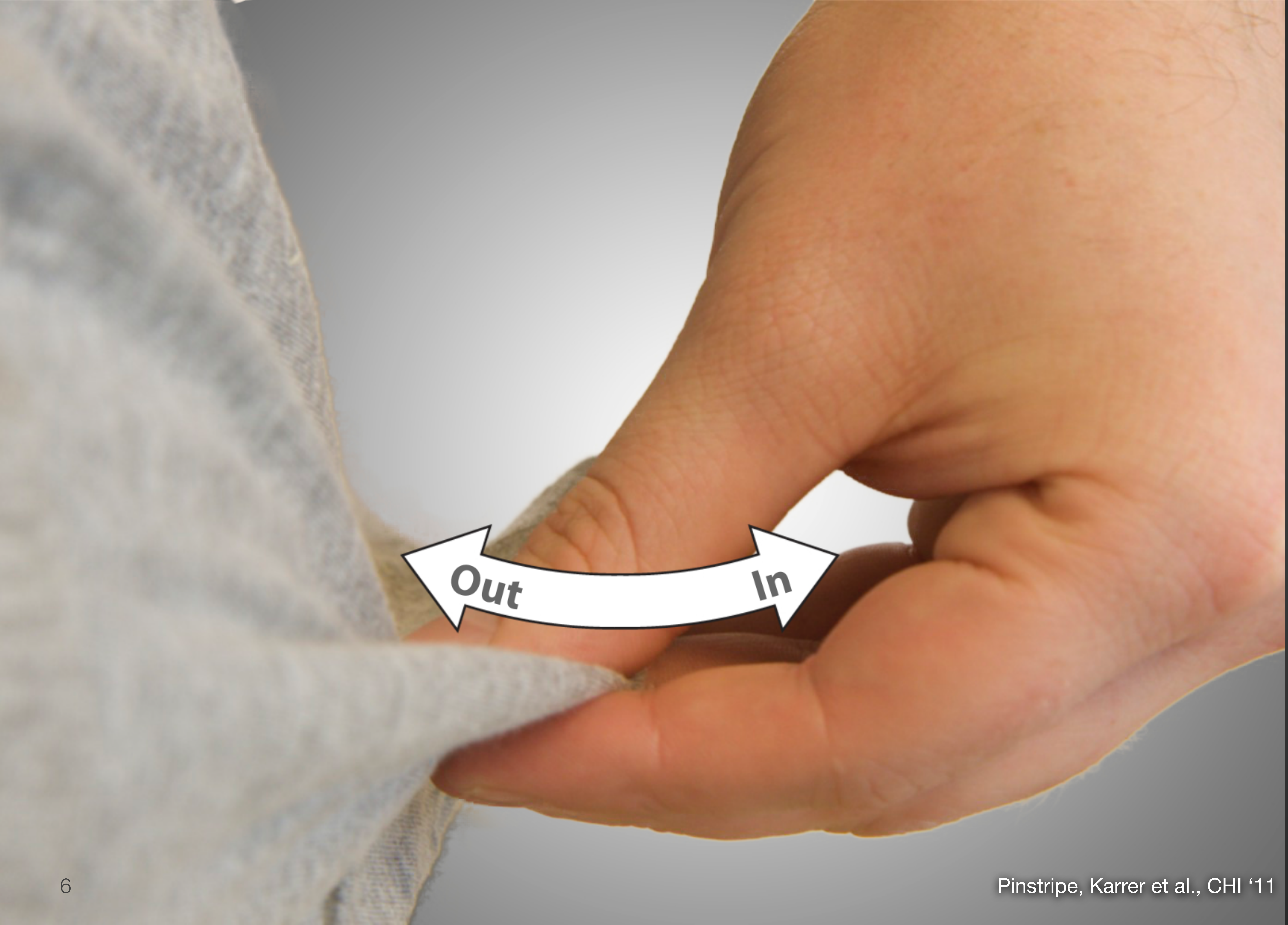
Photo by Skylar Kang

Photo by Charlotte May

# Textile Interfaces for Shortcuts

Image from Youtube Video “Jacquard — Be More” (https://youtu.be/hbcjfhjlJOs?t=32)

# Textile Interfaces for Touch Input




Pinstripe, Karrer et al., CHI ‘11

# New Interaction Possibilities


Albaugh et al., CHI ’19 (video figure)

# Digital Fabrication of Soft Actuated Objects by Machine Knitting

Albaugh et al., CHI ’19

Albaugh et al., CHI ’19 (video figure)

# Digital Fabrication of Soft Actuated Objects by Machine Knitting

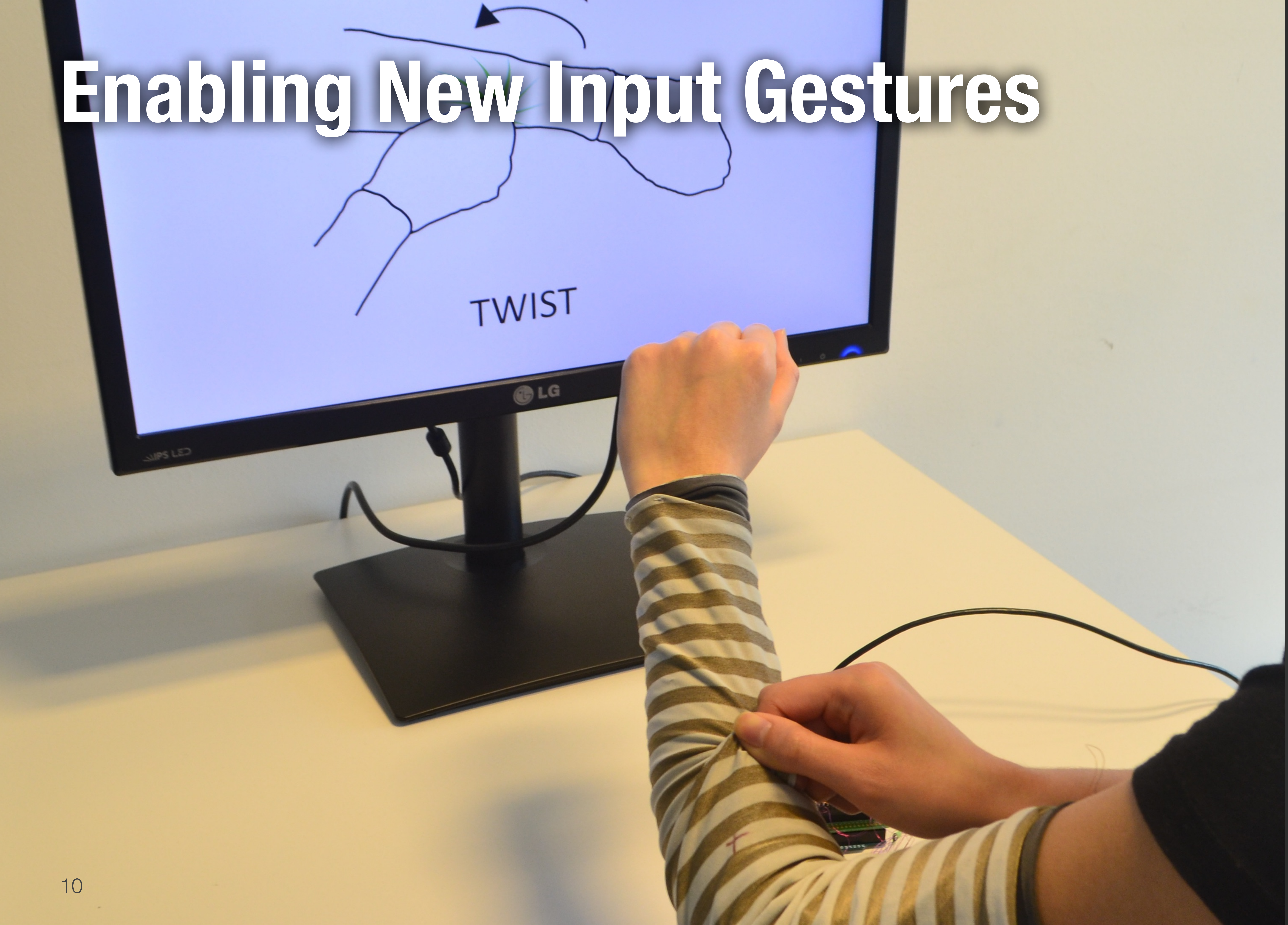
Albaugh et al., CHI ’19

Youtube: “Jacquard — Be More” (https://youtu.be/hbcjfhjlJOs?t=32)

Pinstripe, Karrer et al., CHI ‘11


# Input

# Enabling New Input Gestures



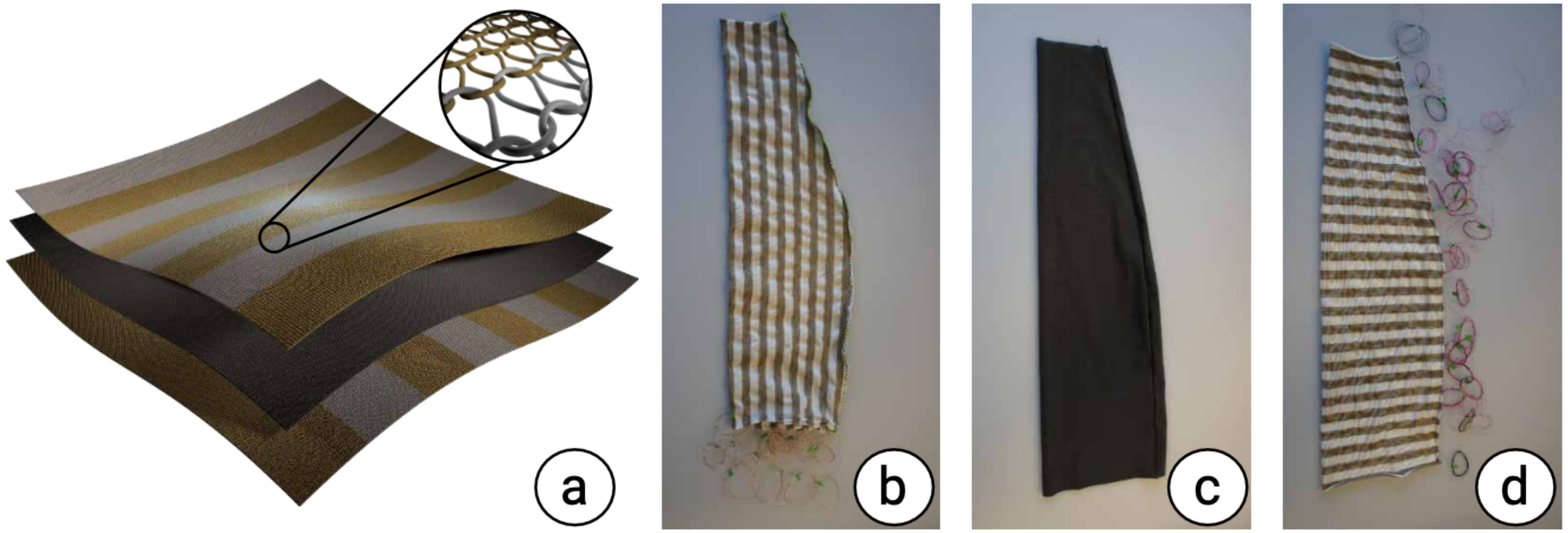

## SmartSleeve

Parzer et al.,
UIST ‘17

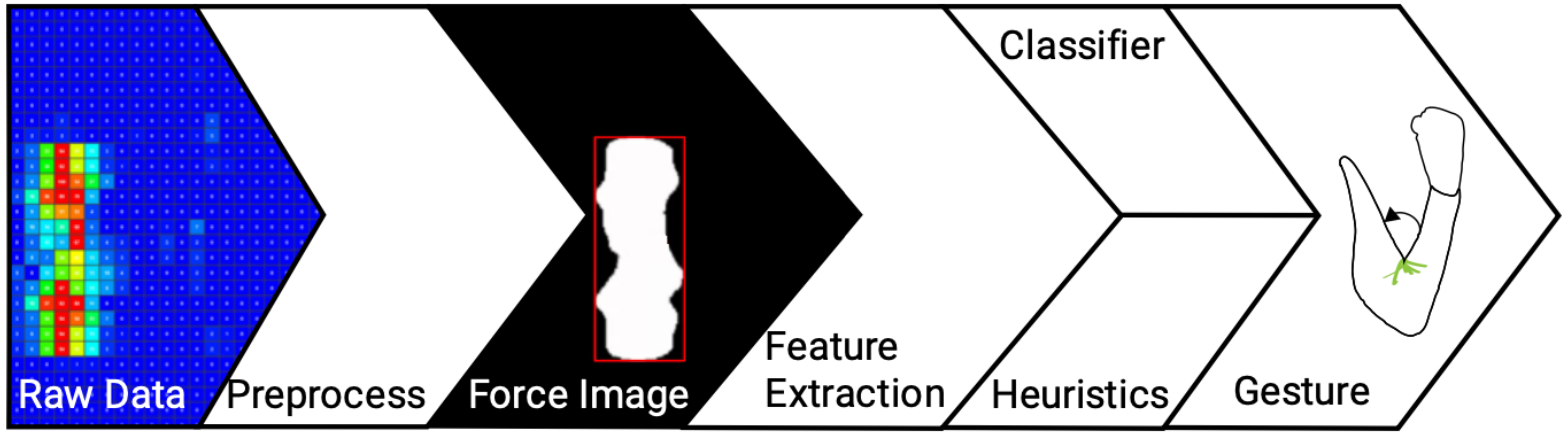
RWTH AACHEN UNIVERSITY

# Enabling New Input Gestures

Parzer et al., UIST '17




- Conductive stripes on top & bottom layer
- Middle layer is pressure sensitive




Parzer et al., UIST ‘17

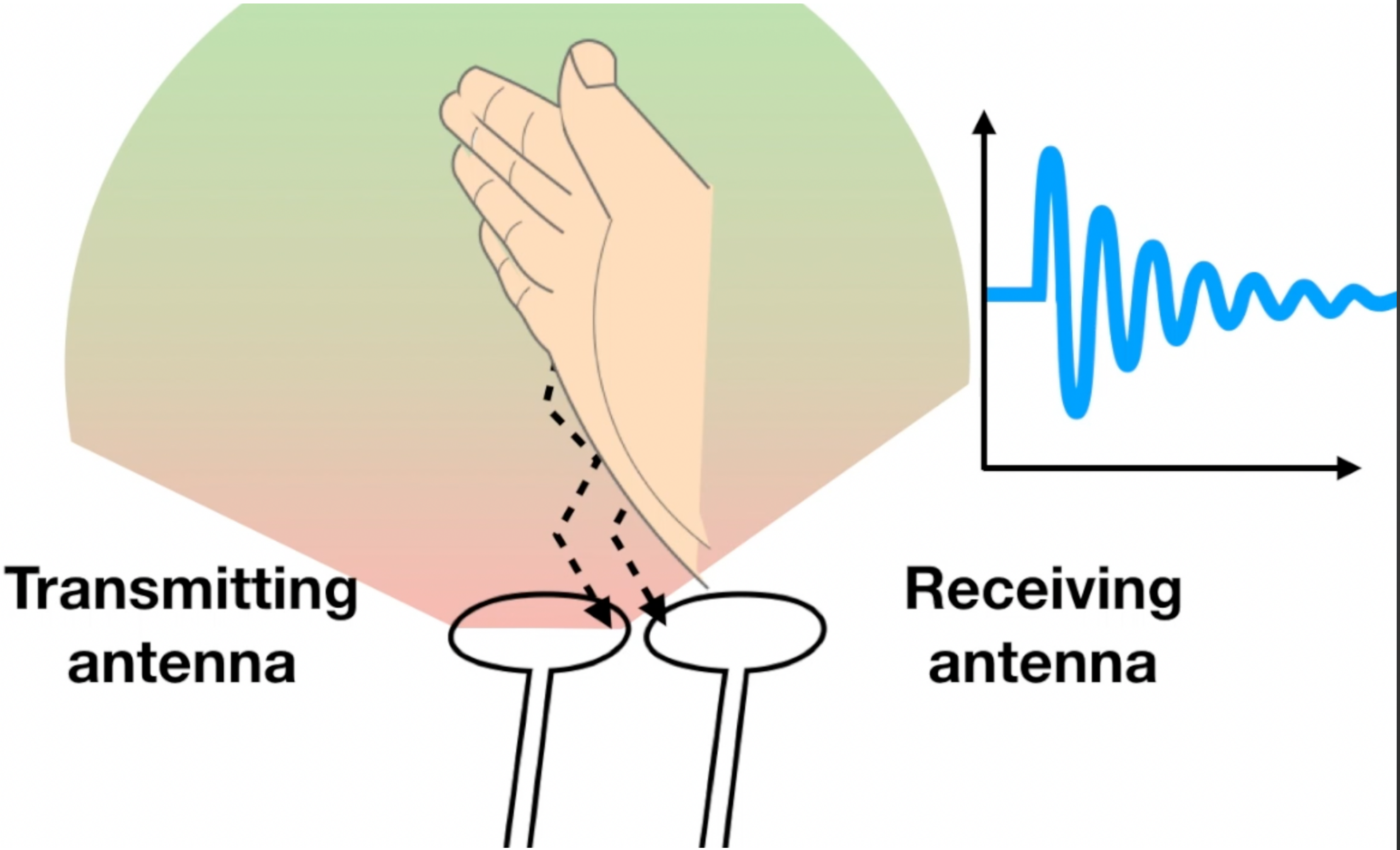
# Touchless Input

**Fabriccio: Touchless Gestural Input on Interactive Fabrics**

Wu et al., CHI ‘20



image from video figure of Fabriccio by Wu et al., CHI ‘20




# Fabriccio: Touchless Gestural Input on Interactive Fabrics

Wu et al.,
CHI ‘20

image from video figure of Fabriccio by Wu et al., CHI ‘20

# Mid-Air Gestures

Wu et al., CHI ‘20

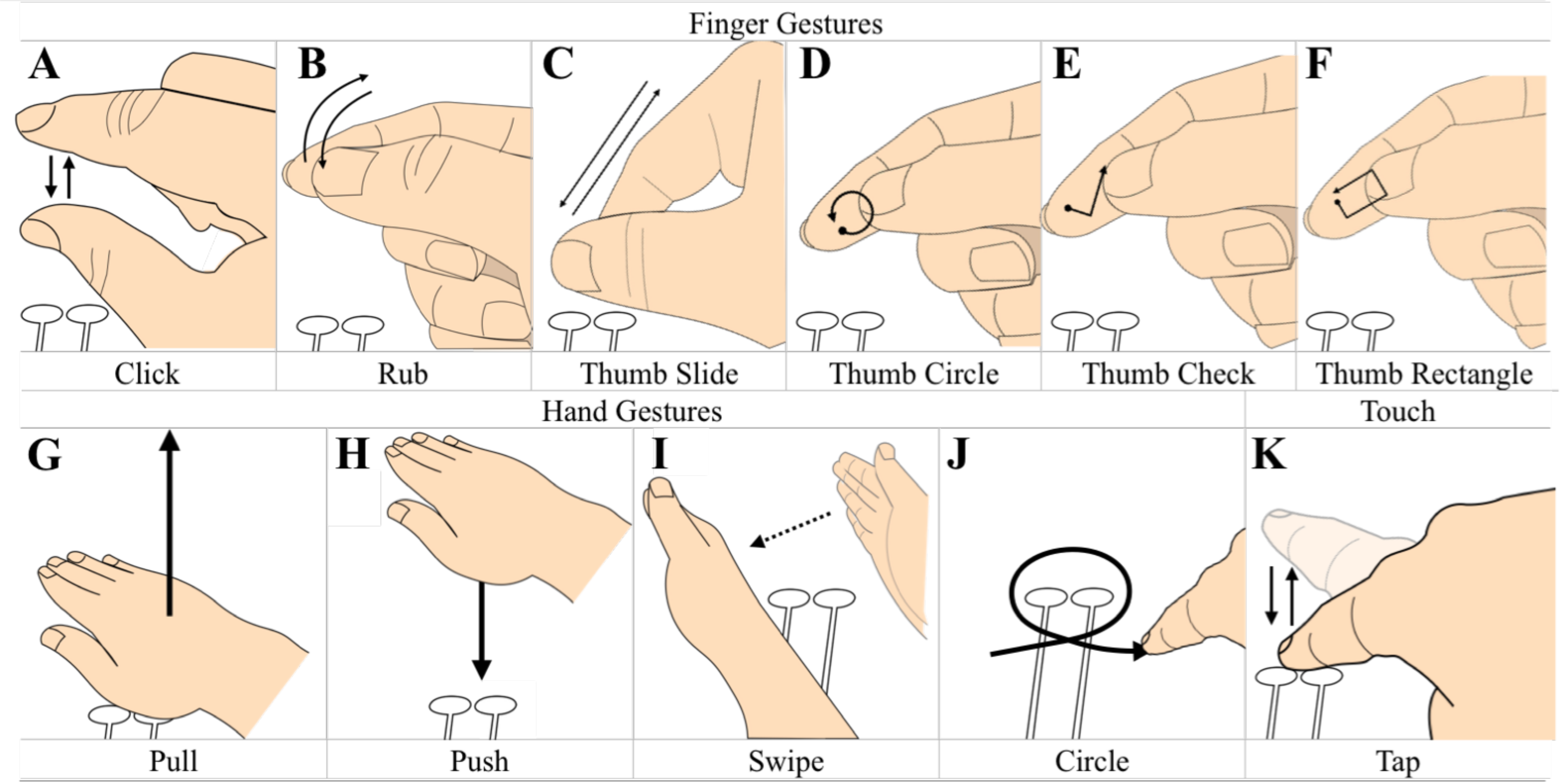


Photo by Houzlook.com

# Interface Design for Non-Wearables (in the Home)



RWTH AACHEN UNIVERSITY

https://www.apple.com



# Controlling Home Devices

- Commands & names must be known
- Not bound to a location/device
- Not accessible for everyone
- Navigation costs

# Are Textile Controllers Accepted?

**Interactive FUrniTURE**

Brauner et al., ISS ’17



Interactive FUrniTURE, Brauner et al., ISS ’17 (https://www.youtube.com/watch?v=FTNe6ryD57A)

