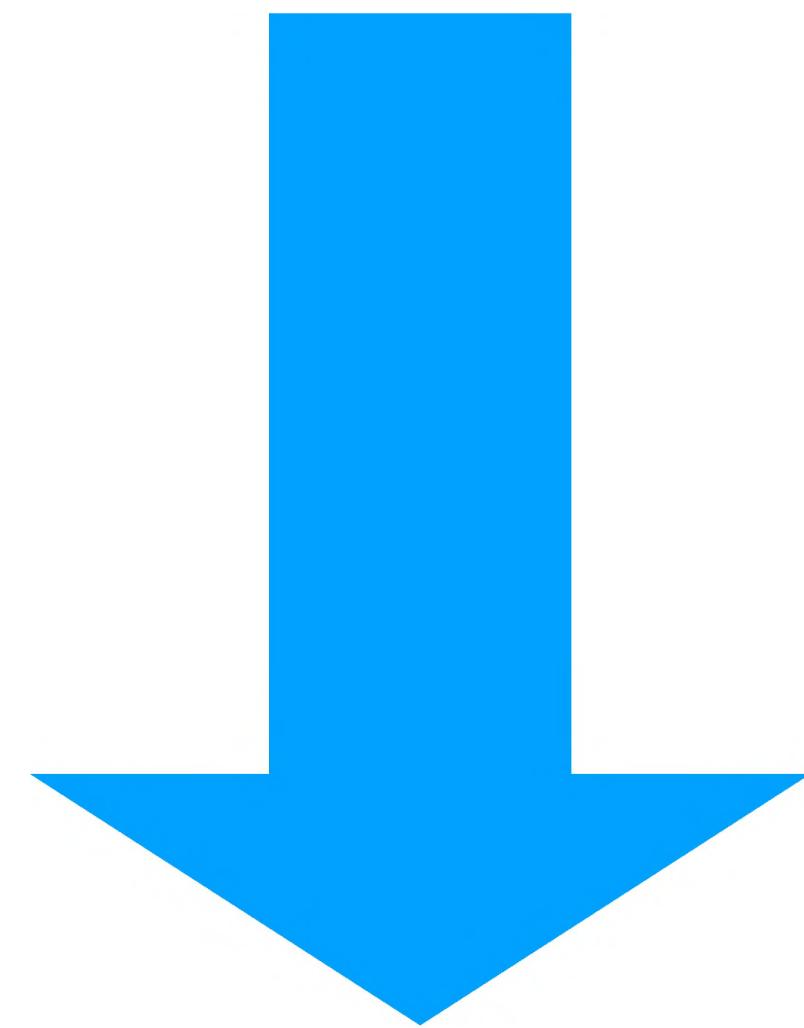


# New materials



# New factors

# Technological explorations



## User perception study

## New device design

## Interaction beyond shapes

## Challenges and future work

User perception study



New device design

Interaction beyond shapes

Challenges and future work

# User perception study

Non-permanence

Privacy

lity

**Policy and Ethics**

Ownership

**SOCIETAL**

Security

**Isolating Factors**

**Psychophysical experiment studying**

**the impact of softness**

**on users' shape perception ability**

**DESIGN**

Affect