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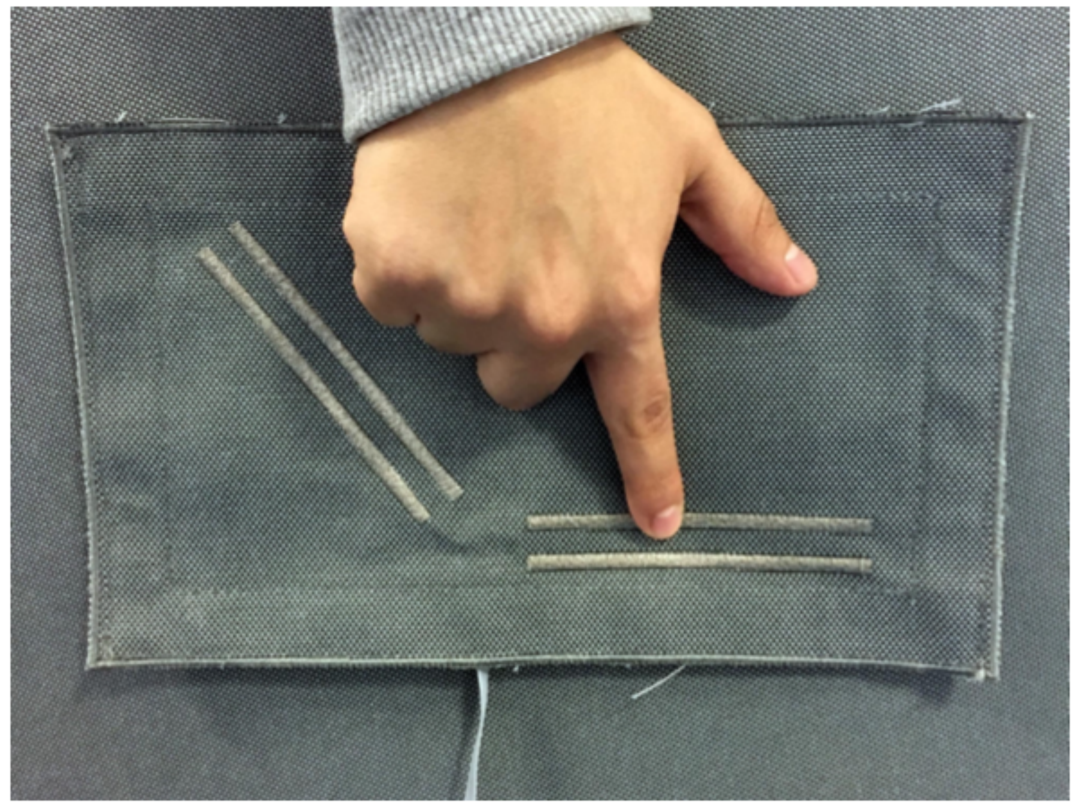
# Textile Controllers Vs. Remote Controls

Brauner et al., ISS ’17

(a) Touch the fold

(b) Bend the fold



(c) Touch the stitches

(d) Plastic remote control

## Study investigating *acceptance*

- Introductory survey
- Participants explored controller and performed example tasks (Think Aloud)
- Evaluation using UEQ & TAM scales

# Textile Controllers Vs. Remote Controls

Brauner et al., ISS ’17

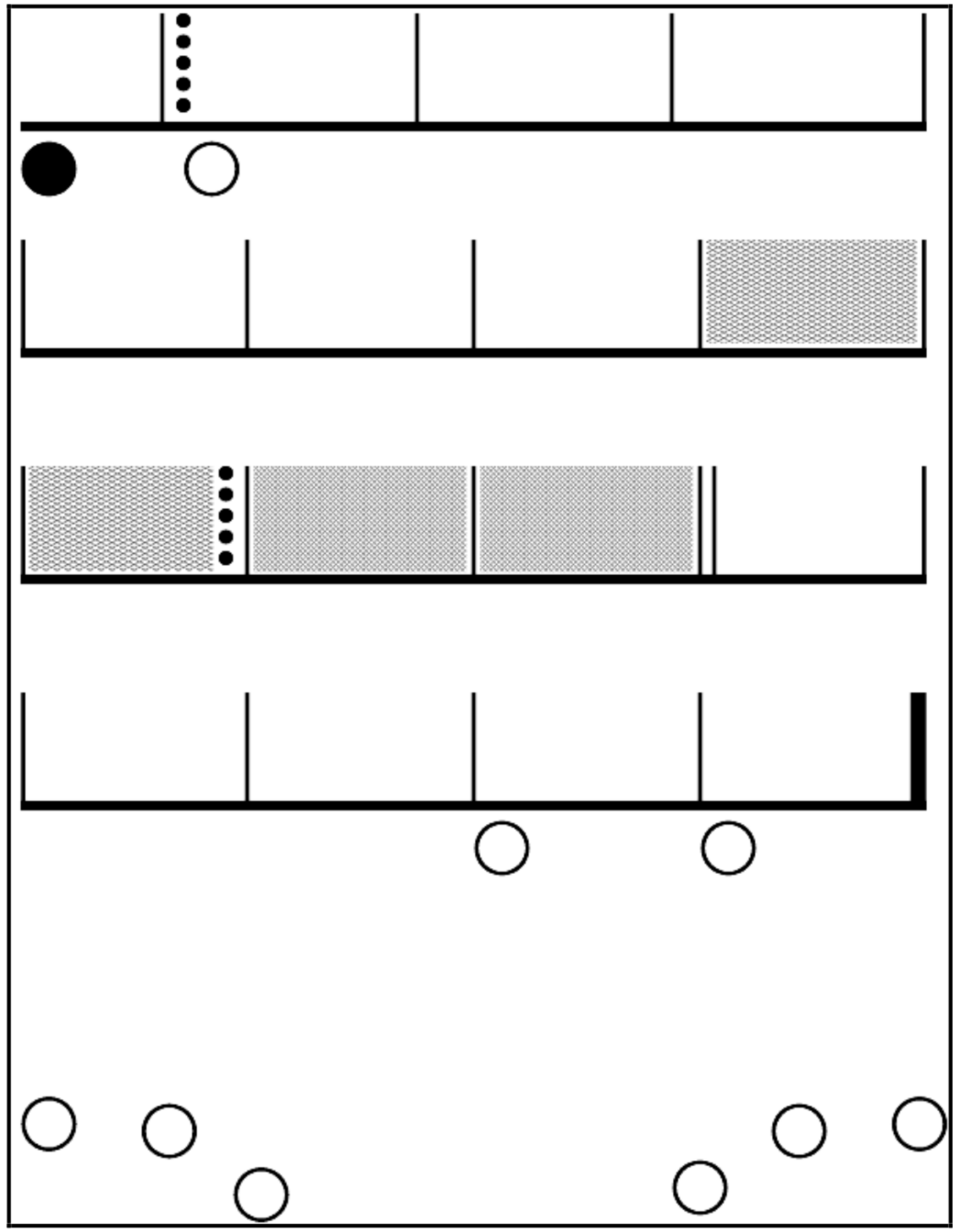
## Results

- Plastic remotes received best practicability scores, but lower *intention to use* scores
- “[Participants valued] the **spatial and physical closeness** of the interaction surface to the target [… and] the **intimate relation** between textile controllers […] to the environment which they control”
- Participants liked the folding interaction, but visually preferred the stitched textile interface due to their **subtlety**

# Design Guidelines for Textile Interfaces

# The Design of Complex Tactile User Interfaces

Challis and Edwards, "Design Principles for Tactile Interaction", 2001



- Tactile music notation for visual impaired people
- Visuals were directly mapped to haptic elements
  - Line thickness → Height of PVC overlays
  - 1st & 2nd time bar → Texture
- Control buttons in the bottom

# The Design of Complex Tactile User Interfaces

Challis and Edwards, “Design Principles for Tactile Interaction”, 2001

## User test

- 5 blind-folded & 1 blind musicians
- Step-by-step tutorial
- Task 1: Explore & describe new overlays
- Task 2: Change settings and retrieve a description of the change

## Concluded design principles

- Avoid empty space
- Provide help for exploration
- Avoid double clicking
- Don’t expect users to overreach  to explore the interface
- Visual-to-tactile mapping unlikely to be the most efficient design
- Tactile components should be simple

# Design Investigation of Embroidered Interactive Elements on Non-Wearable Textile Interfaces

Mlakar and Haller, CHI '20

# Process to Initial Design Assumptions

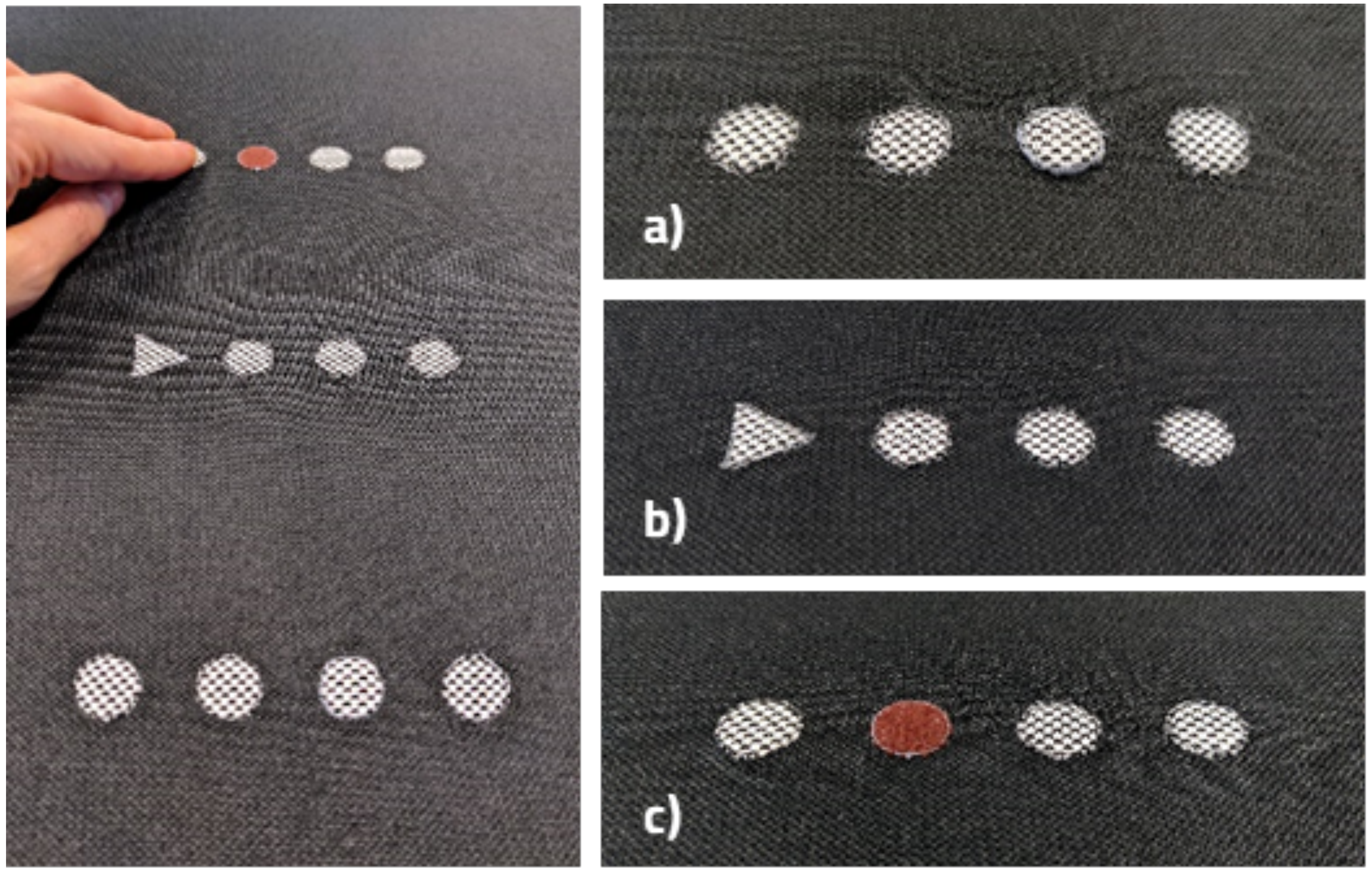
Mlakar and Haller, CHI '20

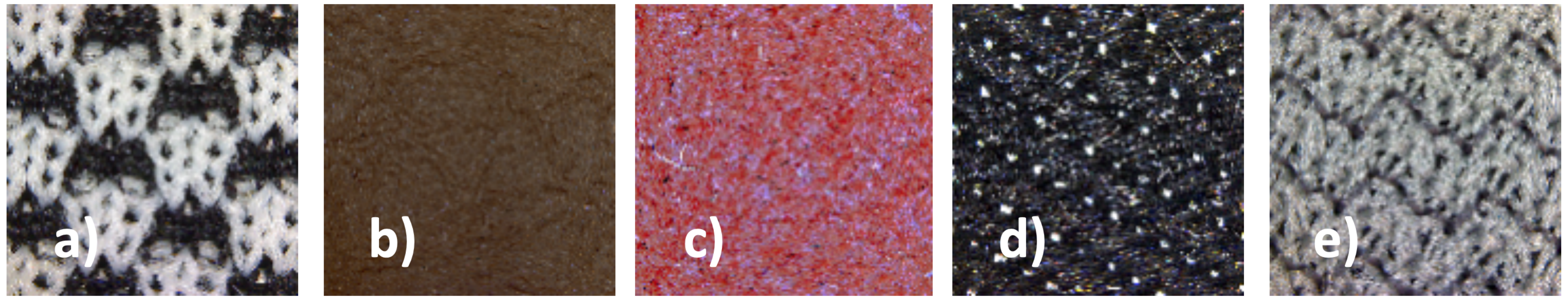
**5 statements from researchers and industry experts**

- Contrasting by texture, shape, height will always stand out
- Shapes should be at least 6.5 mm big; optimal size ≈13 mm
- Interactive elements can be curved inward and outward
- Shape can indicate commands
- Shapes should be simple

# E1: Recognizing Tactile Contrast

Mlakar and Haller, CHI '20

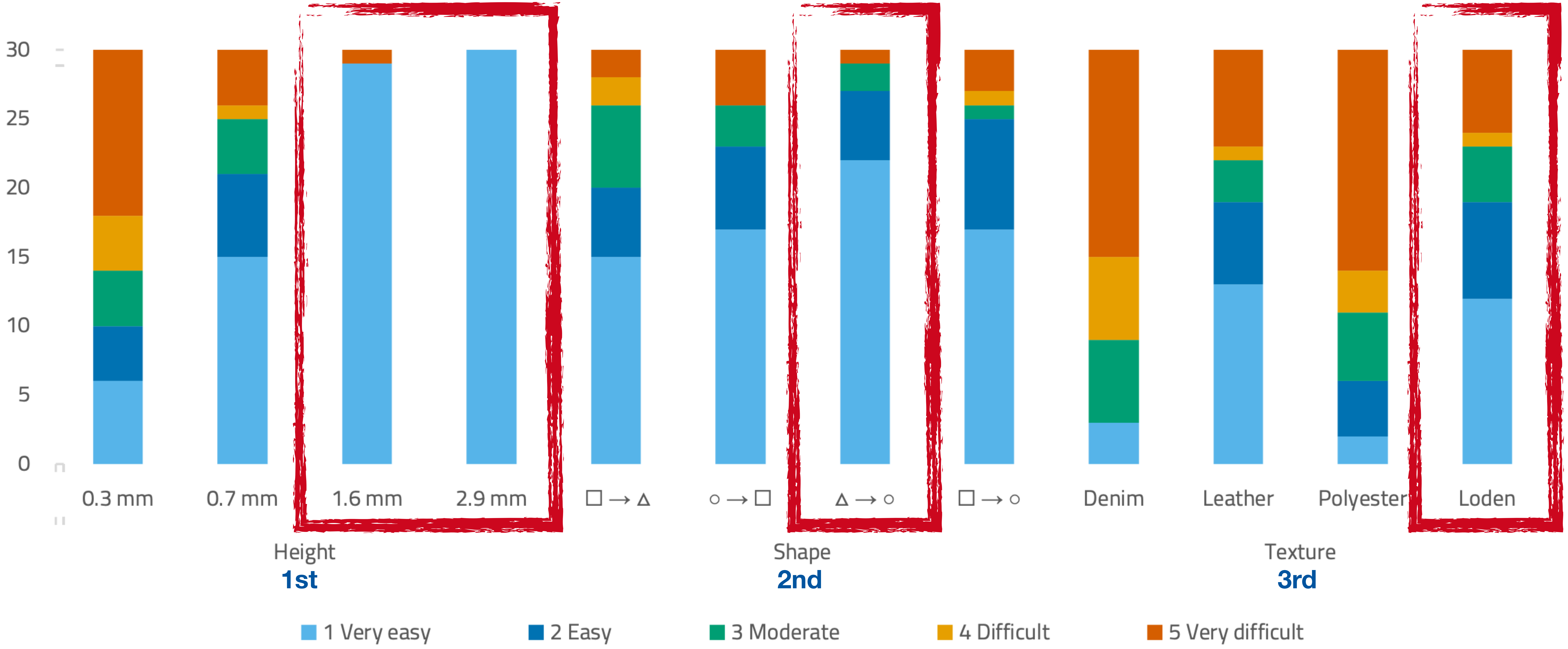



polyester/ cotton | artificial leather | loden | denim | polyester

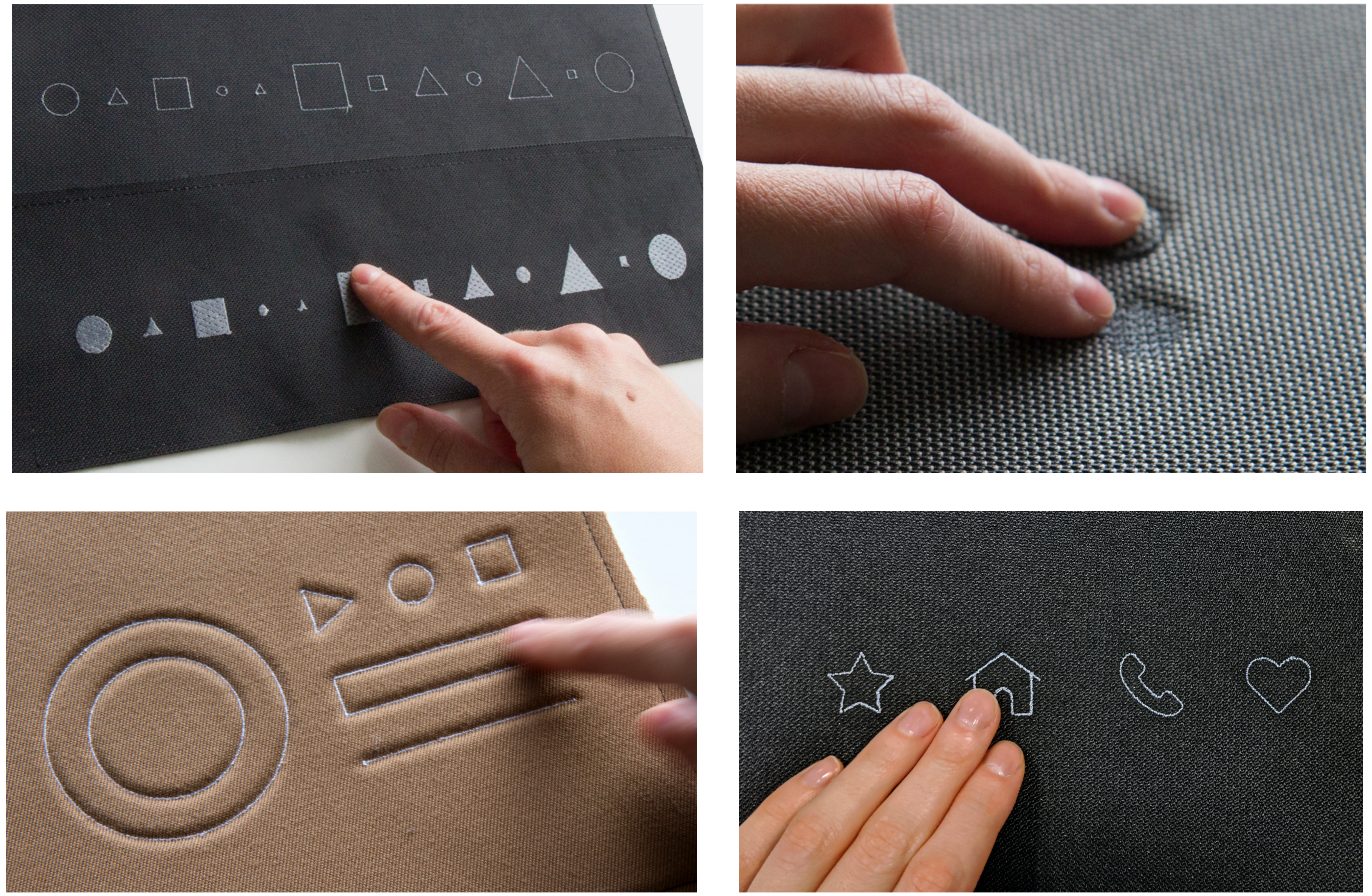
# E1: Recognizing Tactile Contrast

Mlakar and Haller, CHI '20



# Further Experiments

Mlakar and Haller, CHI '20



- Good recognition with ≥ 13 mm
  - Outlines were recognised slightly more often (239 vs. 206 times)
  - No significant difference between shapes
- Recessed button mostly regarded as interactive
- Rectangle was used the most diverse
  - 15 slide, 8 press, 5 both
- Visual symbols hard to recognize:
  - Star 15x, heart 11x, house 3x, phone 2x

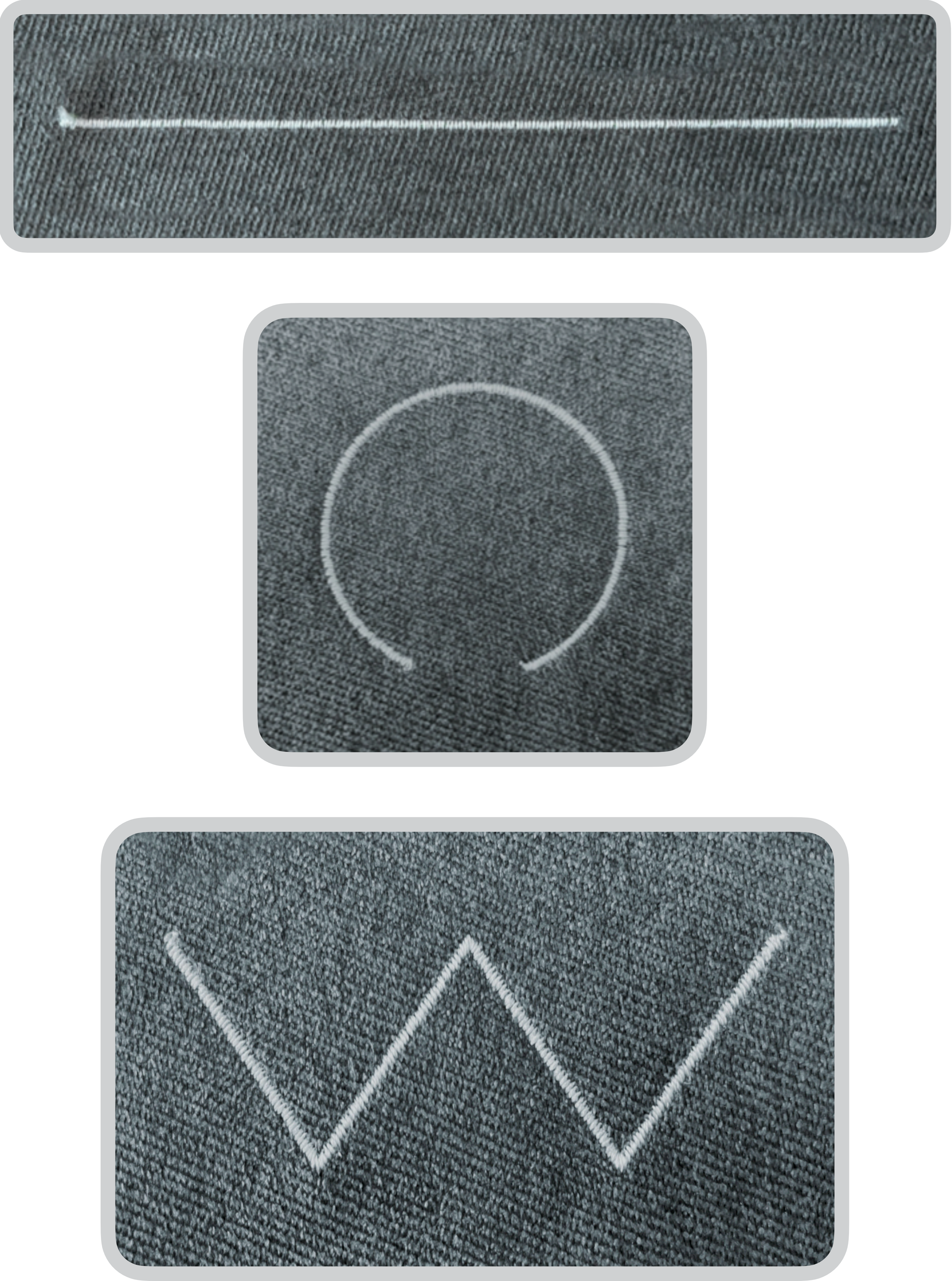
# How to Design Textile Sliders?

## Shaping Textile Sliders

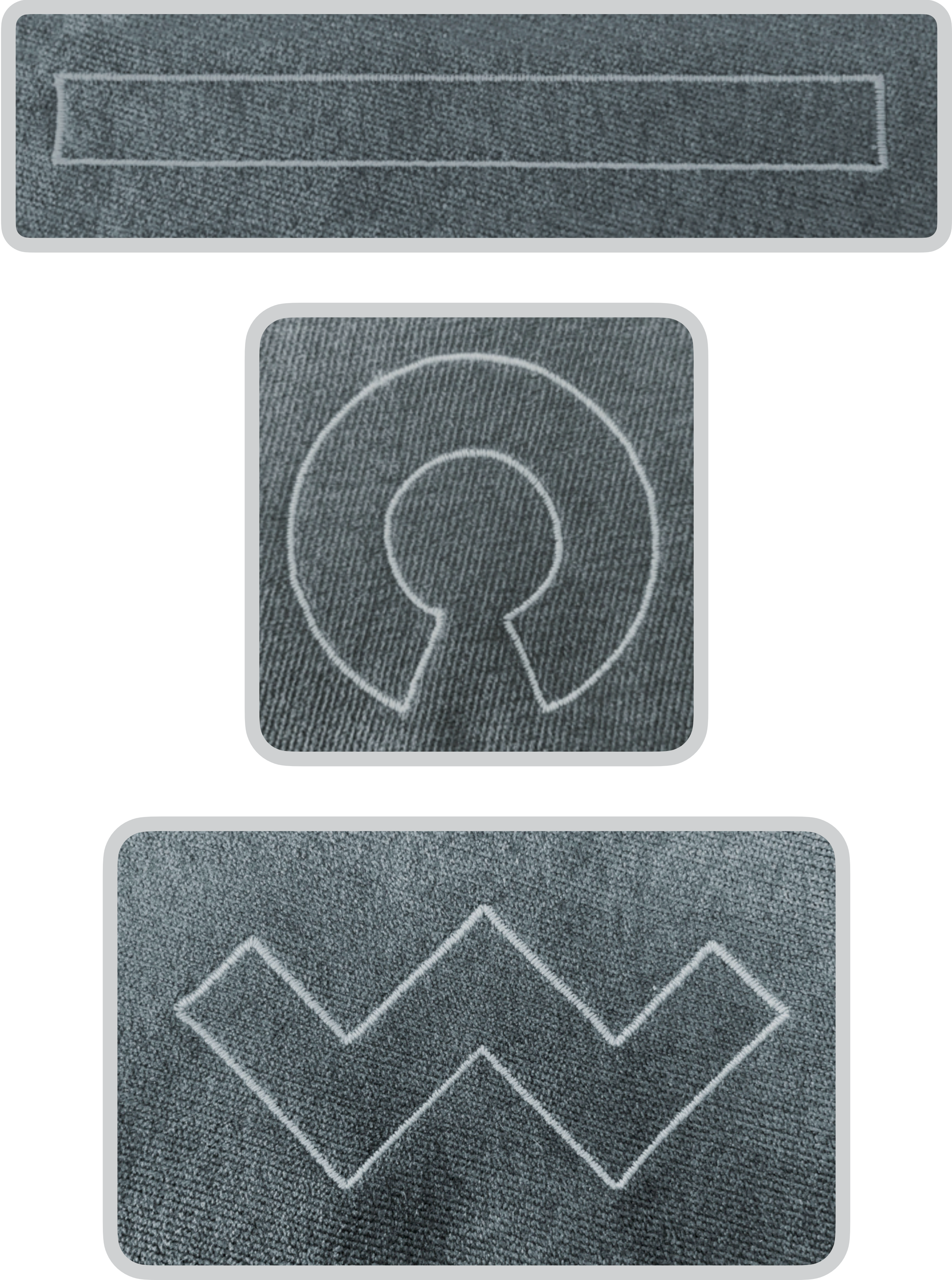
Nowak et al.,
CHI ‘22

# Path & Close Shape Sliders

## Path

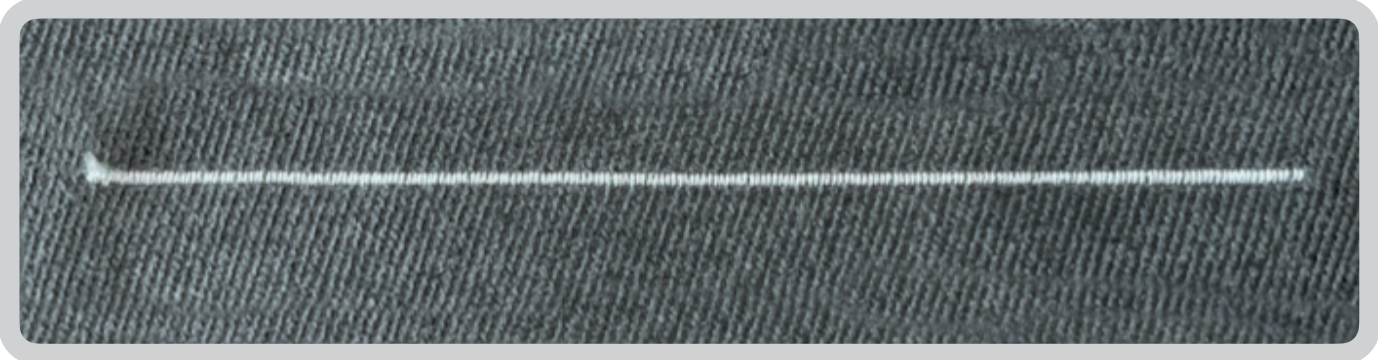


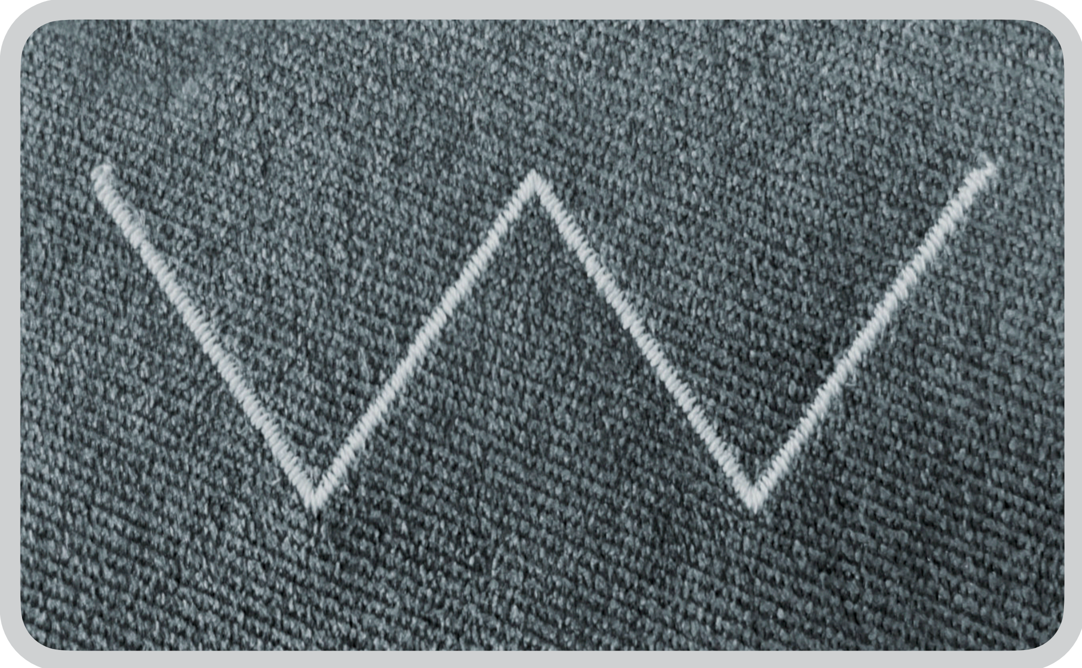
## Closed Shape



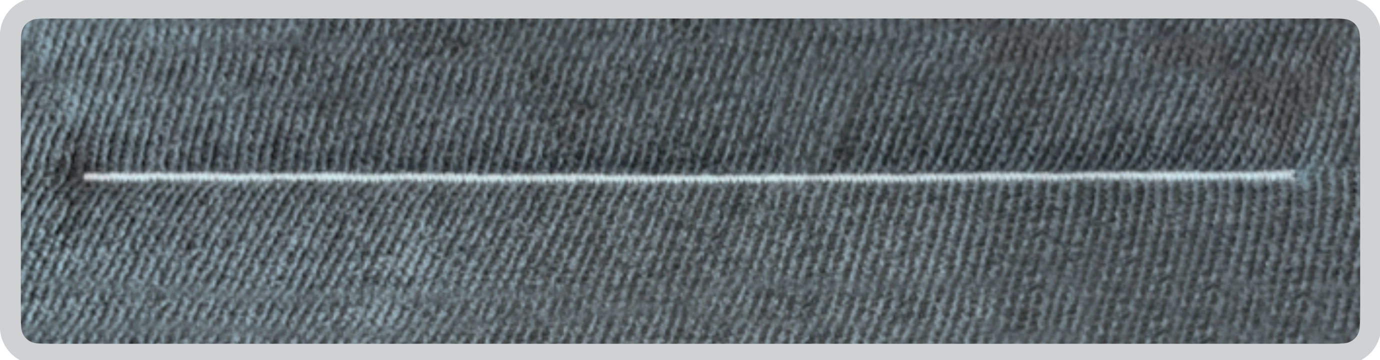
# Path Profiles

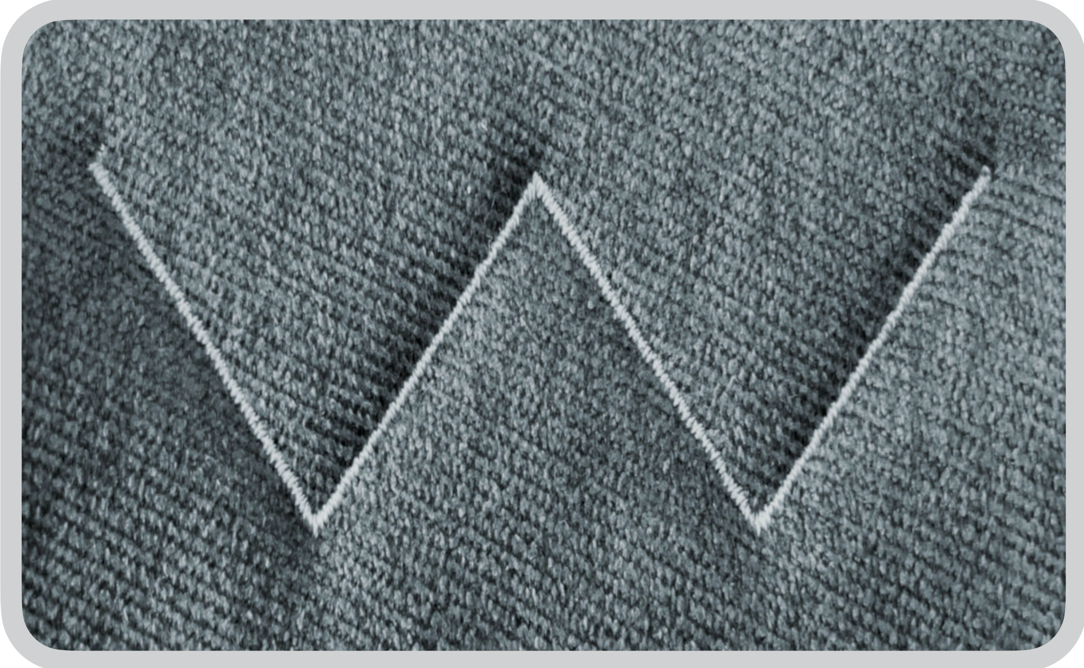
## Raised





## Recessed

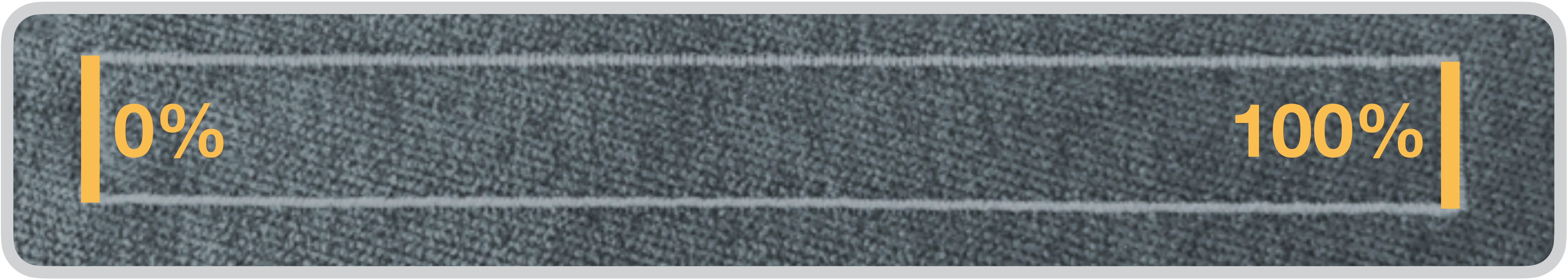




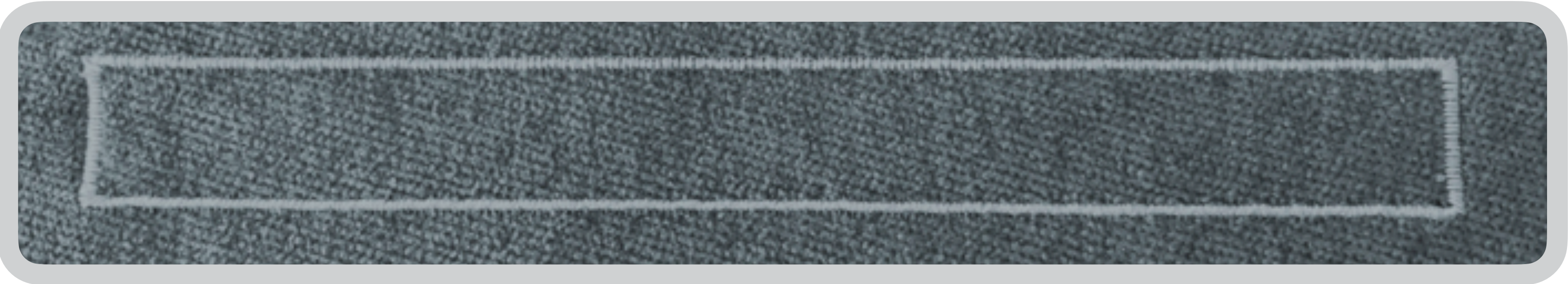
# Closed-Shaped Profiles

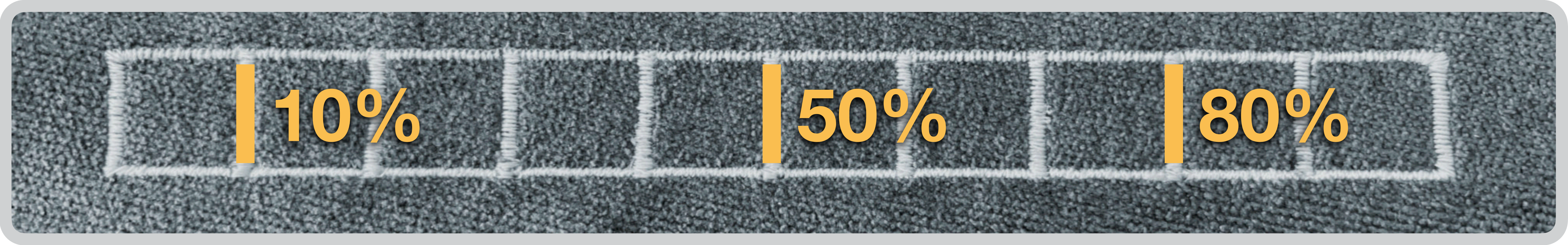
Flat | Raised | Recessed

# Shapes: Rectangle

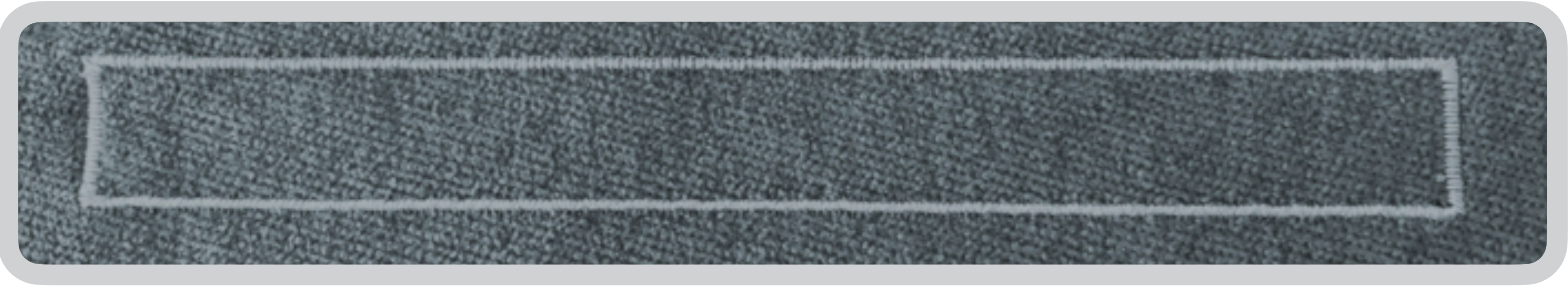


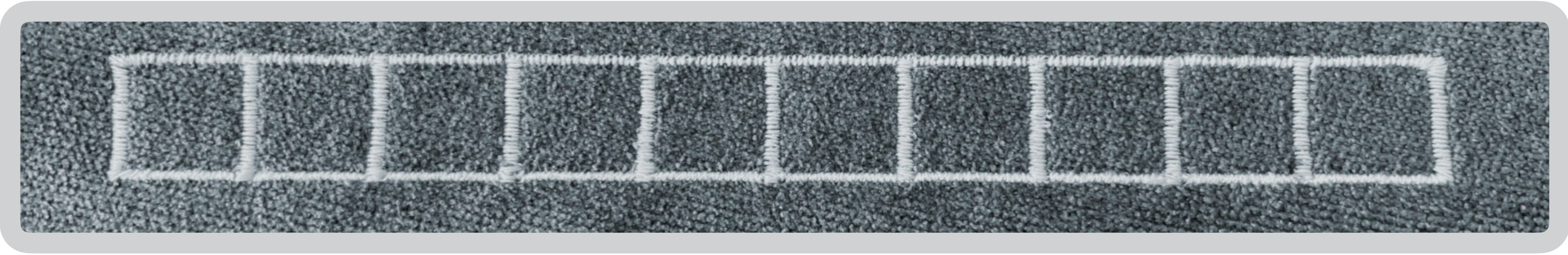
# Shapes: Tick Mark



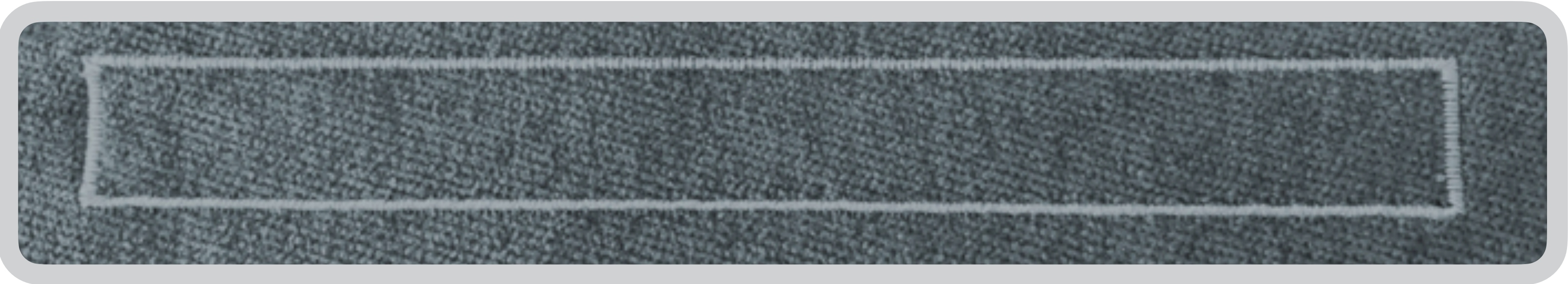


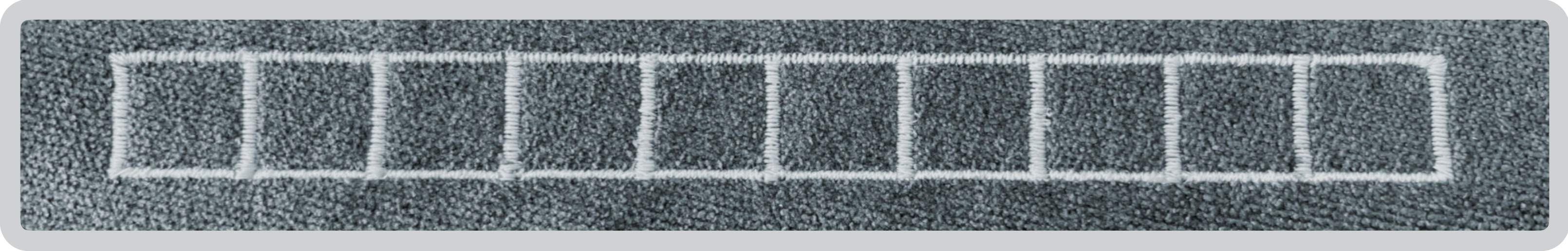
# Shapes: W

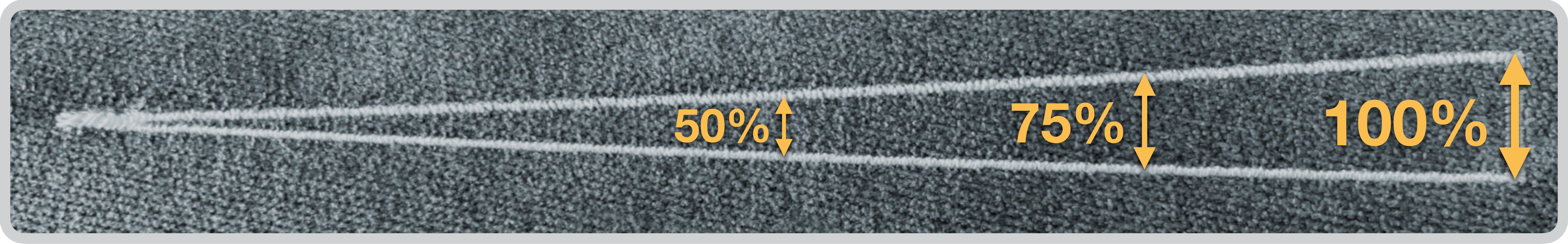




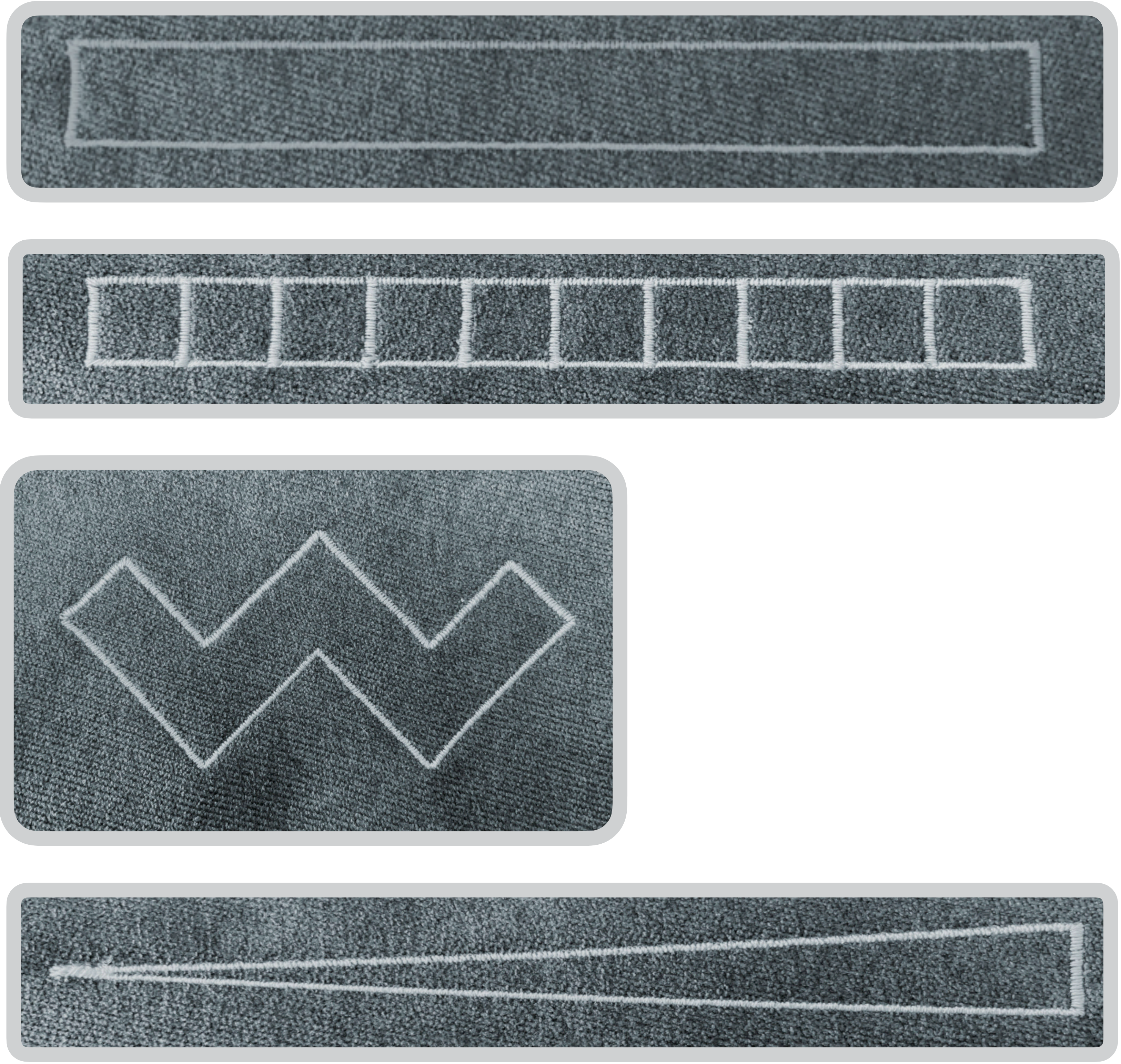