Public engagement

*Replication*

**Temporality**

**Application and Content**

Instrumentation

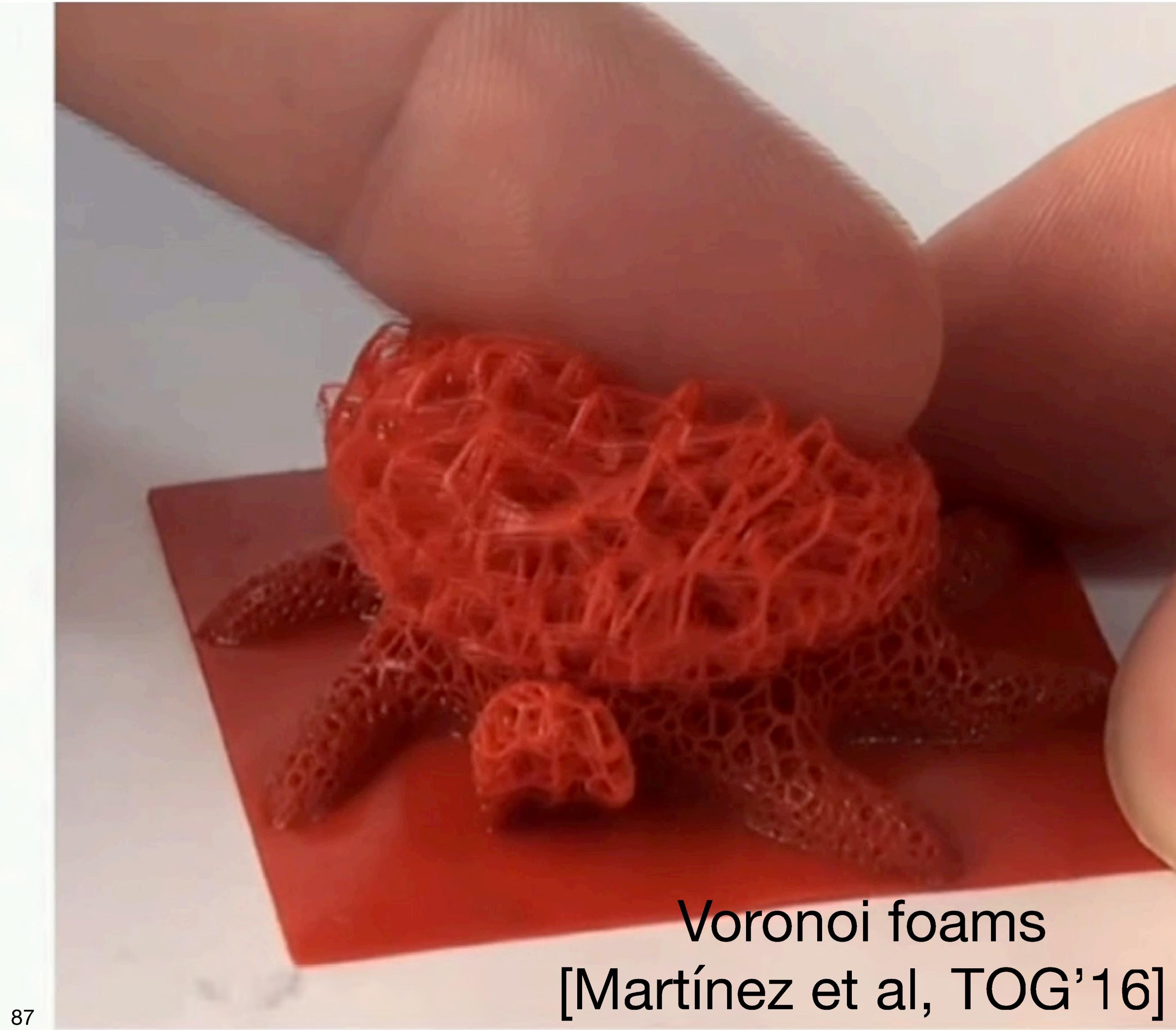
**Soft curved  
UIs**

# Daily objects



Annexing Reality  
[Hettiarachchi et al, CHI'16]

# Customised UIs



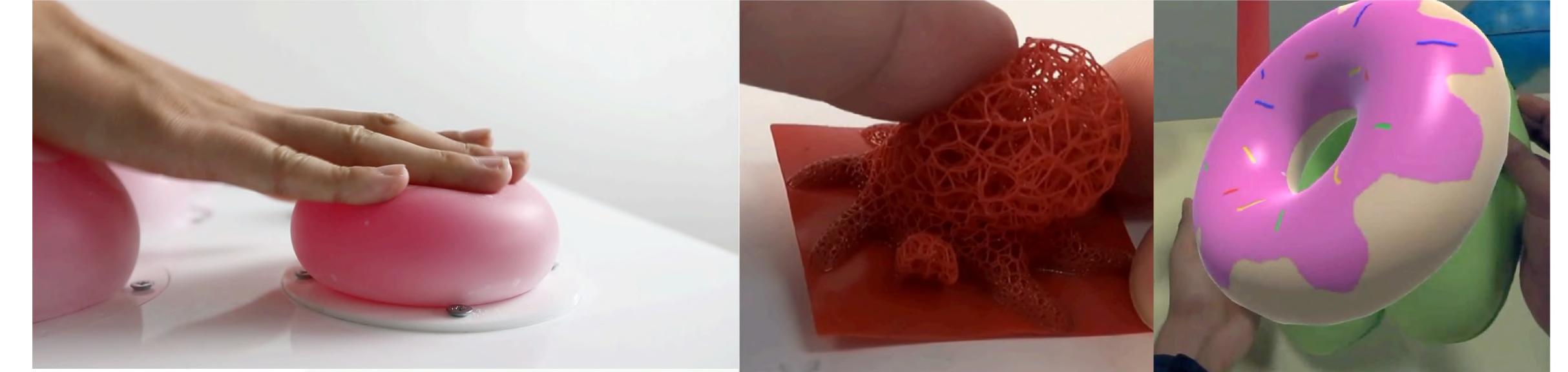
Voronoi foams  
[Martínez et al, TOG'16]

# Curvature changing UIs

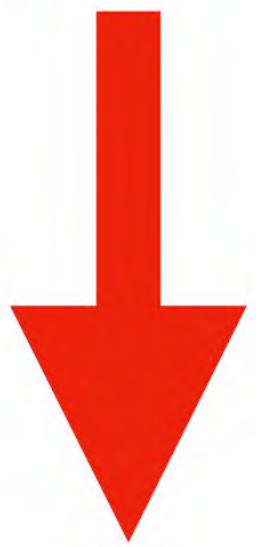


COLORISE  
[Fujii, et al. TEI'18]