# Shapes: Triangle

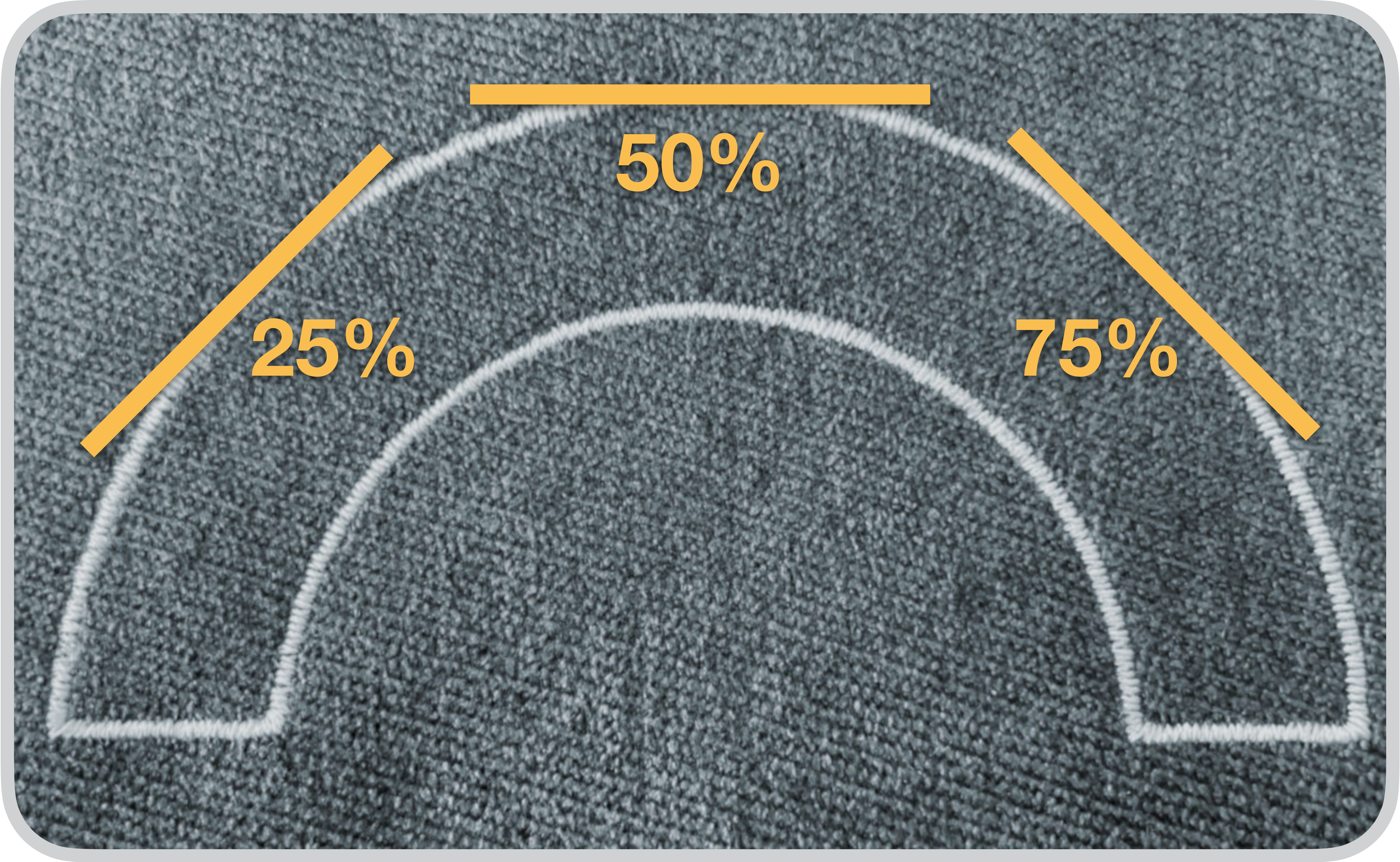




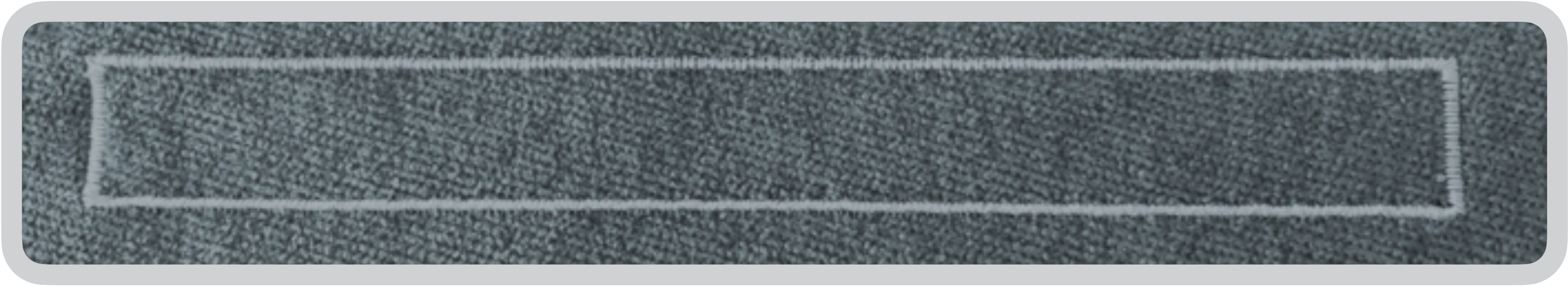


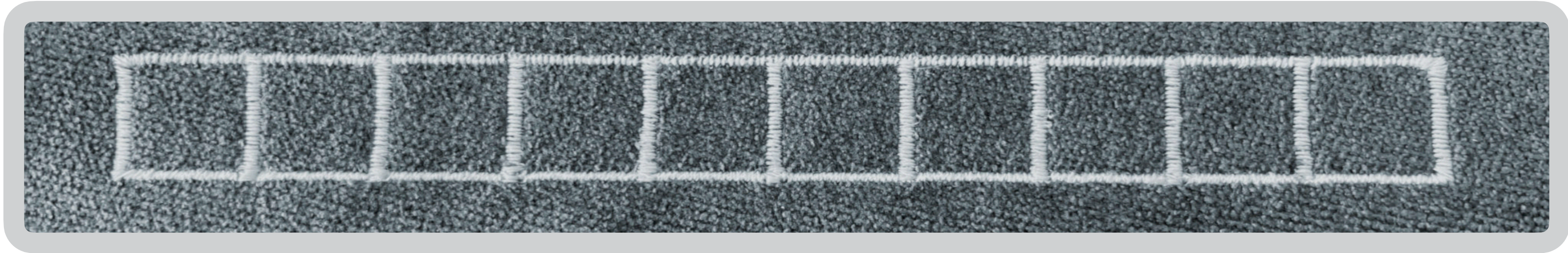
# Shapes: Rainbow

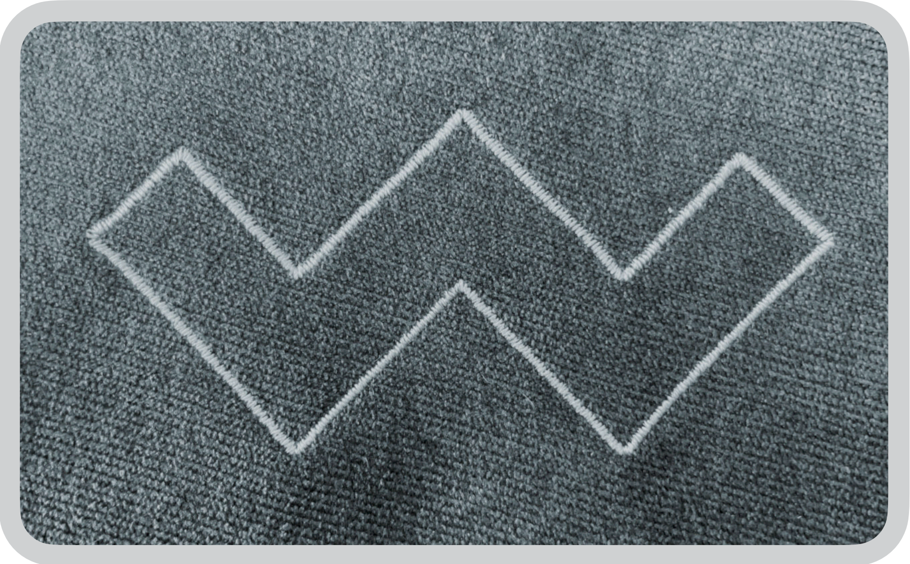


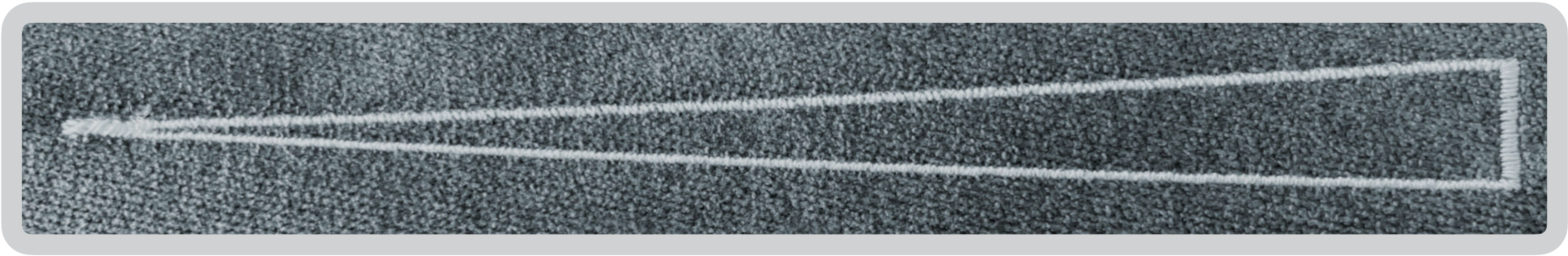


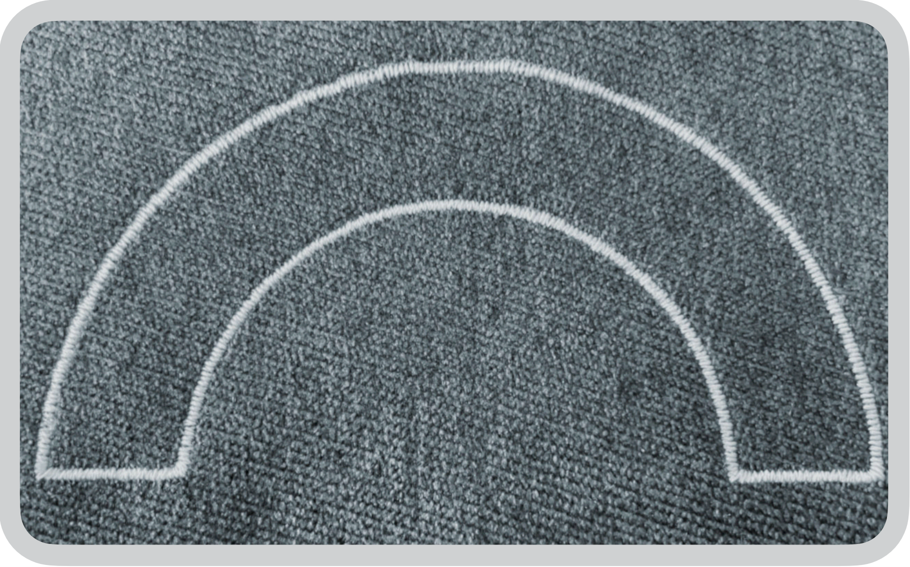
# Shapes: Horseshoe

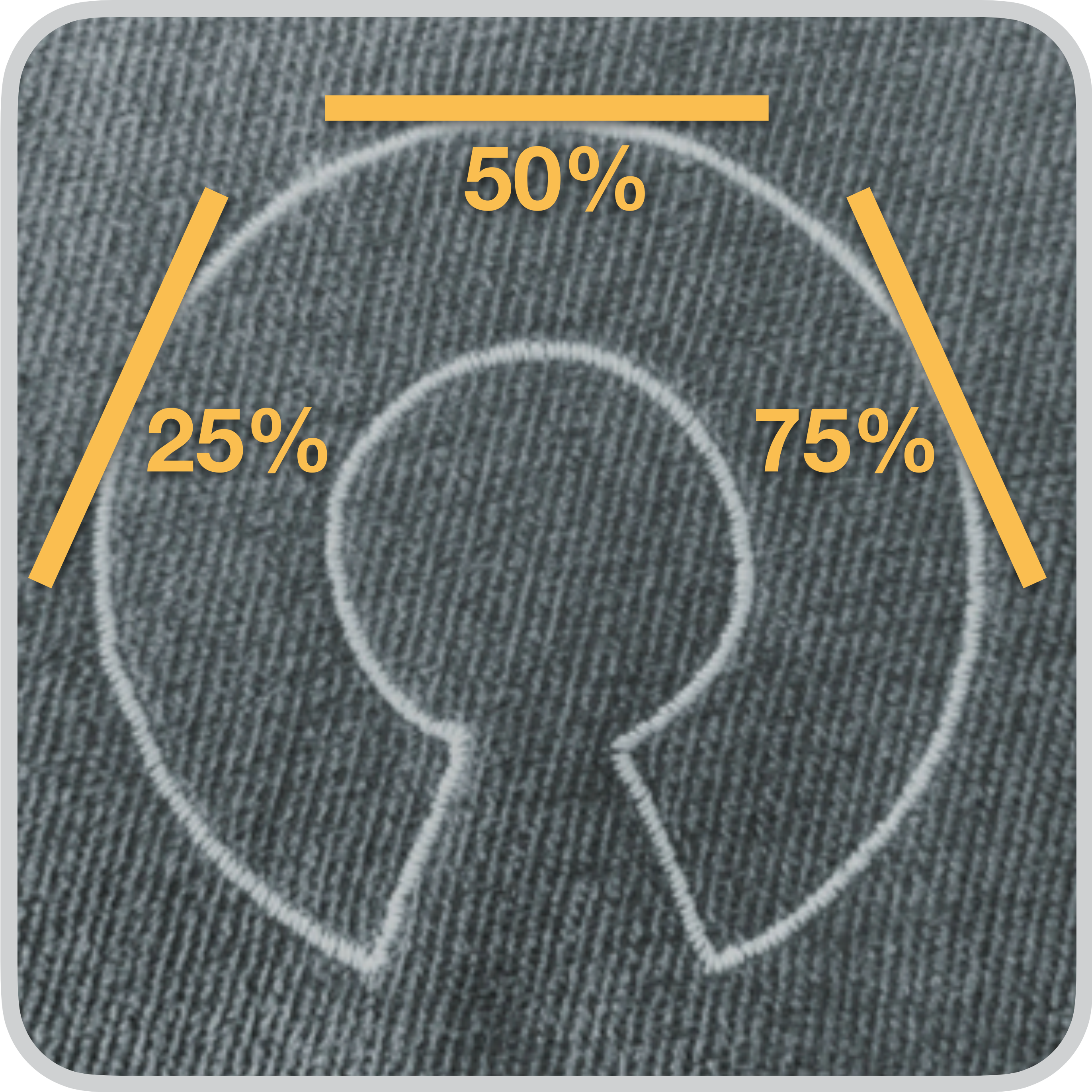






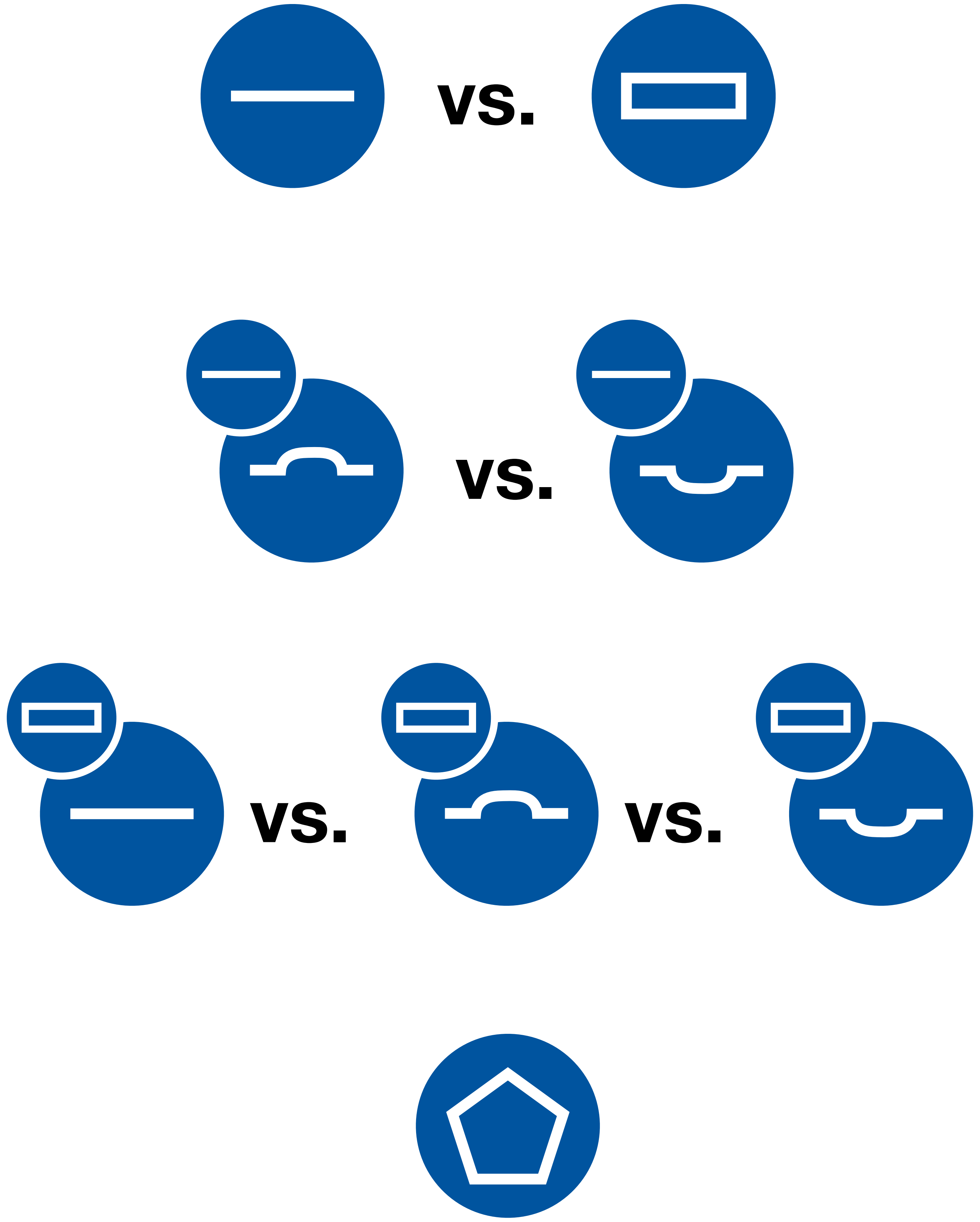




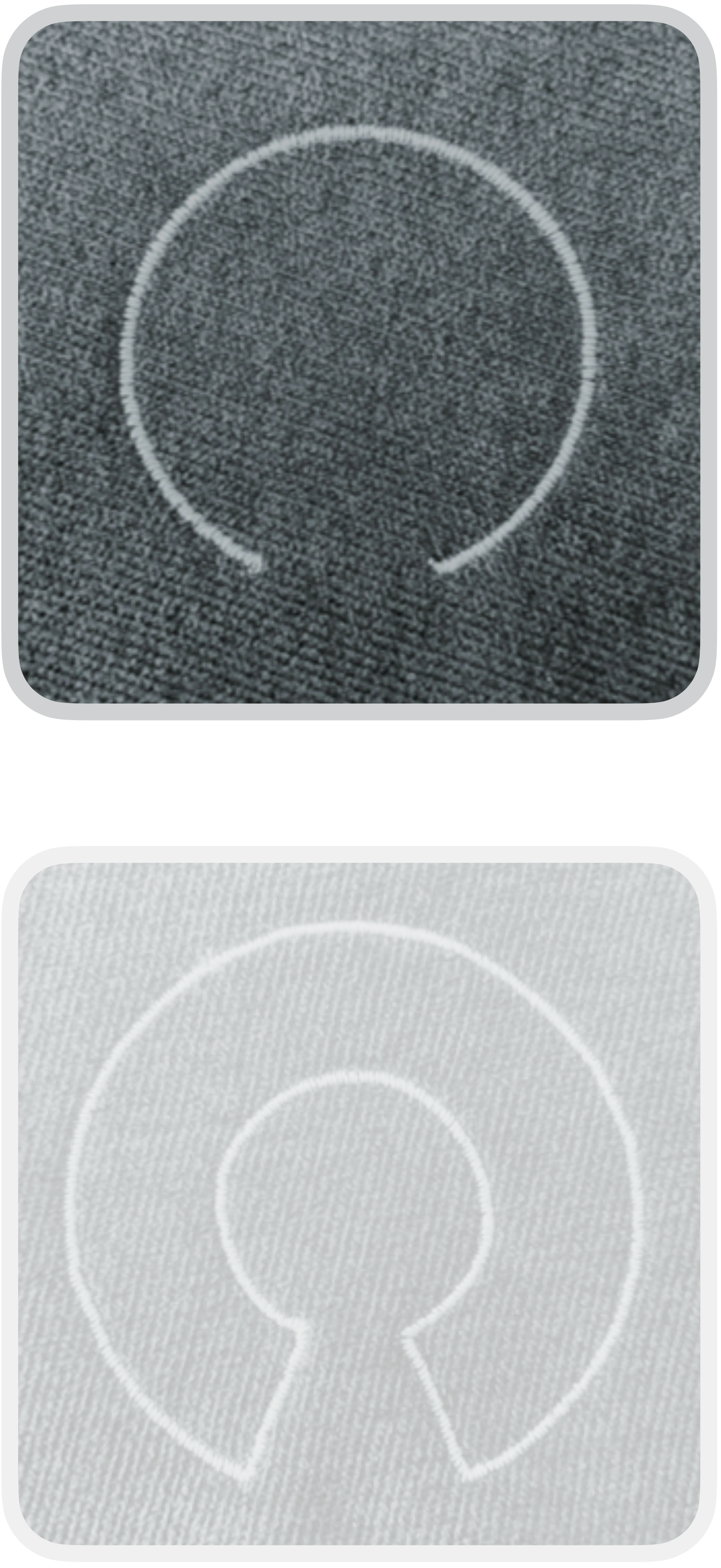


# User Study 1

20 participants
22-28 years old




# Use padding if possible



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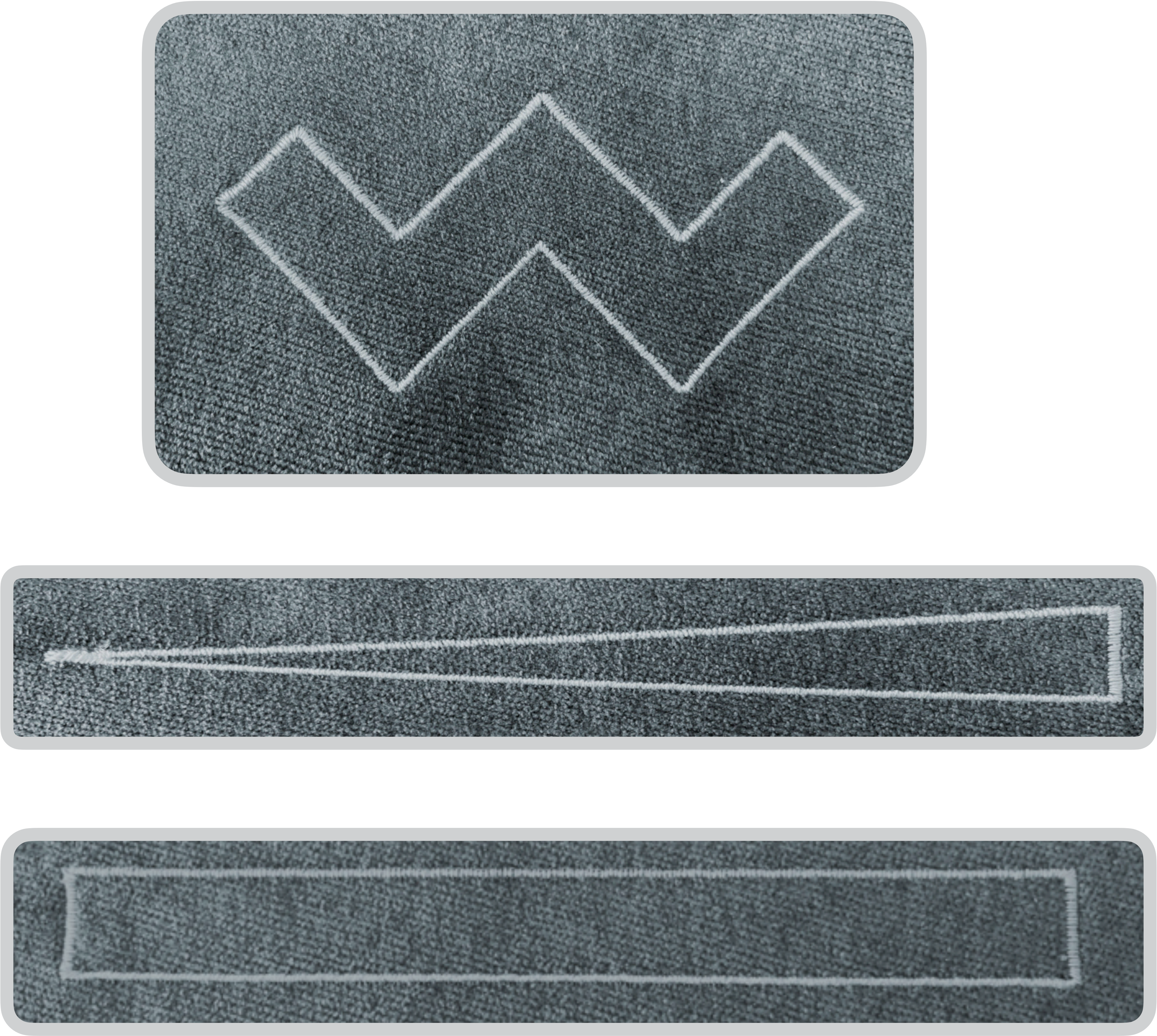
# Recessed sliders support sliding gestures

<

# Users preferred curved sliders and tick marks



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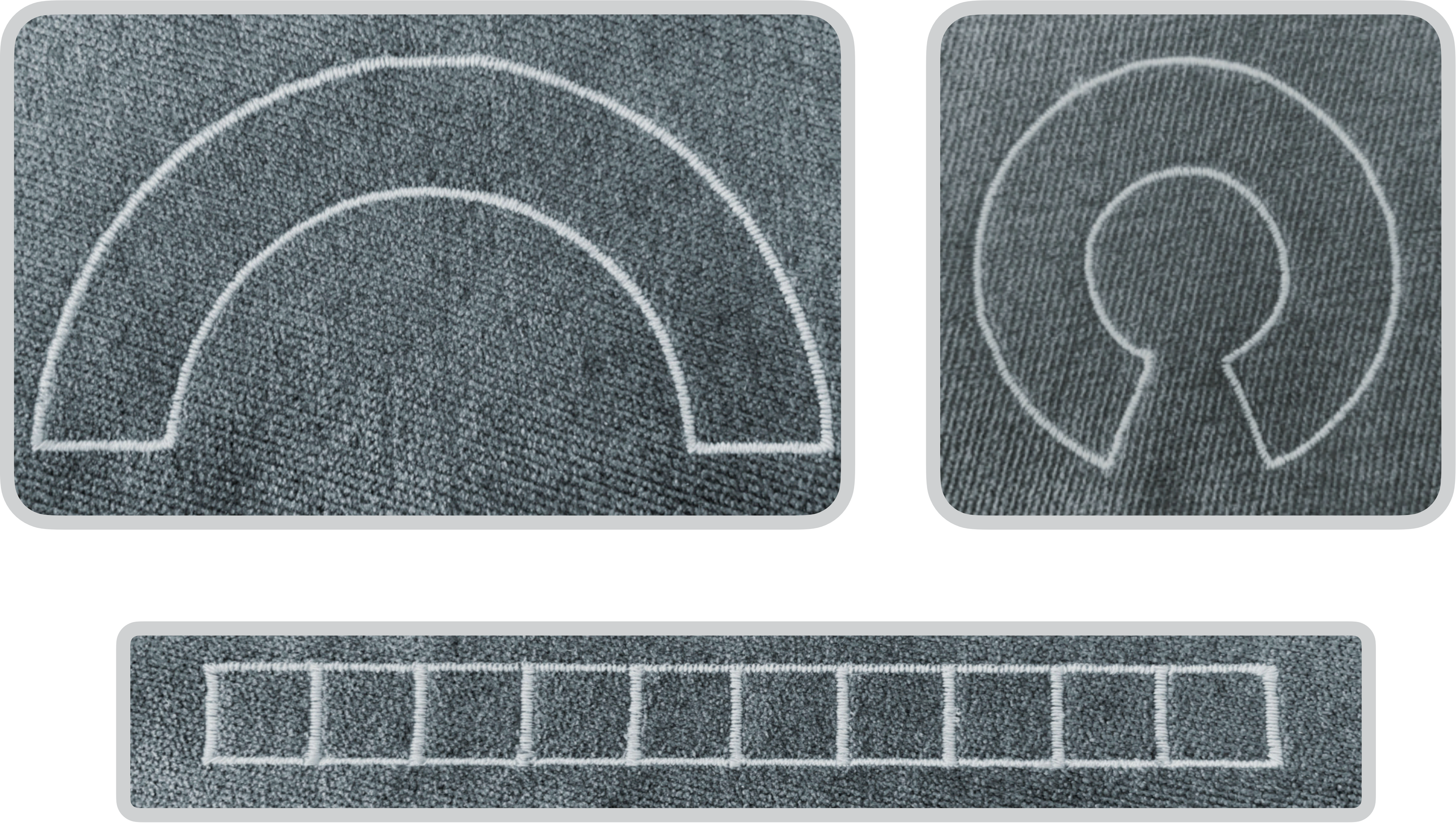


# User Study 2: Helping users orientating

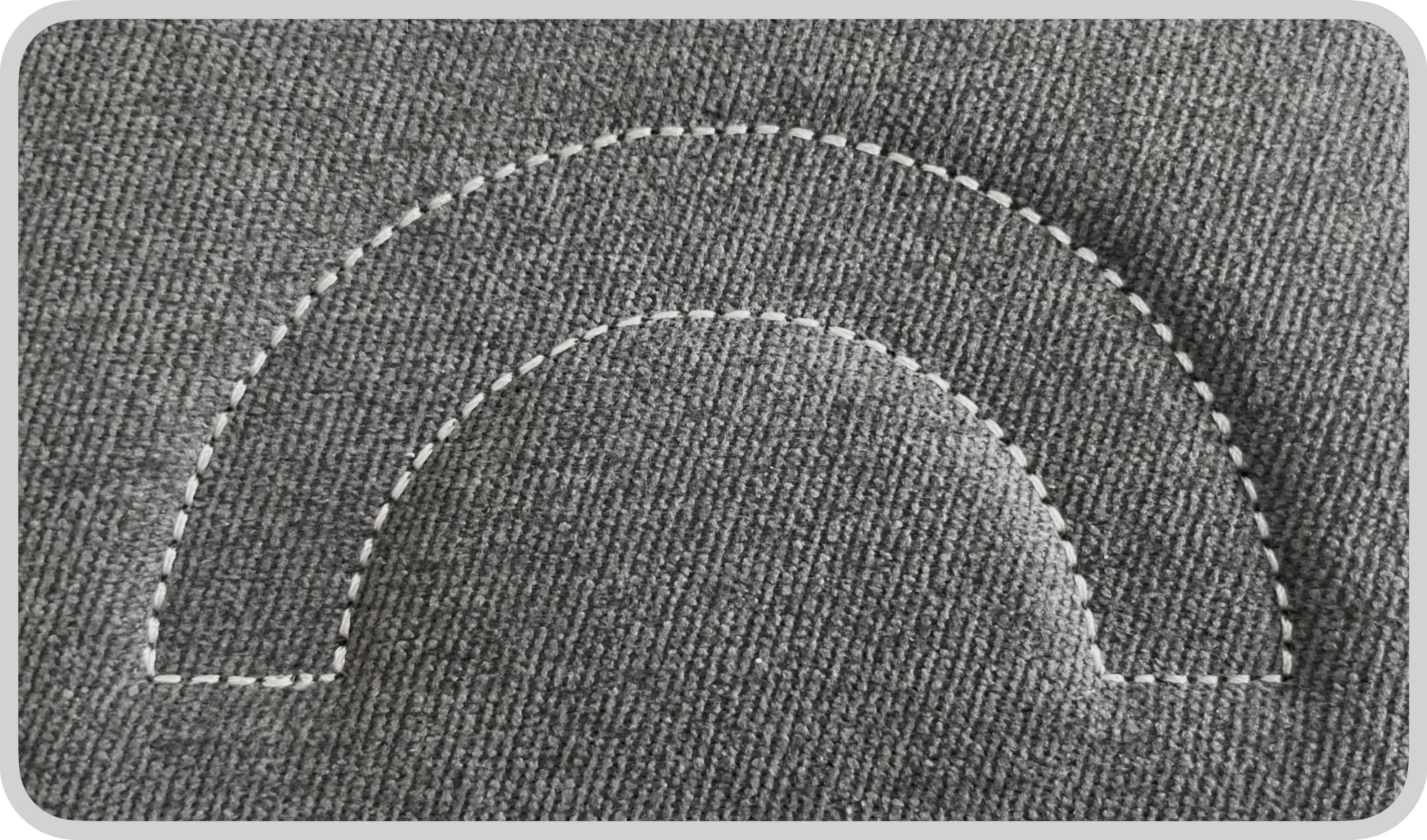
**20 participants**
22-30 years old

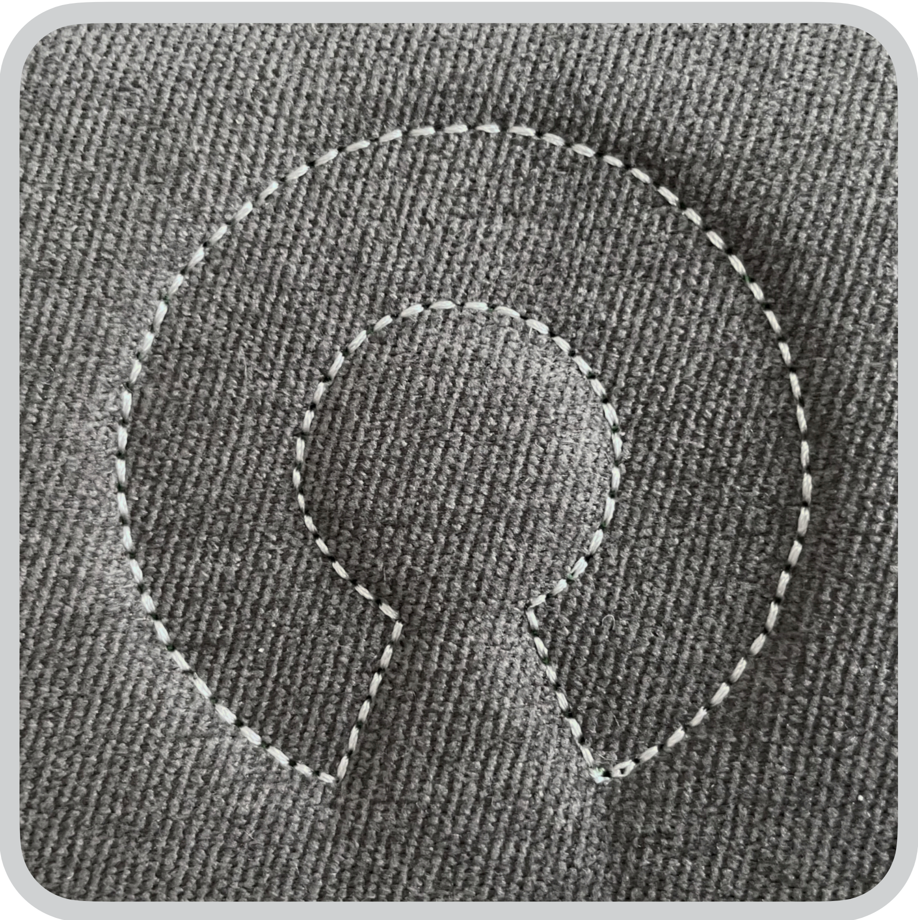
Selection task

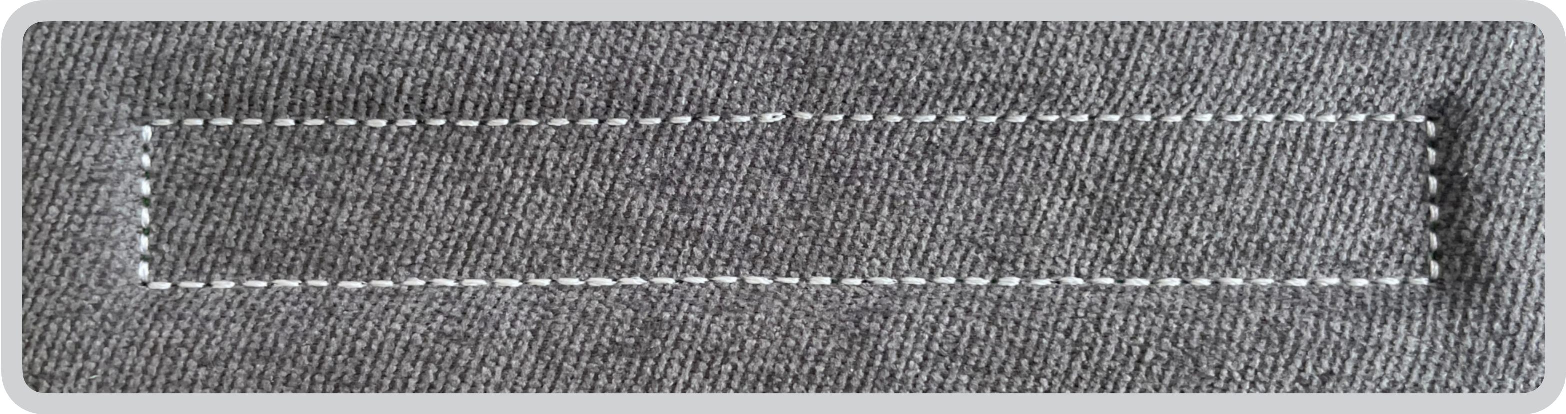
Estimation task

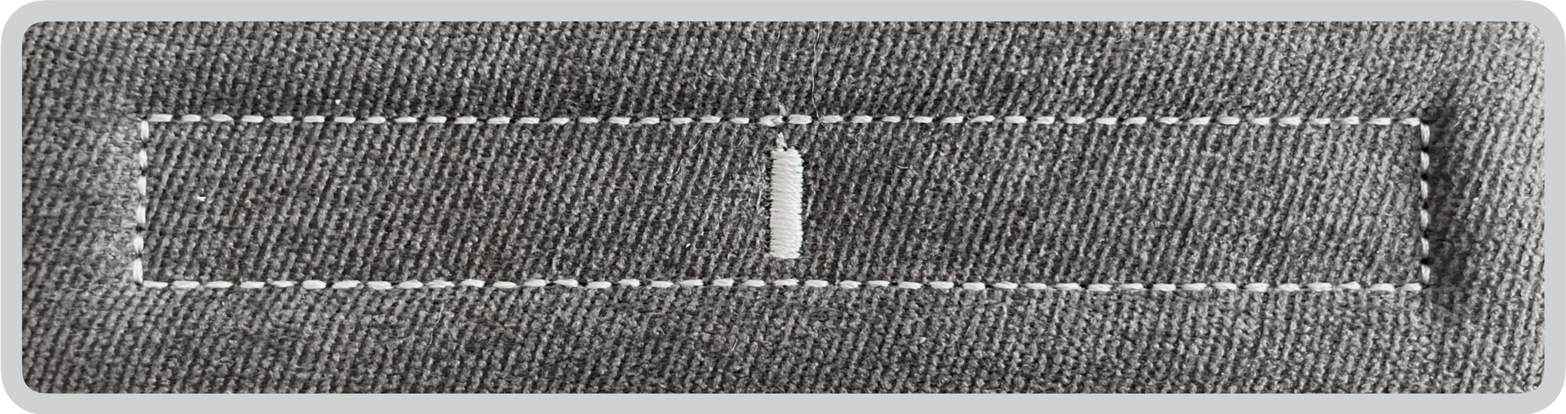
# Selection Task

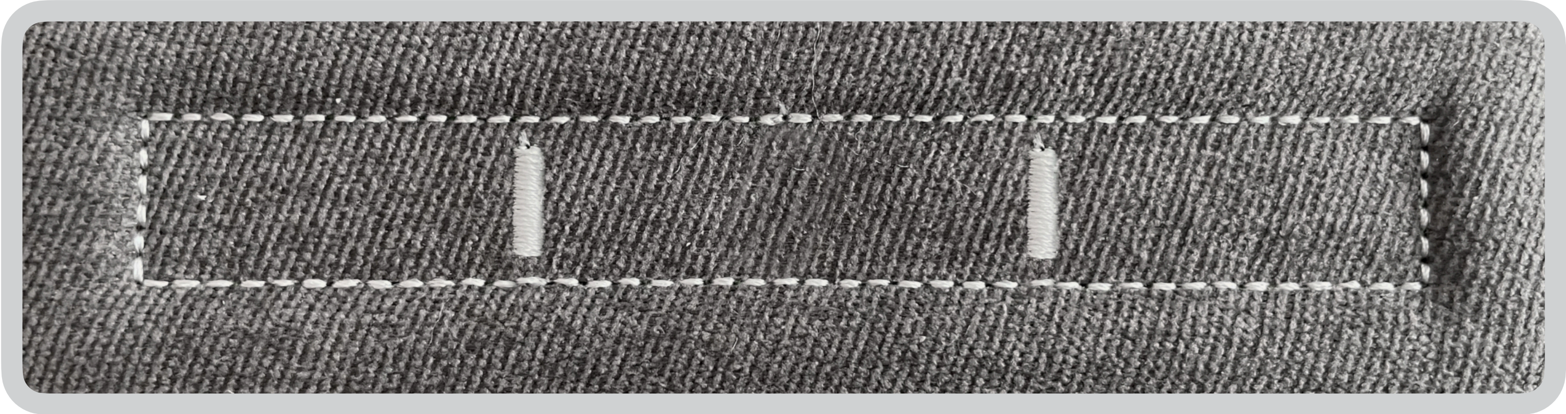
# Selection Task: Sliders

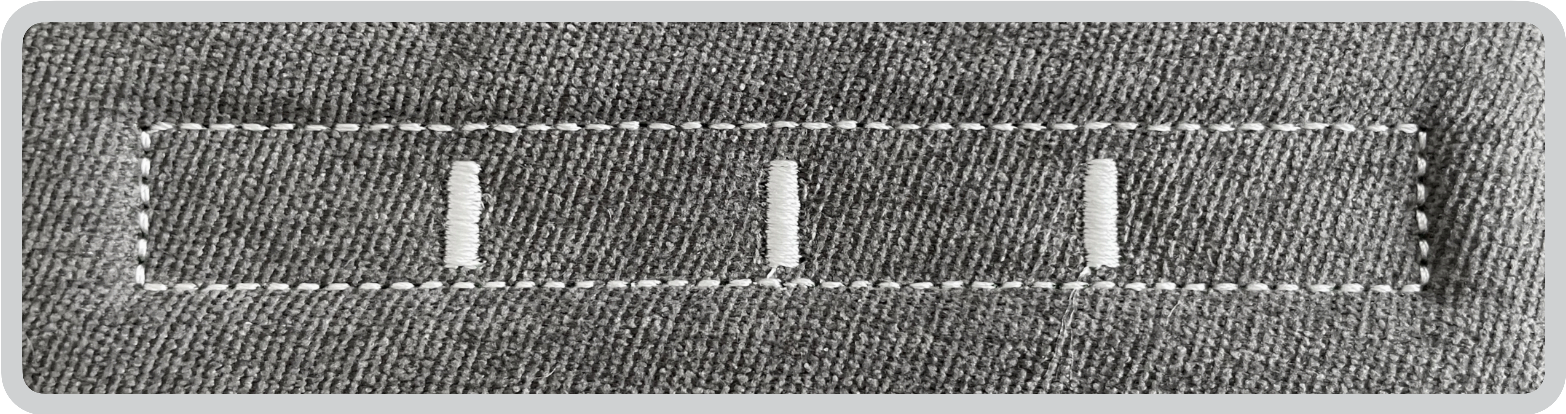


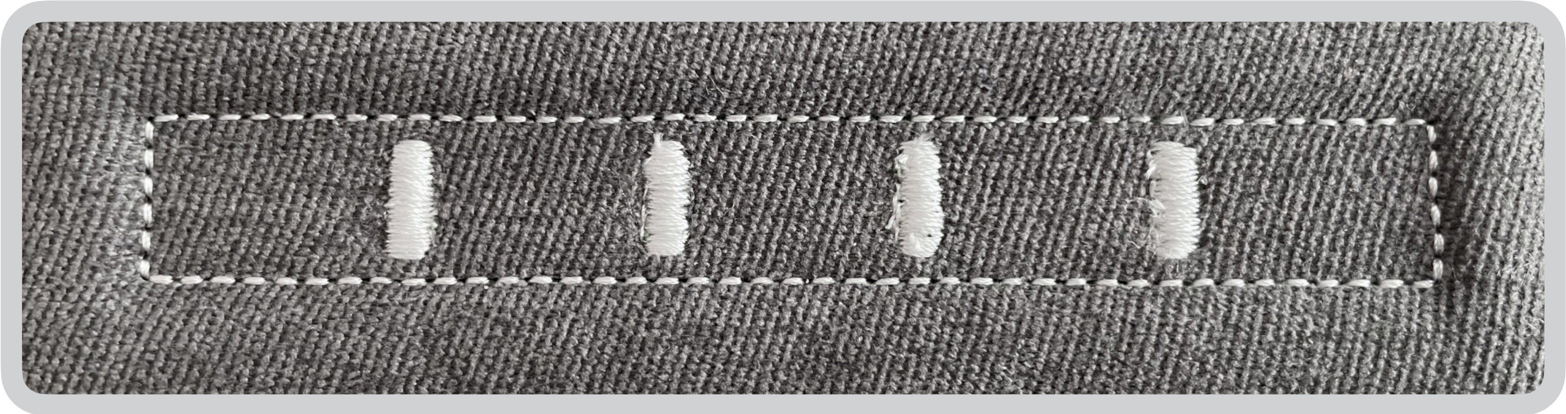


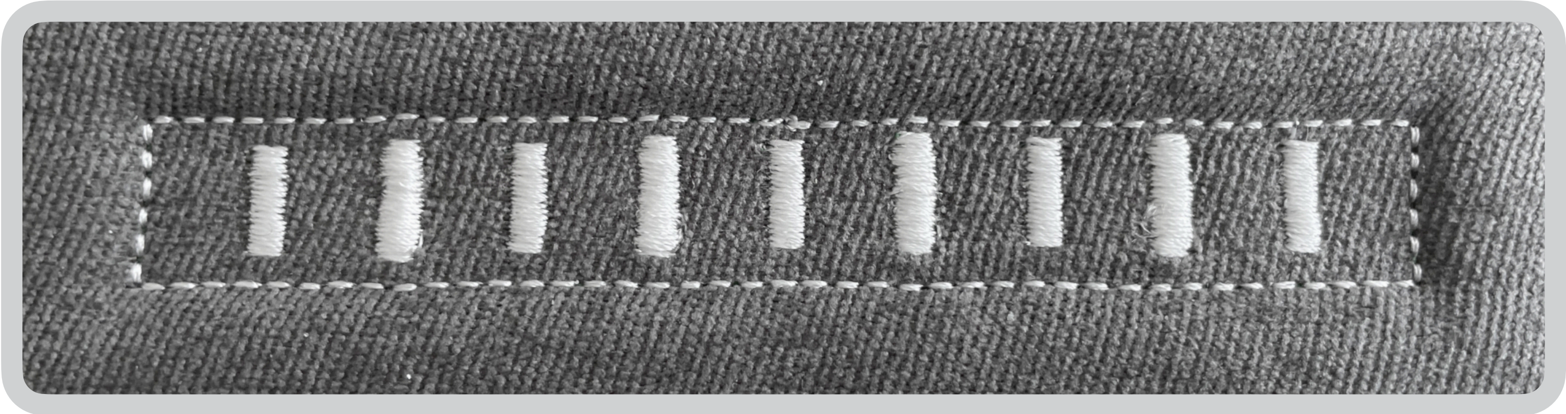