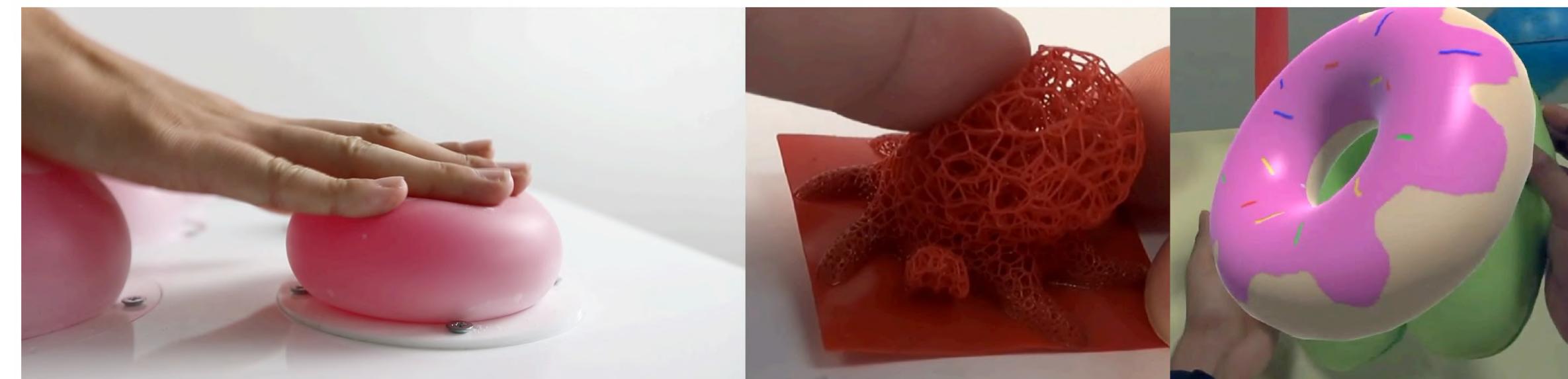
# Efficiency of soft curved UIs



# Curvature perception of a soft UI



## Efficiency of soft curved UIs



# Experiment

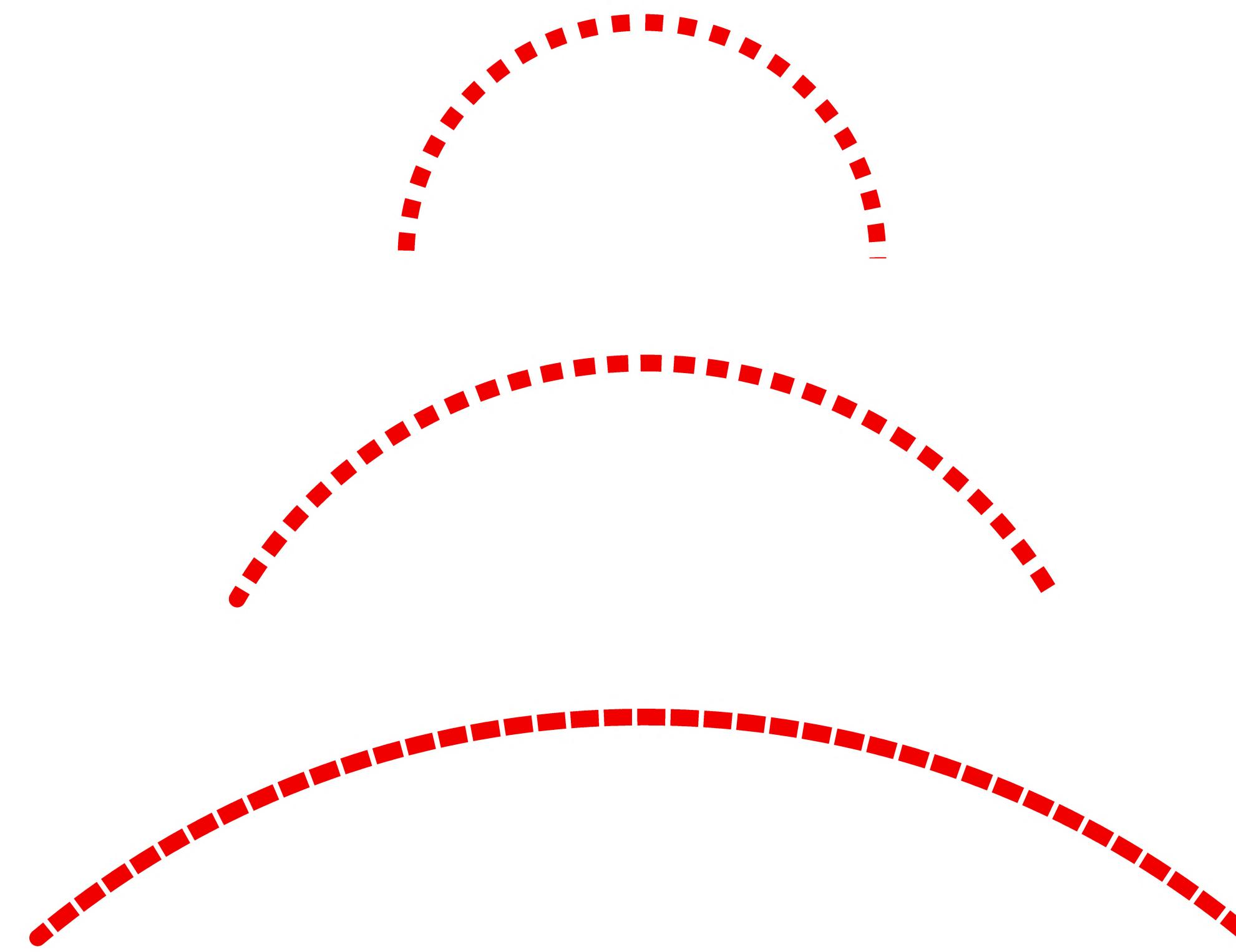
**Curvature** perception  
precision and accuracy  
in **different softness conditions**