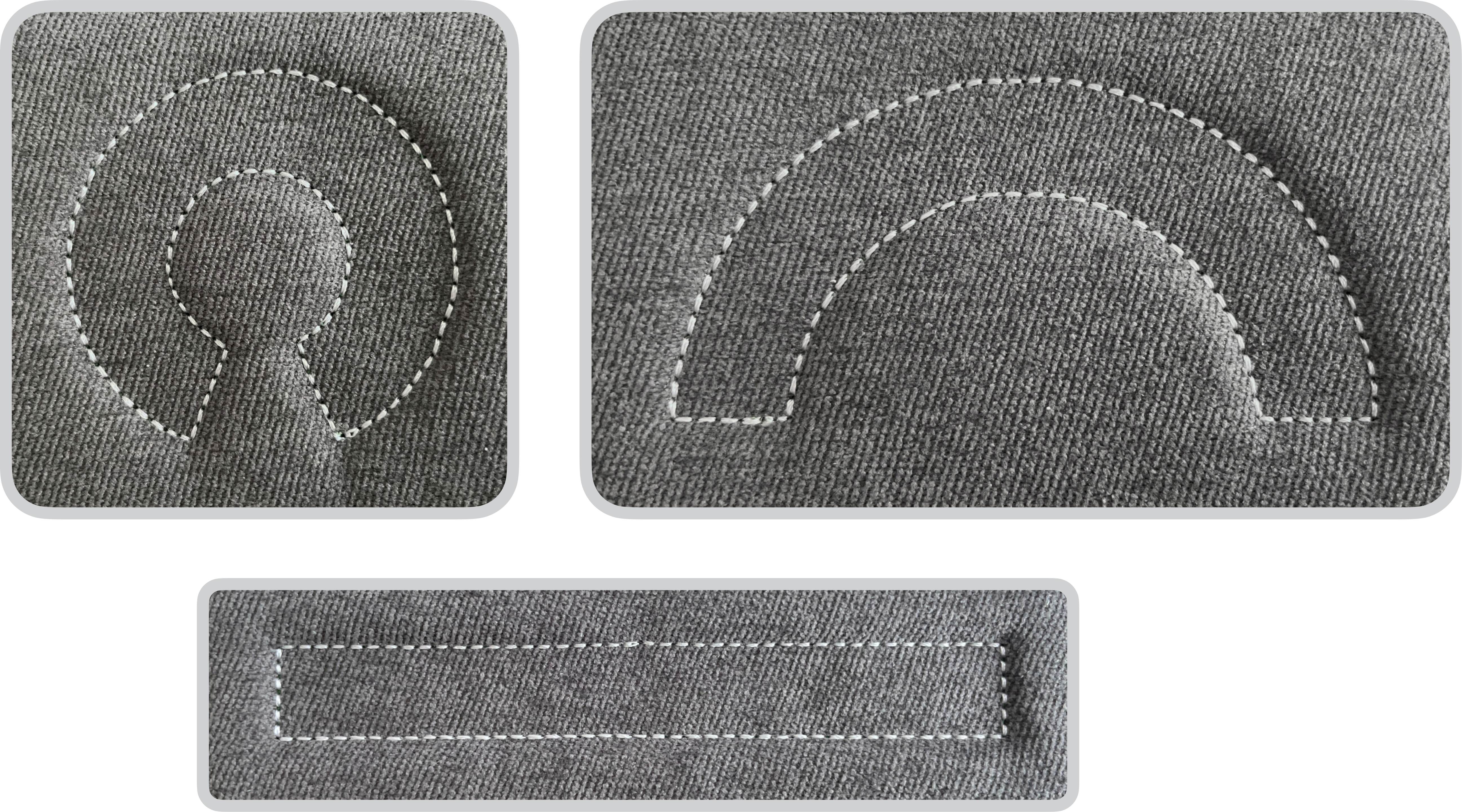








# 20% & 25% steps improve selection accuracy



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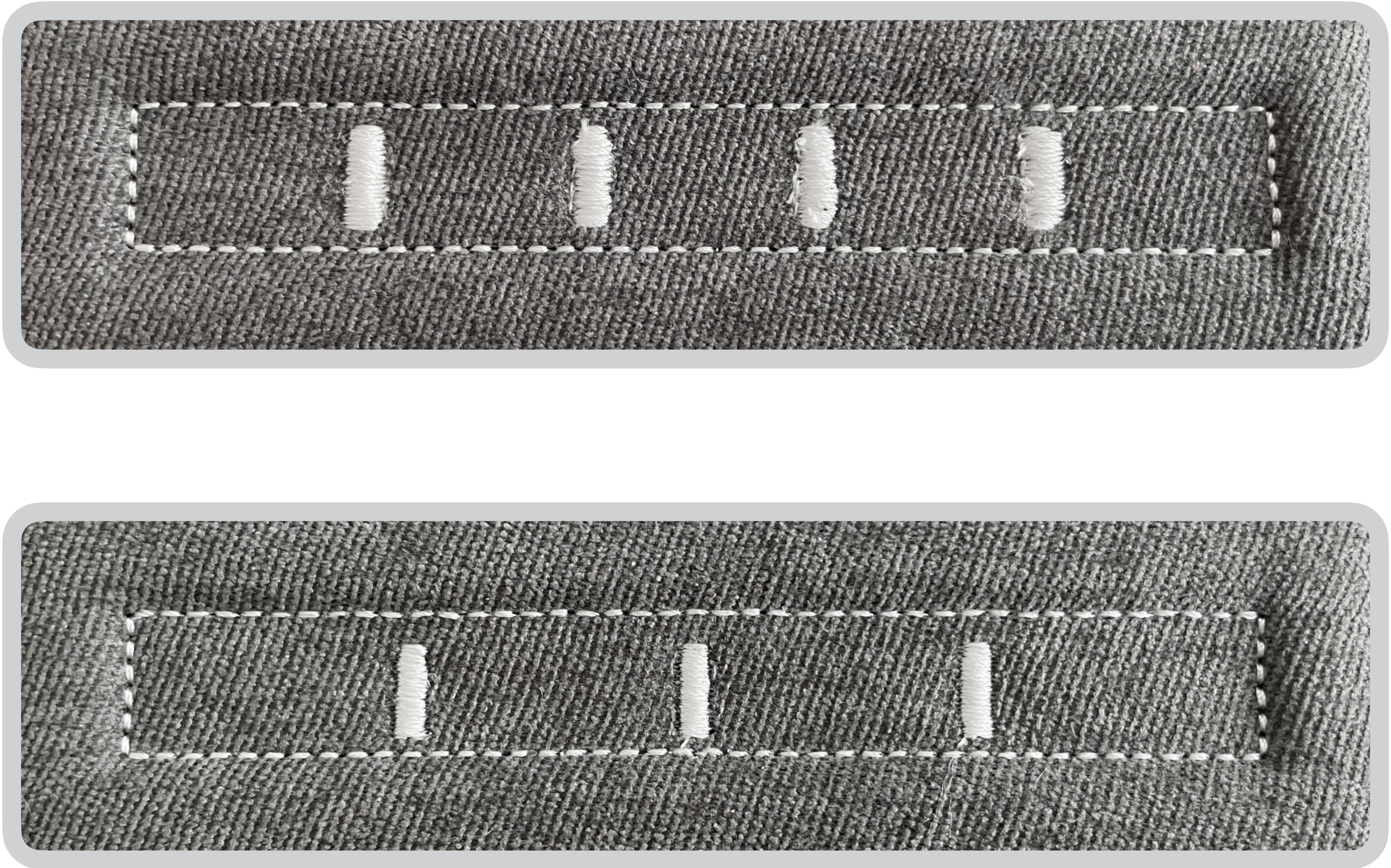
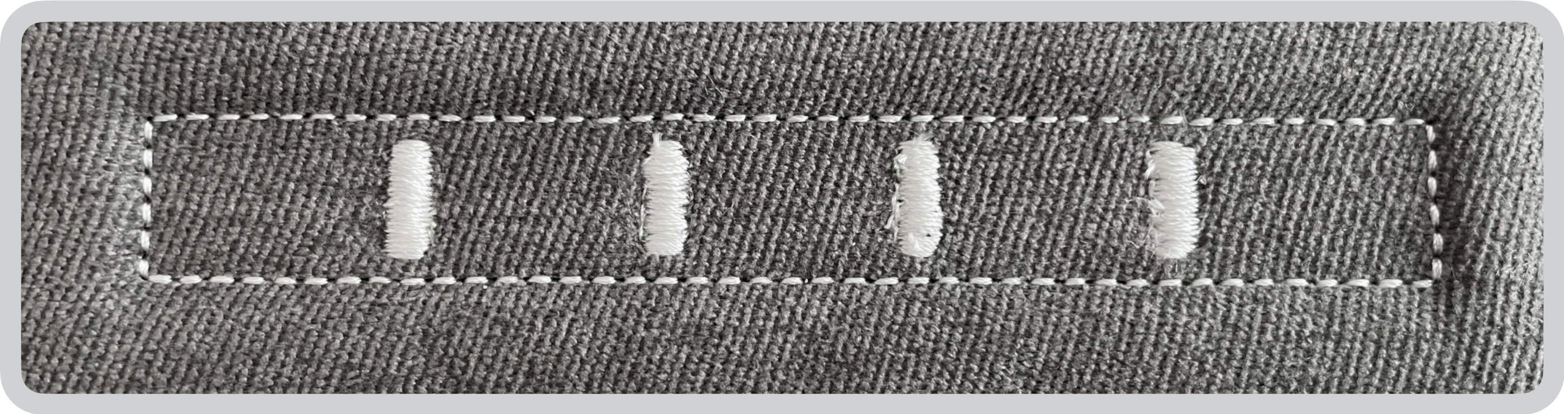


# 25% steps improve selection speed



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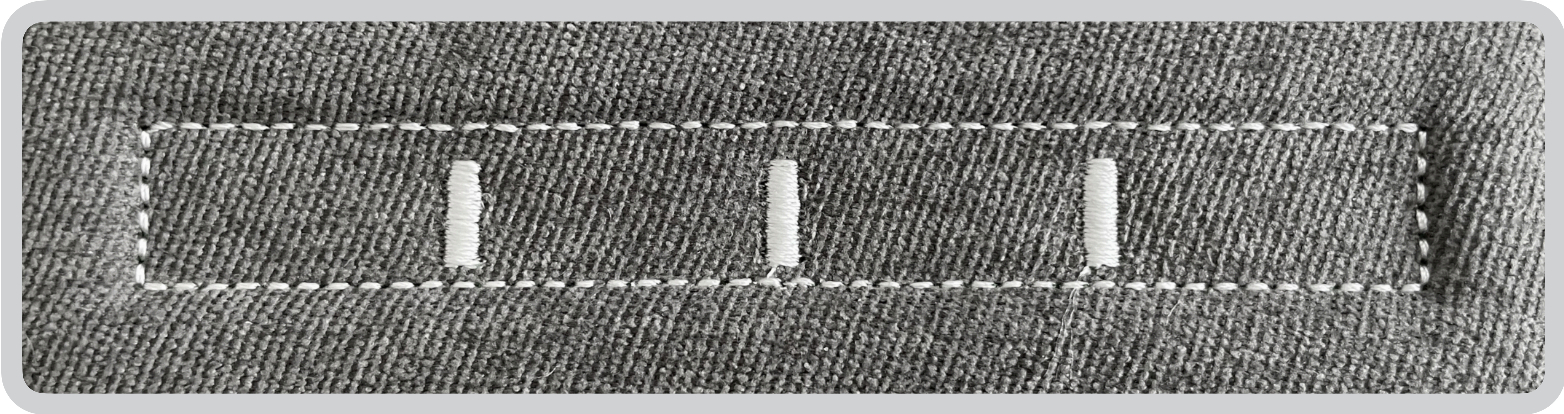
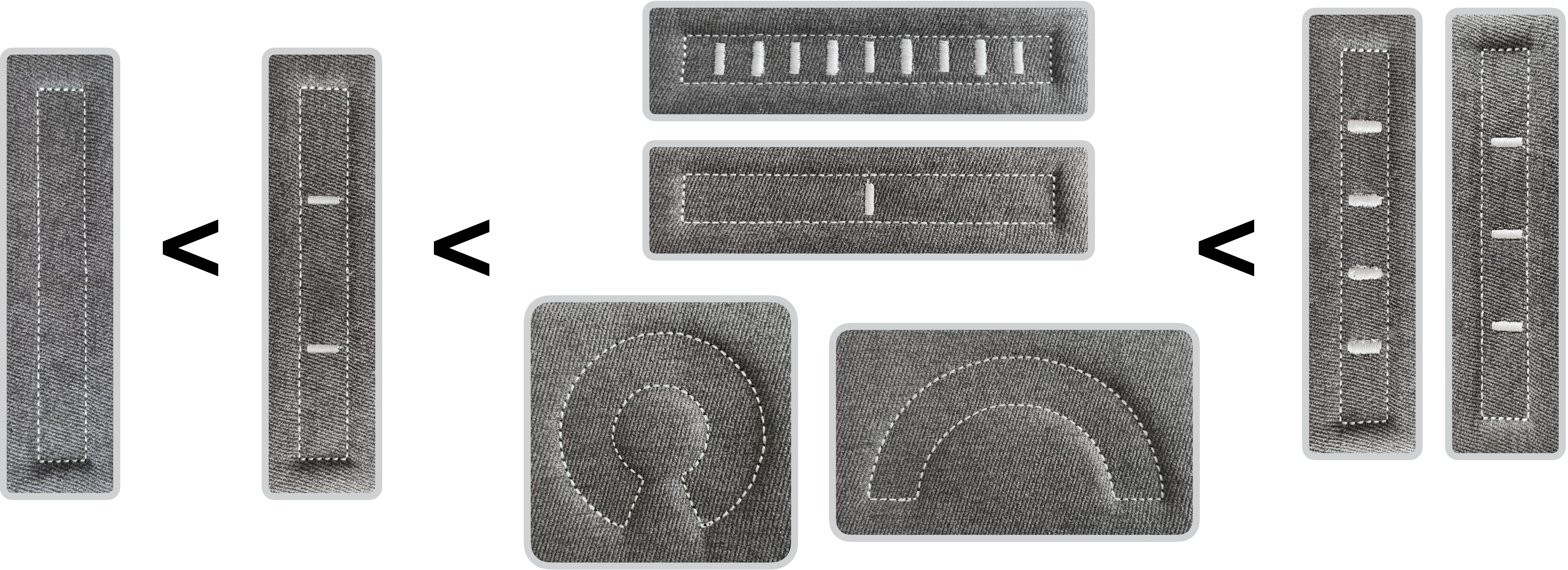
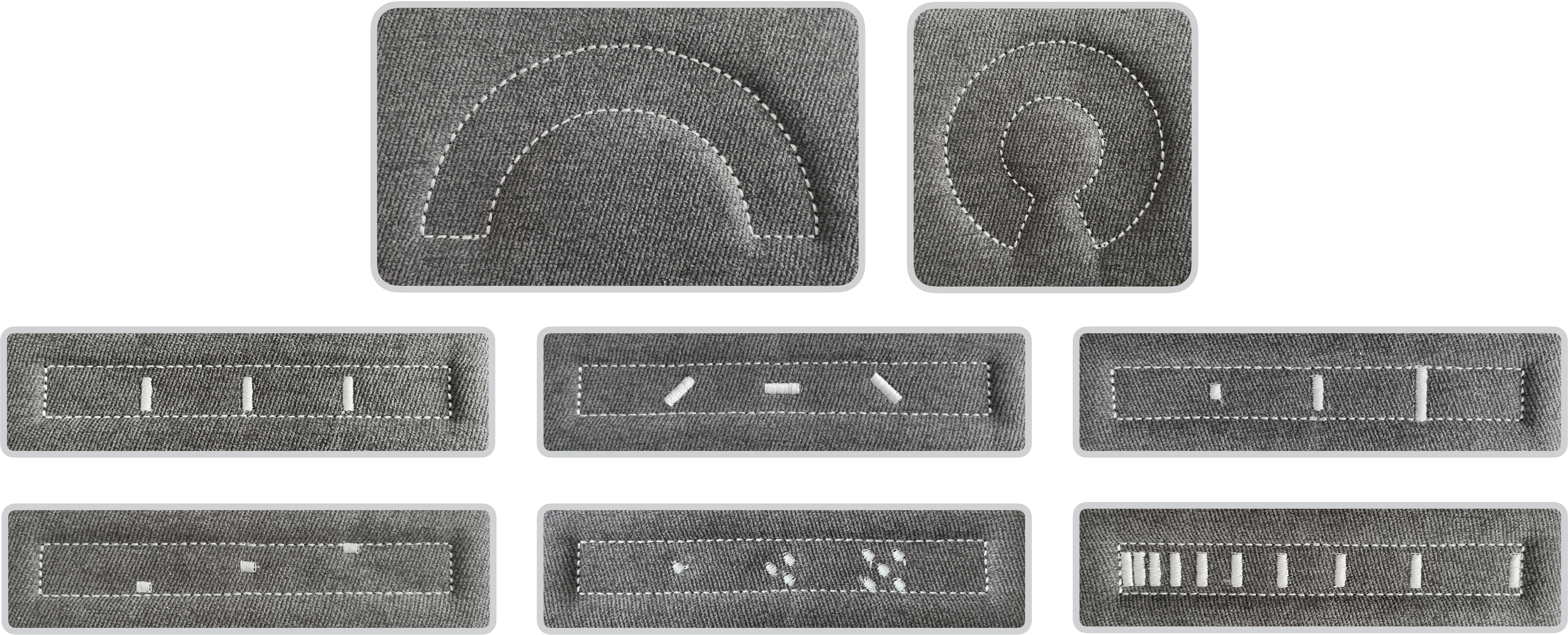


# Any additional orientation help was appreciated



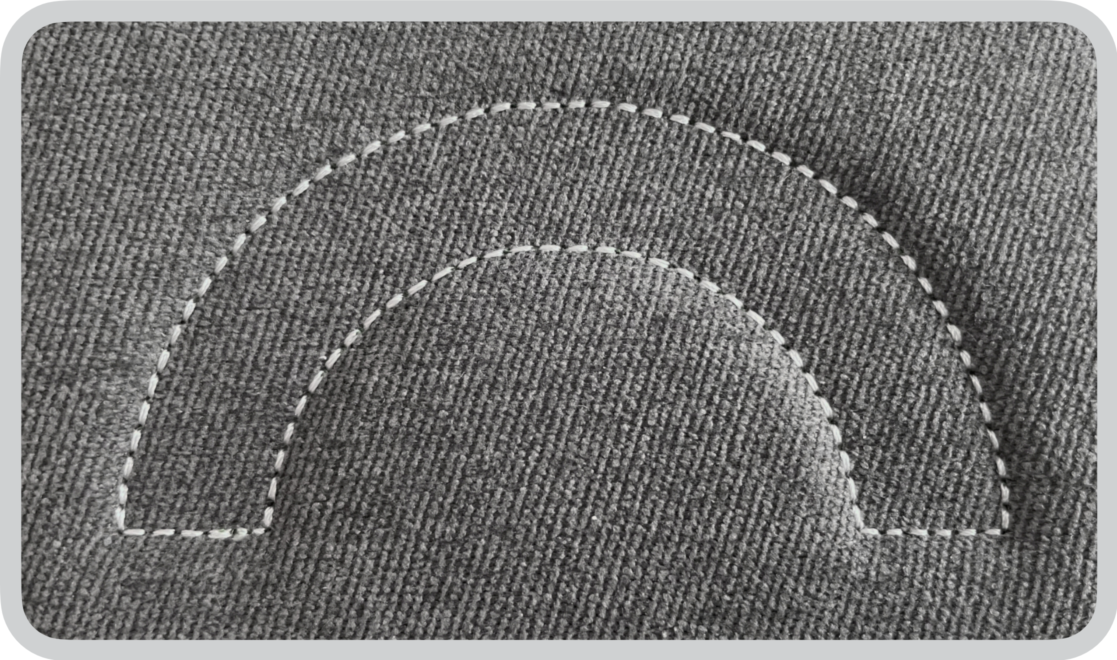
# Estimation Task: Sliders

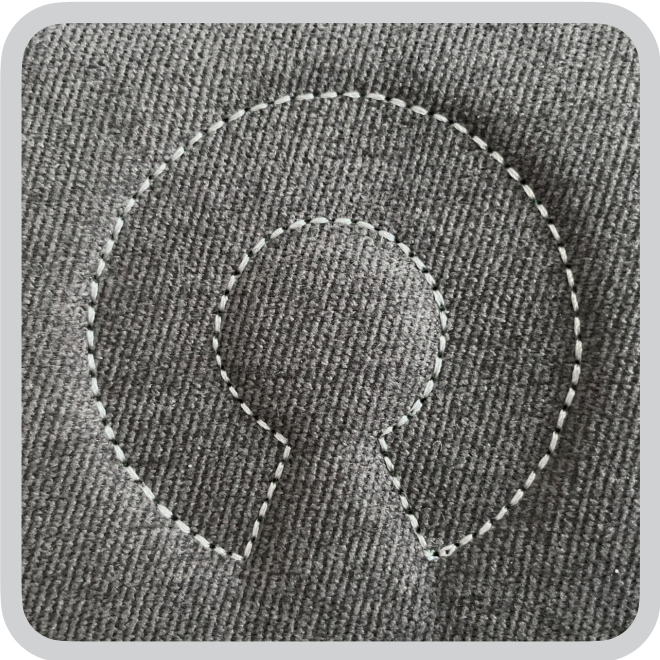


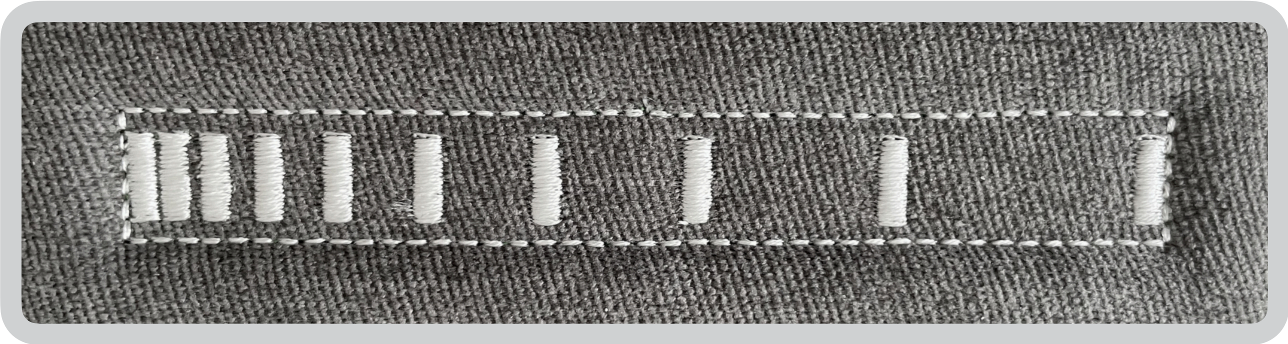
# Estimation Task

- Estimate as fast as possible
- As little movement as possible
  - Increases internal validity

# Equidistant ticks improve the estimation







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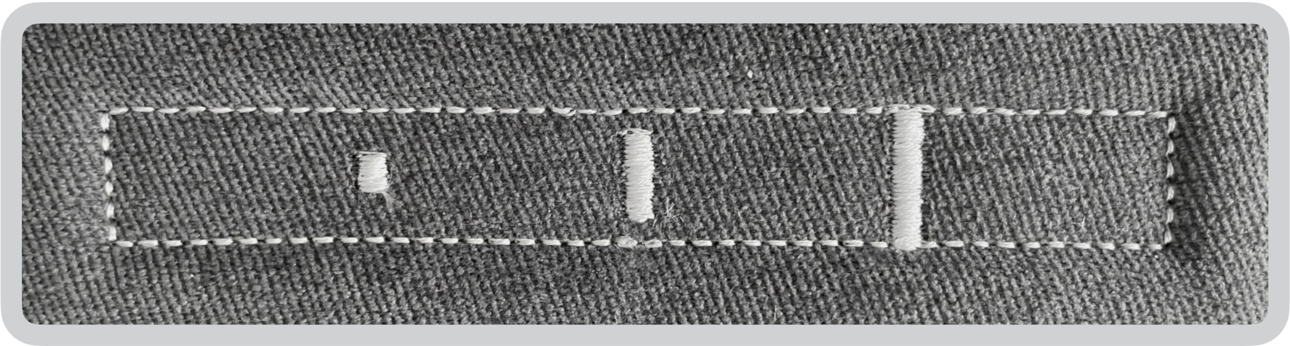
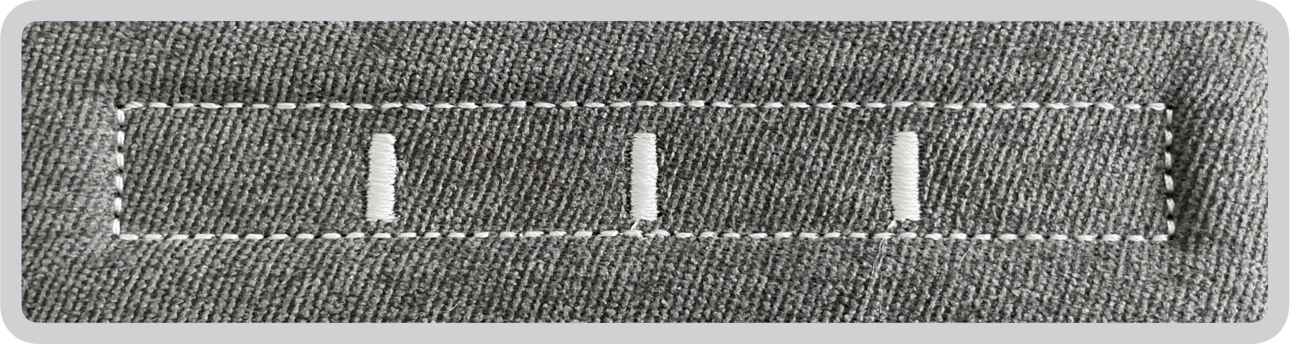
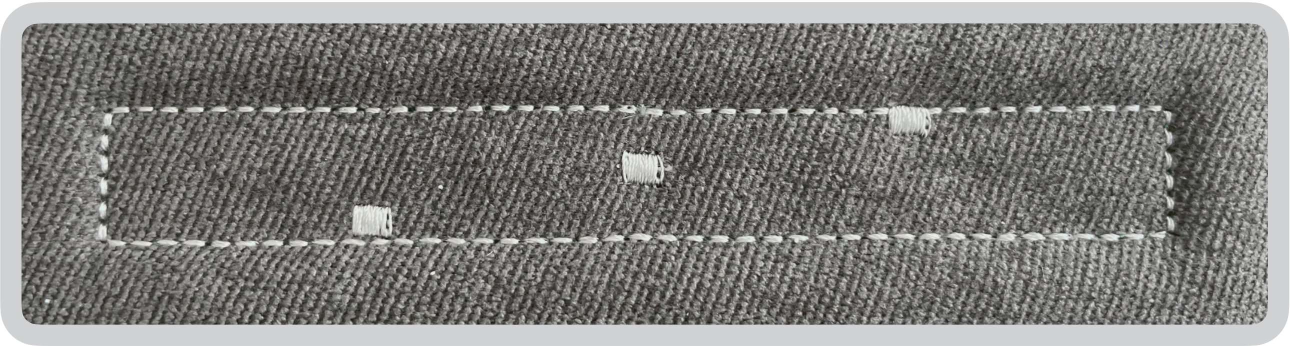
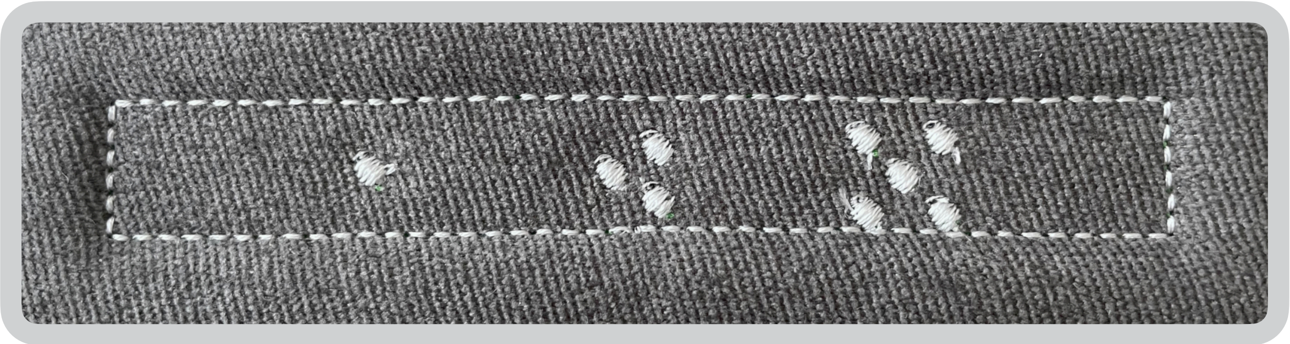
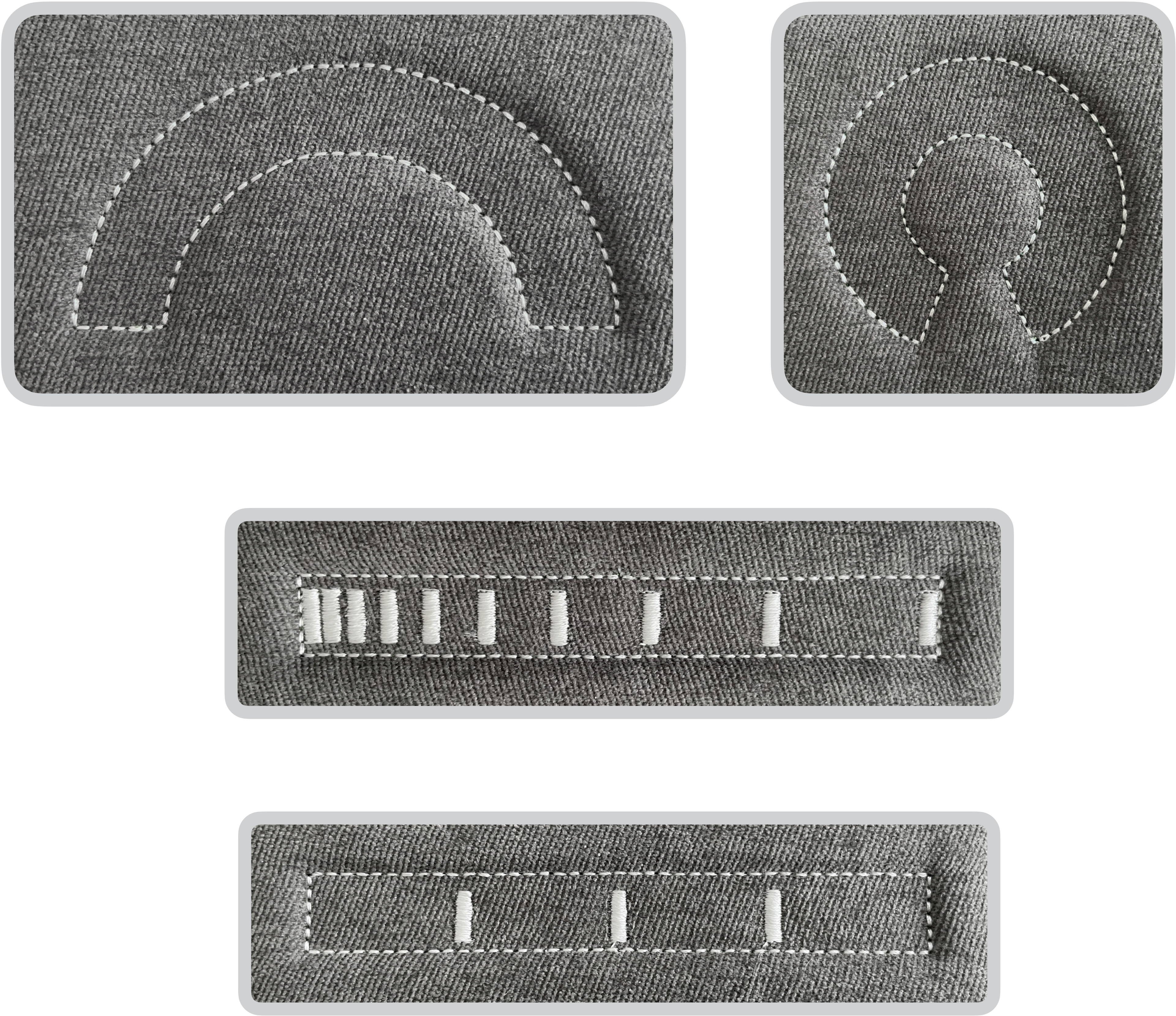








# Equidistant, varying tick marks reduce estimation movements



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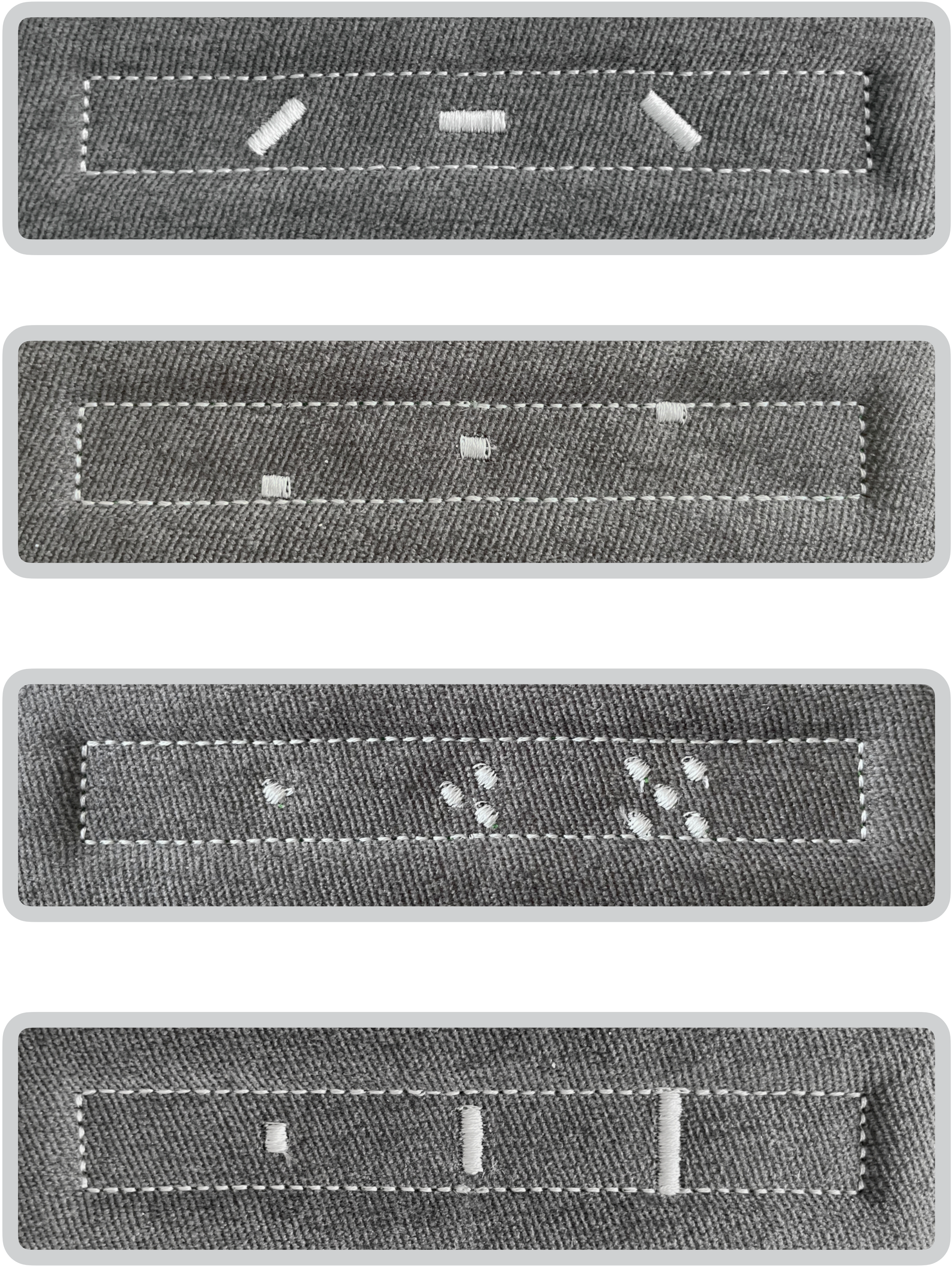
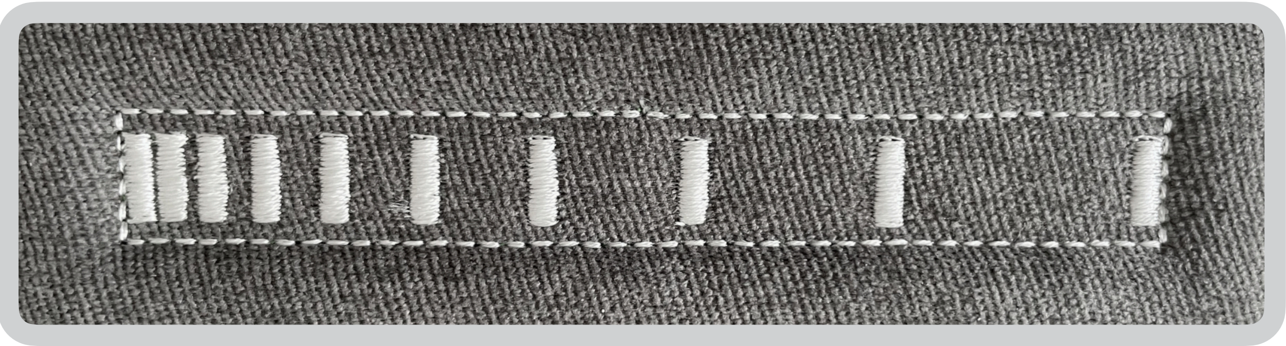


# Equidistant, varying ticks were preferred



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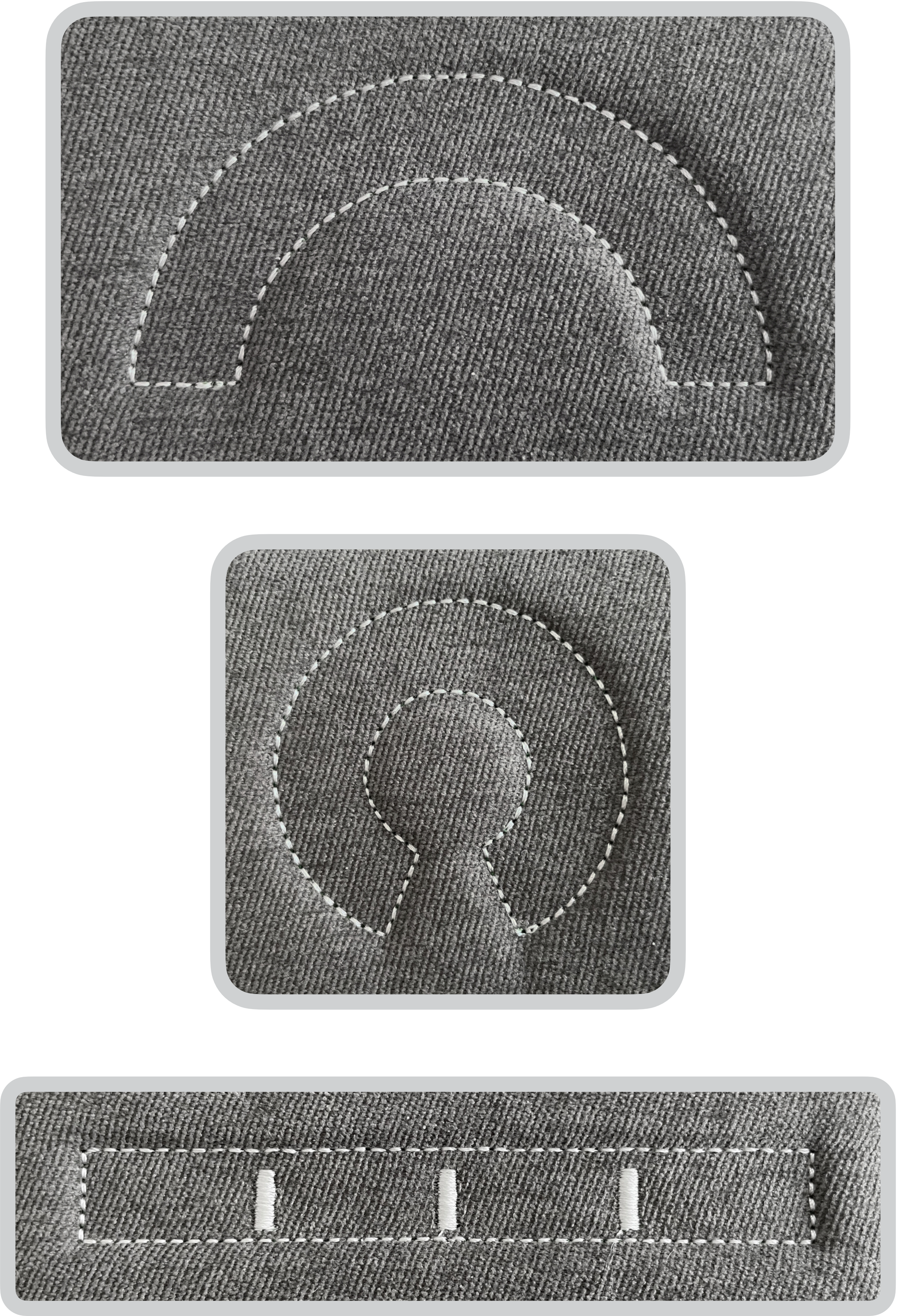