12 Participants (6 women, 6 men,  $M=26.1$  years old,  $SD=4.1$  years)

Registration on [osf.io/scnj9](https://osf.io/scnj9)

# Independent variables

Four softnesses × Three curvatures



# Softness levels

Softness

Shore 00-10



Shore 00-50



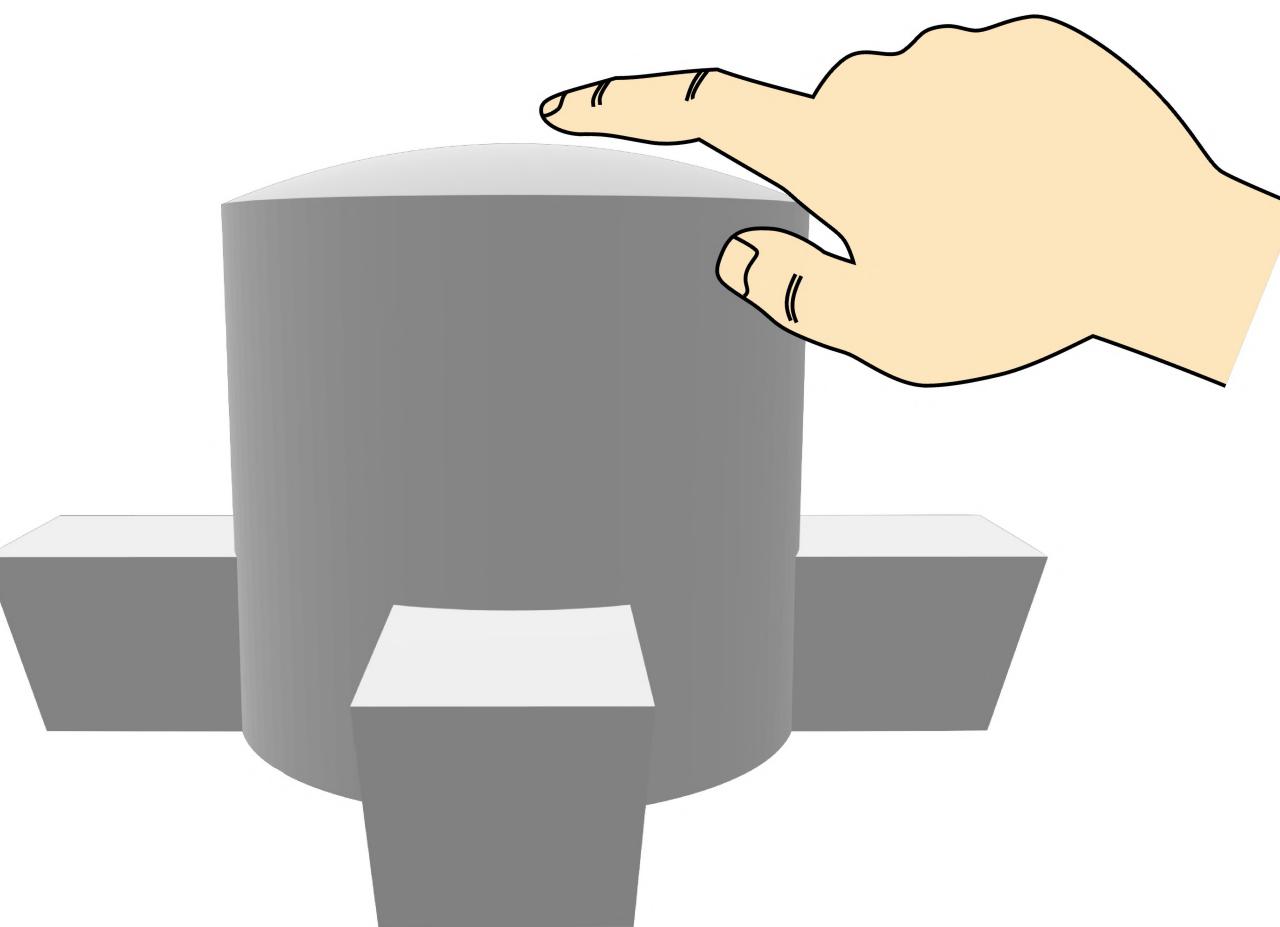
Shore A-30



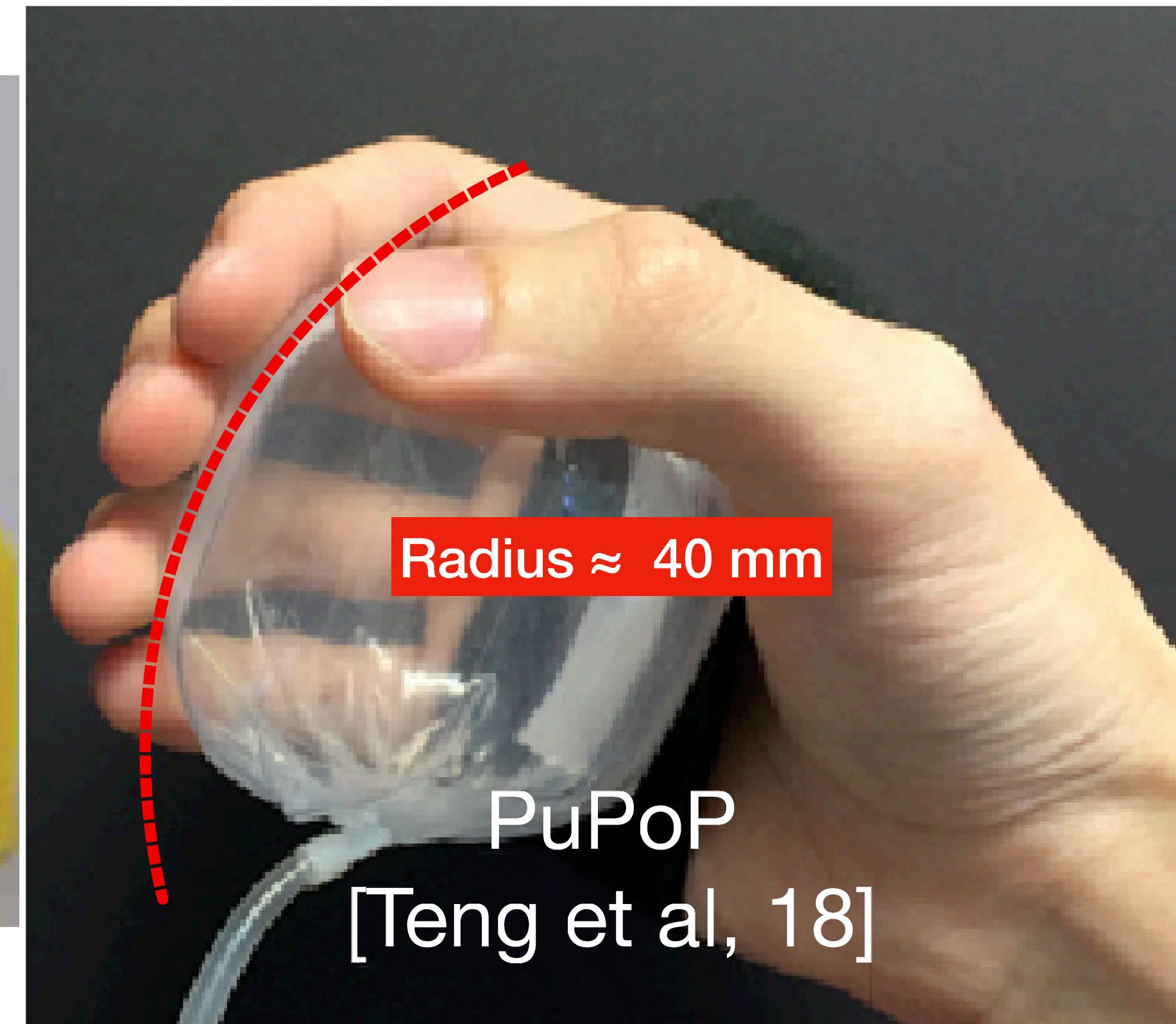
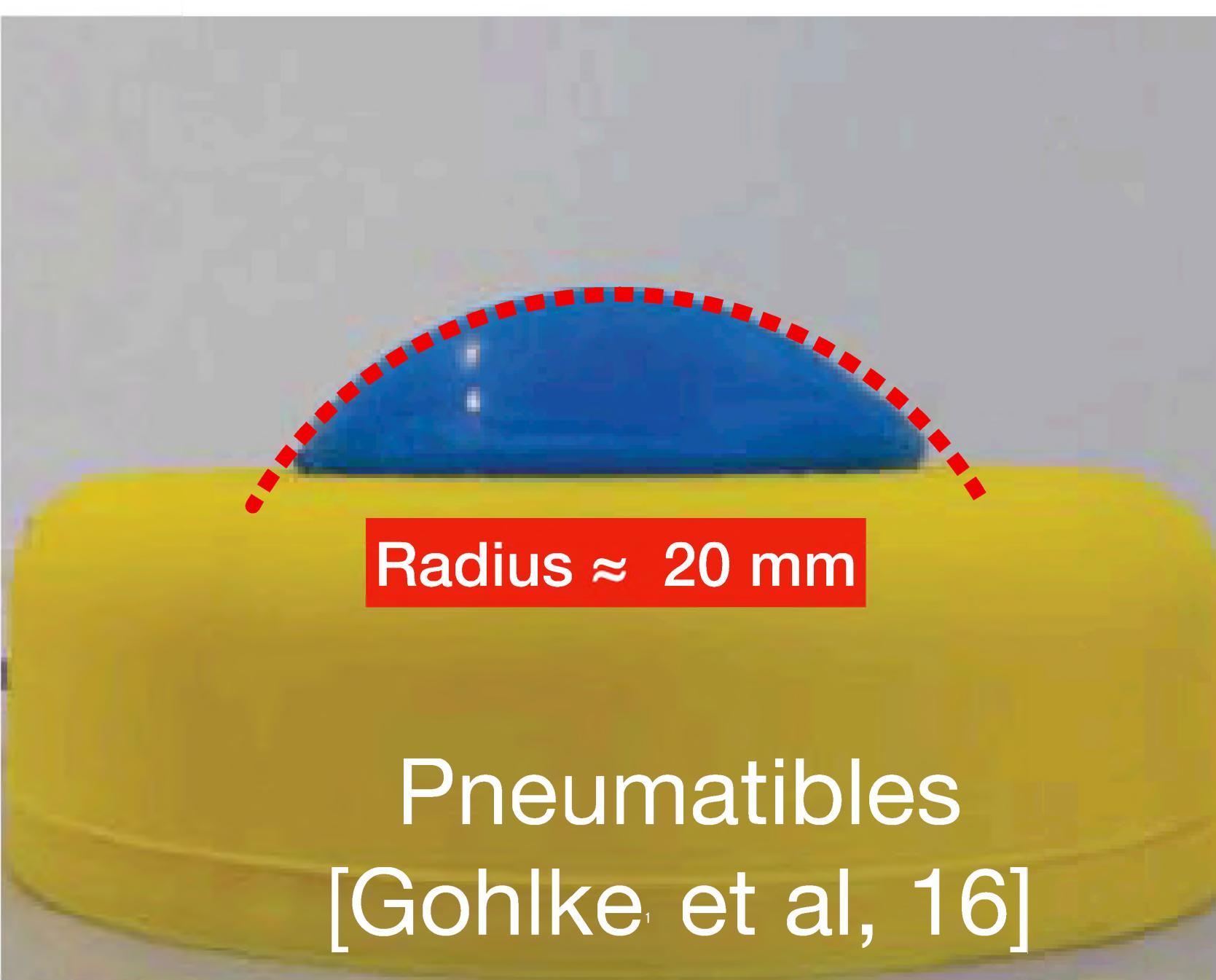
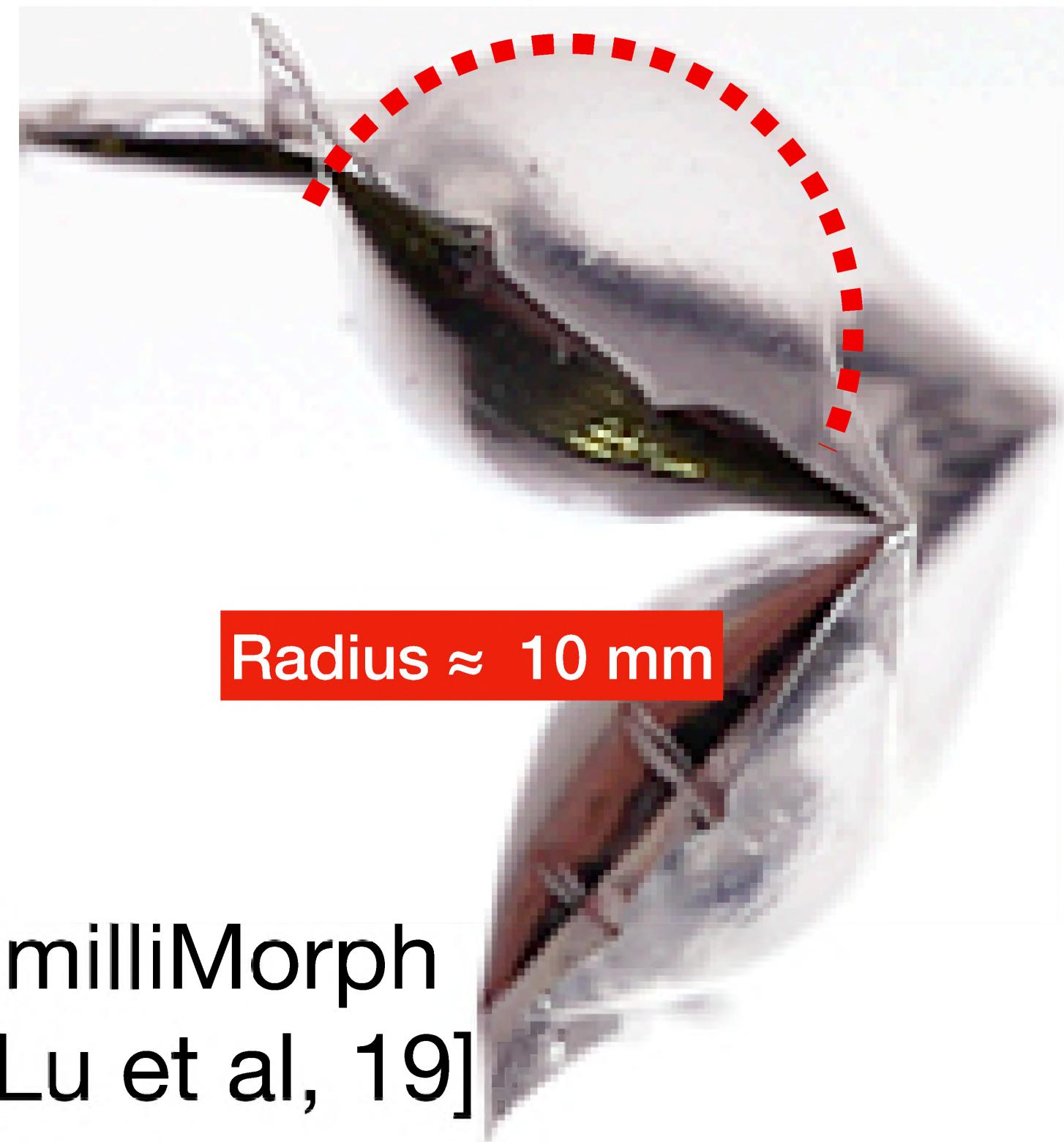