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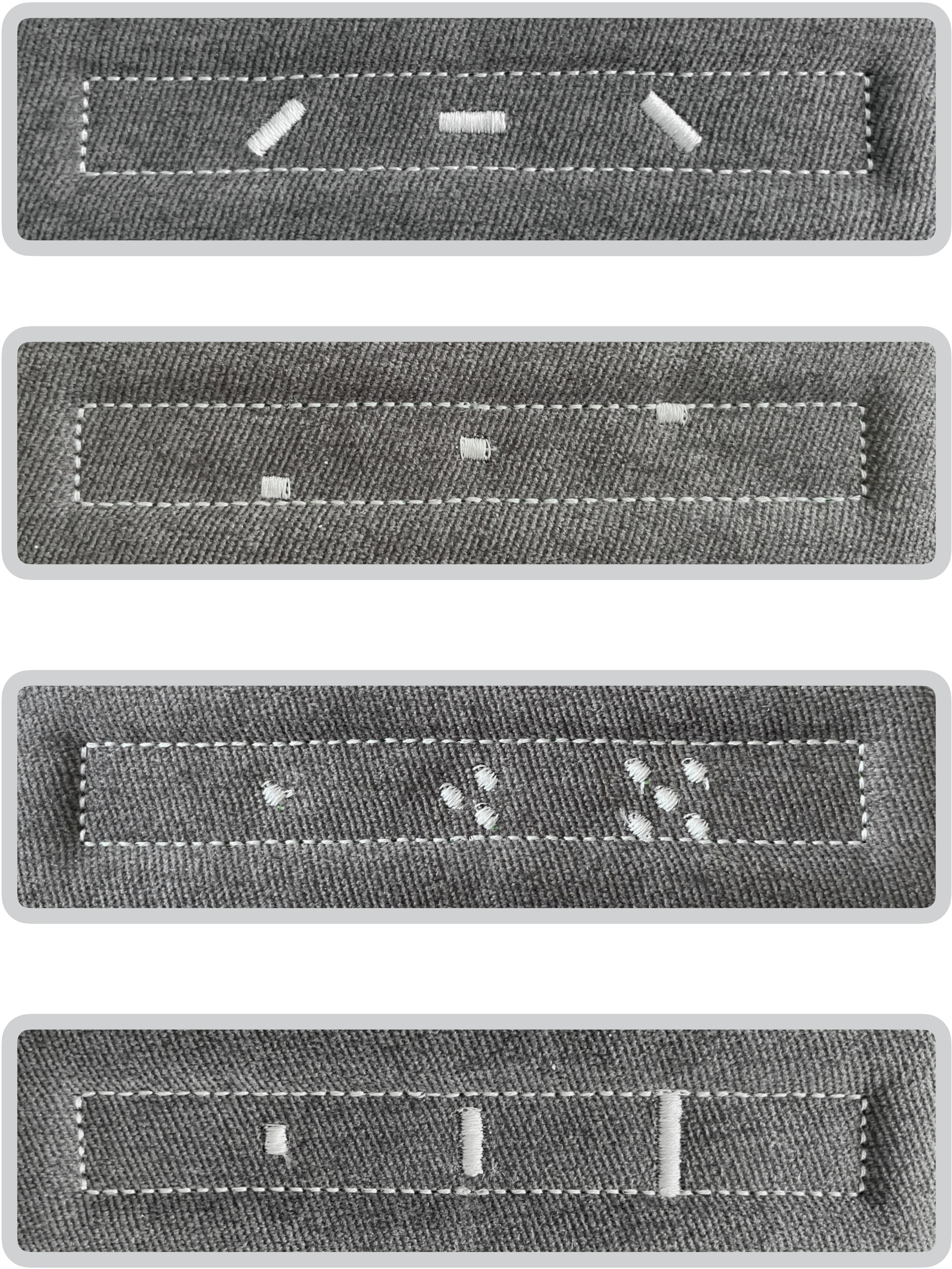


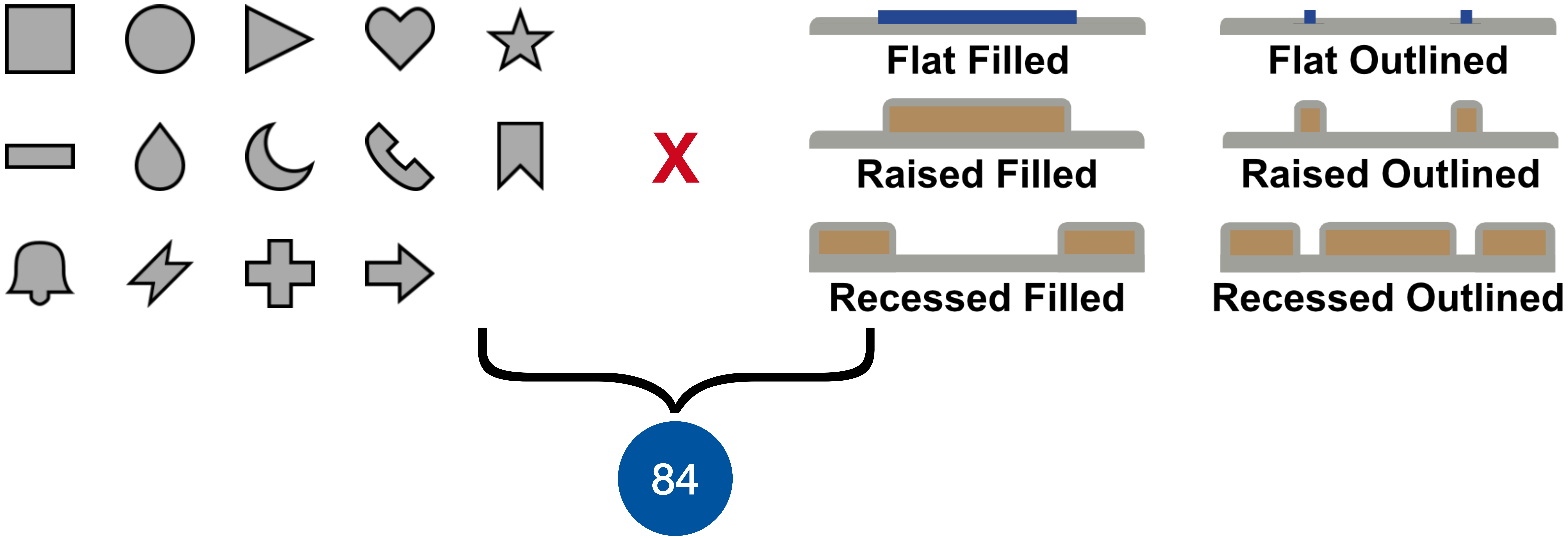
# How to Design Textile Icons?

## What's That Shape?

Schäfer et al., CHI ‘23

# Icon Set

**14 closed shapes** **6 fabrication variants**



Flat Outlined

Flat Filled

Raised Filled

Recessed Filled

Raised Outlined

Recessed Outlined

# User Study

- How well can people recognise the icons without looking?
- We measured:
  - Recognition time
  - Correct, and wrong recognitions
  - Questionnaire data including Likert scales

# Results

Raised Filled

Raised Outlined

Recessed Filled

Recessed Outlined

Flat Outlined

Flat Filled

>92%

~7s

>90%

~7s

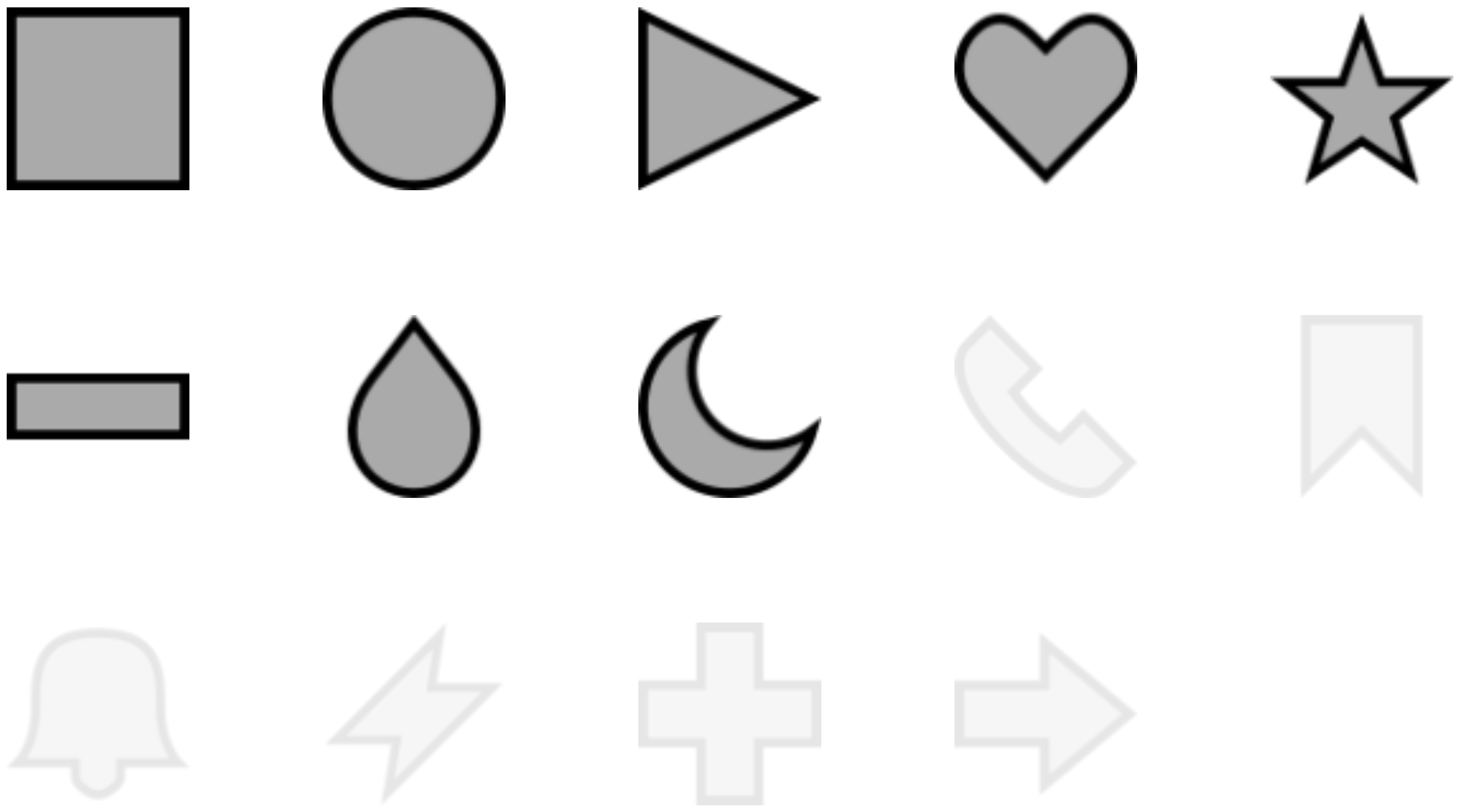
>79%

~9s

<60%

>14s

# Results



> **95% for both raised conditions**

# Results

**100% for both raised conditions (and recessed filled)**

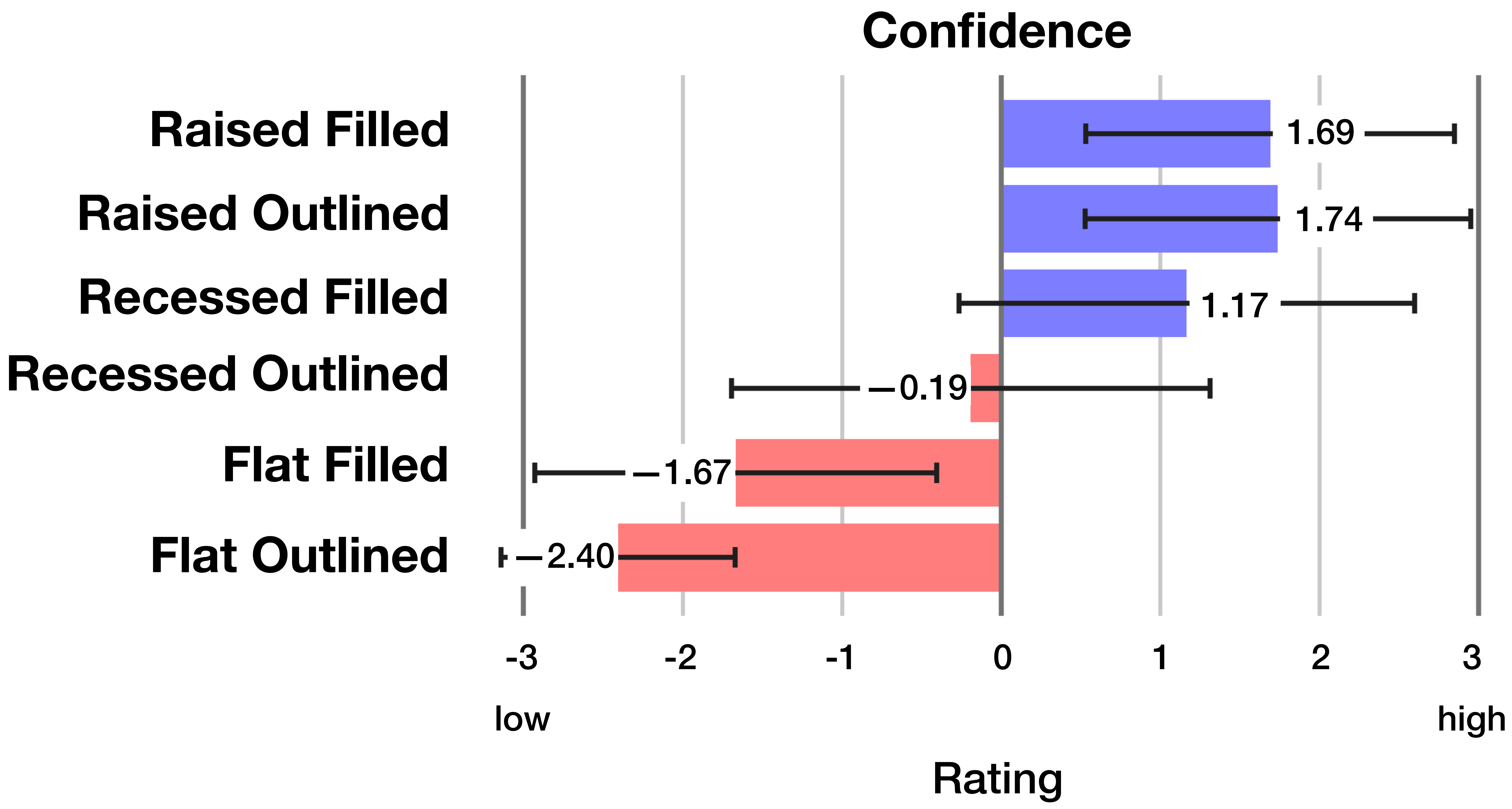
# Results

**Few recognitions**
**Many confusions**

# Results

- Mental demand
- Comfort
- Rough shape recognition
- Detail shape recognition
- Recognition confidence
- Distinguishability from the underlying fabric

# Results



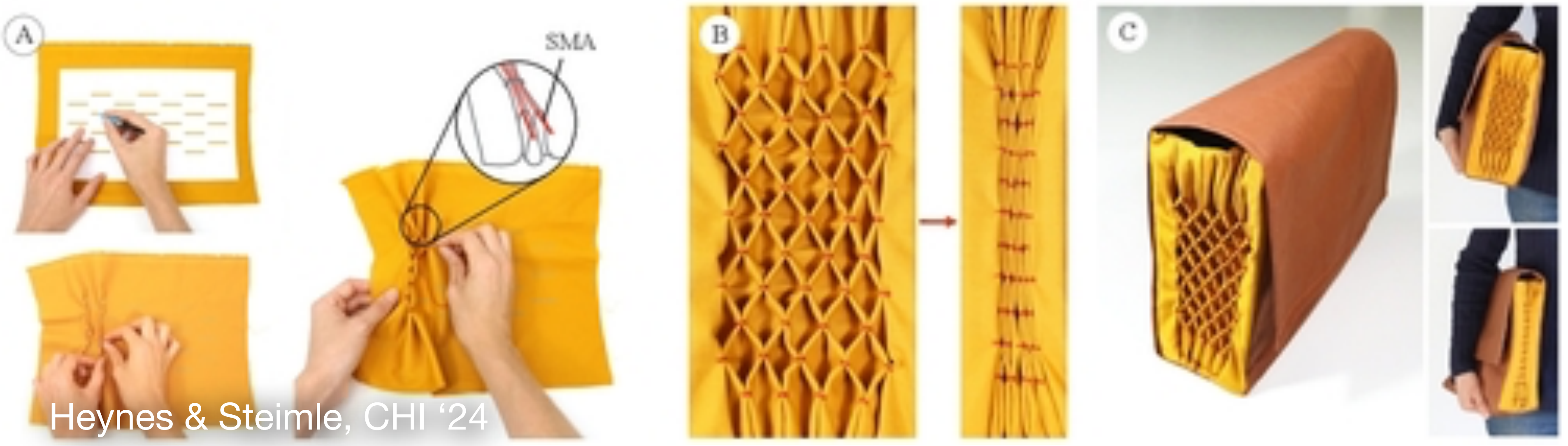
Confidence
Raised Filled
Raised Outlined
Recessed Filled
Recessed Outlined
Flat Filled
Flat Outlined
1.69
1.74
1.17
−0.19
−1.67
−2.40
-3
-2
-1
0
1
2
3
low
high
Rating

# Results


Raised Filled
Raised Outlined
Recessed Filled
>
Recessed Outlined
>
Flat Outlined
Flat Filled

# Continuing Research

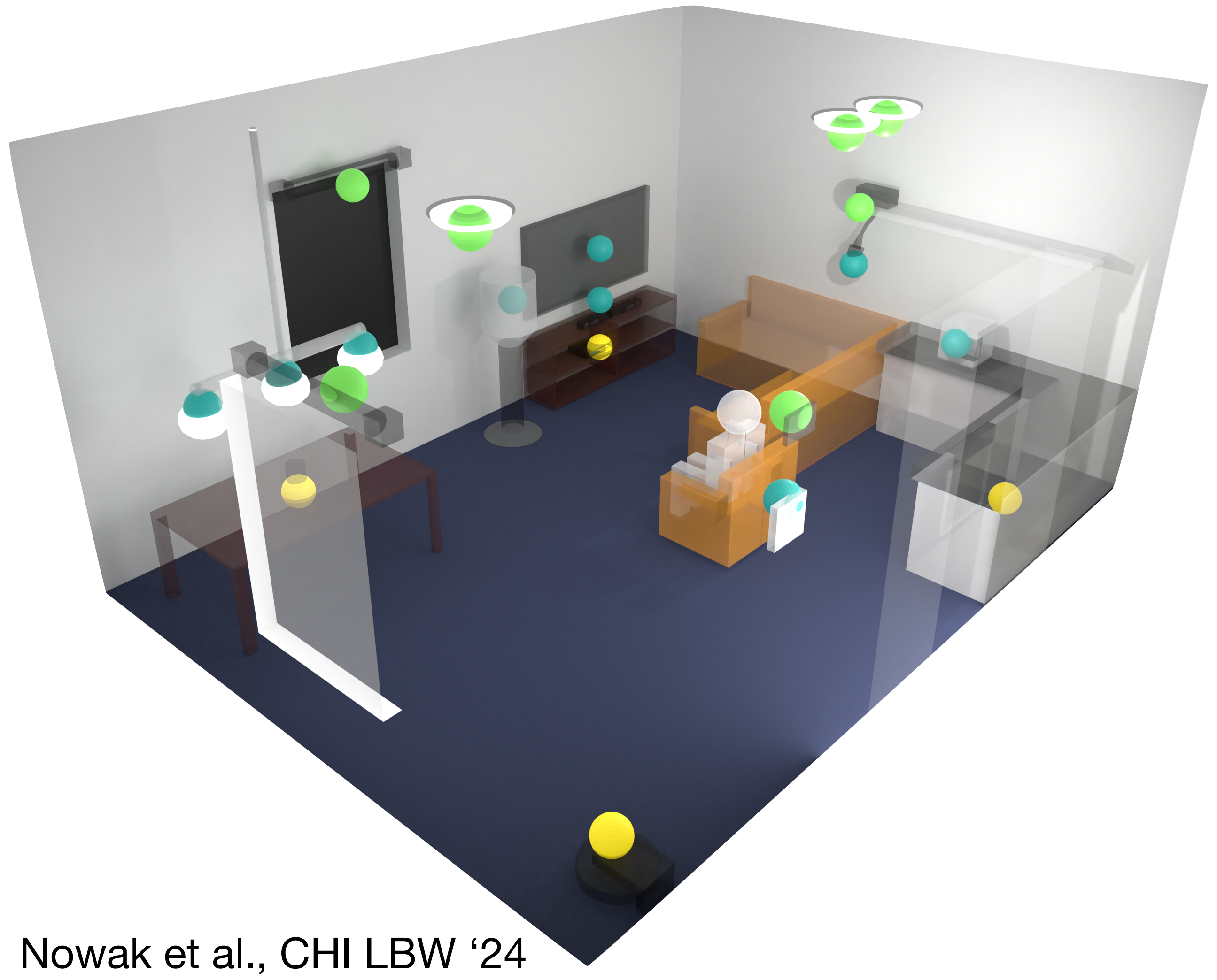
- New input/output approaches



Heynes & Steimle, CHI '24

- Physical properties
  - Fabrication
  - Transferability to other fabrics

- More complex/Multi-Purpose UIs
  - Exploration
  - Semantics
  - Mappings


Nowak et al., CHI LBW '24