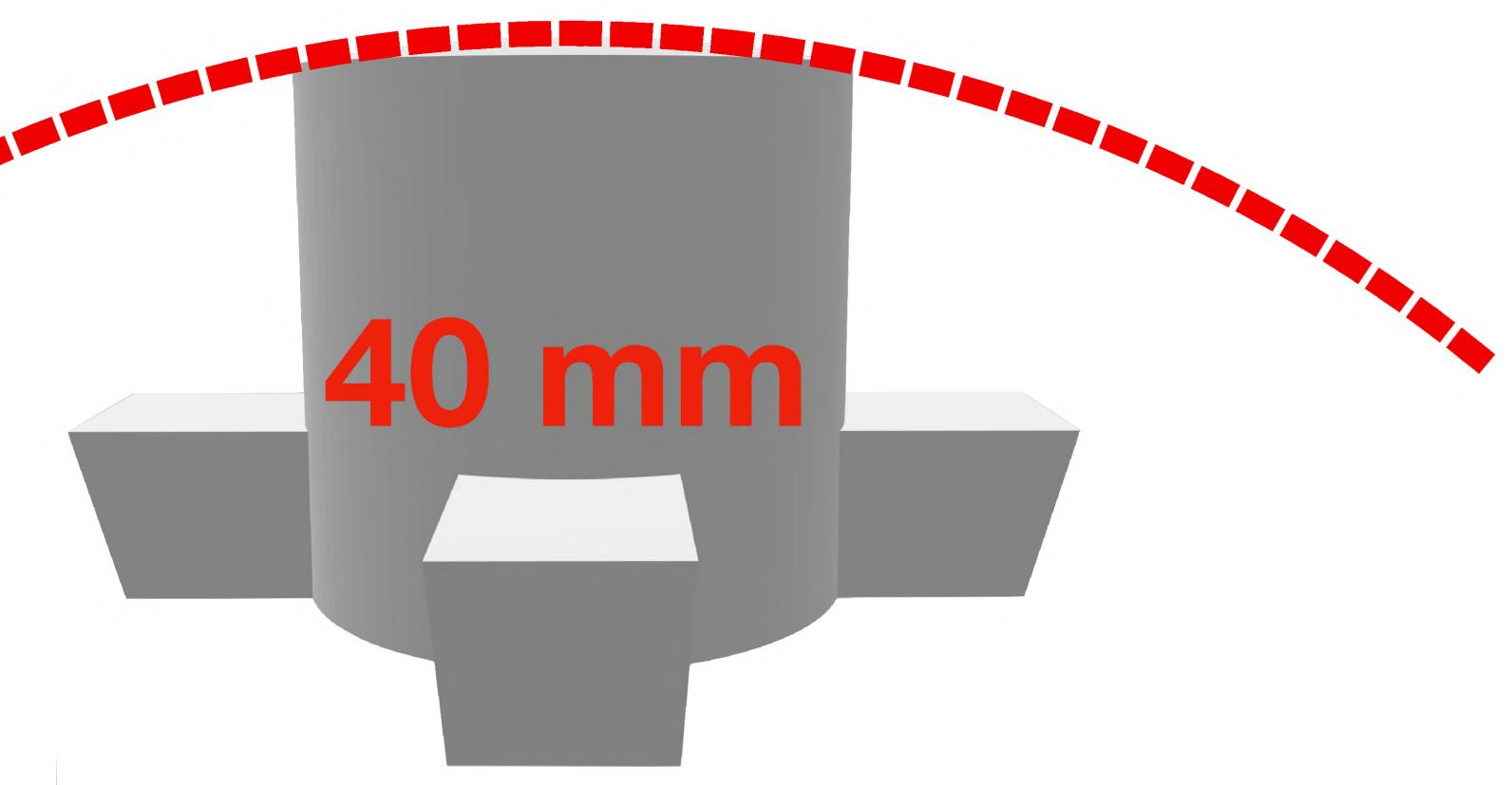
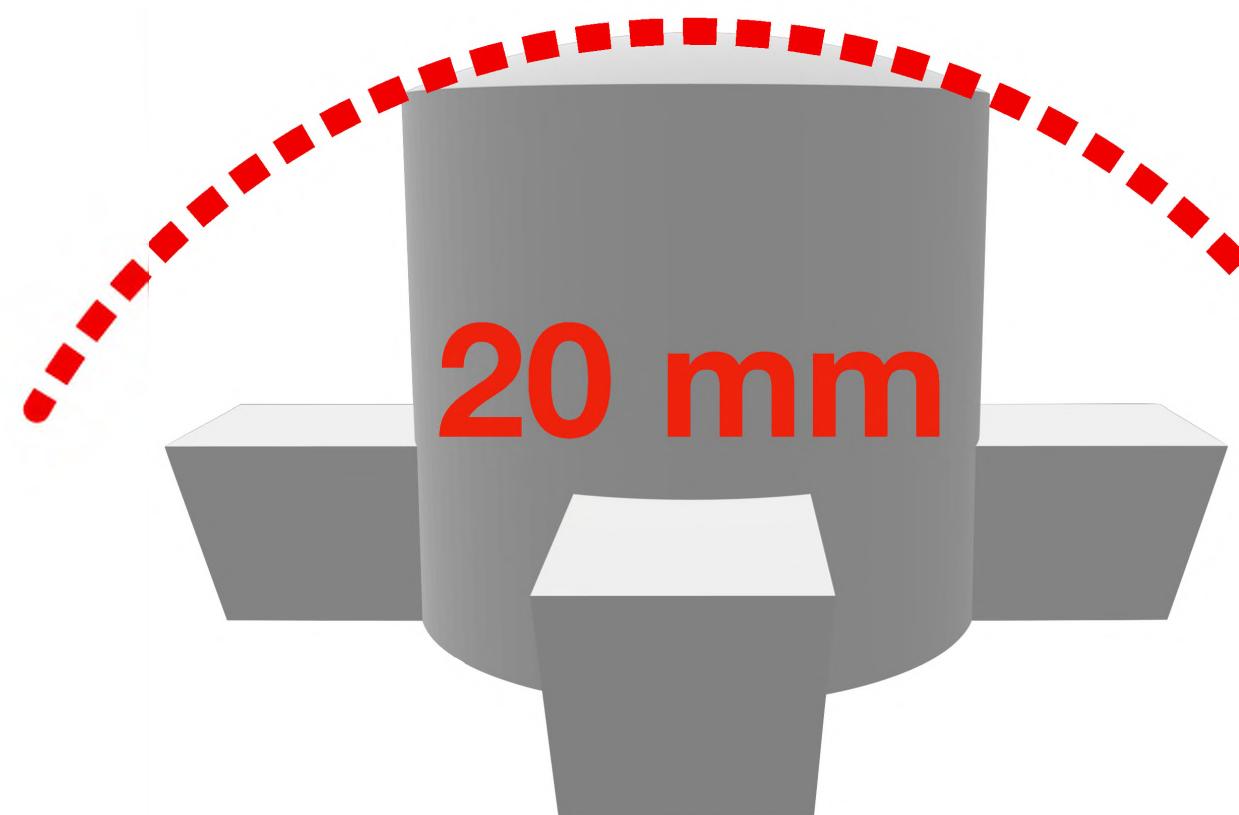
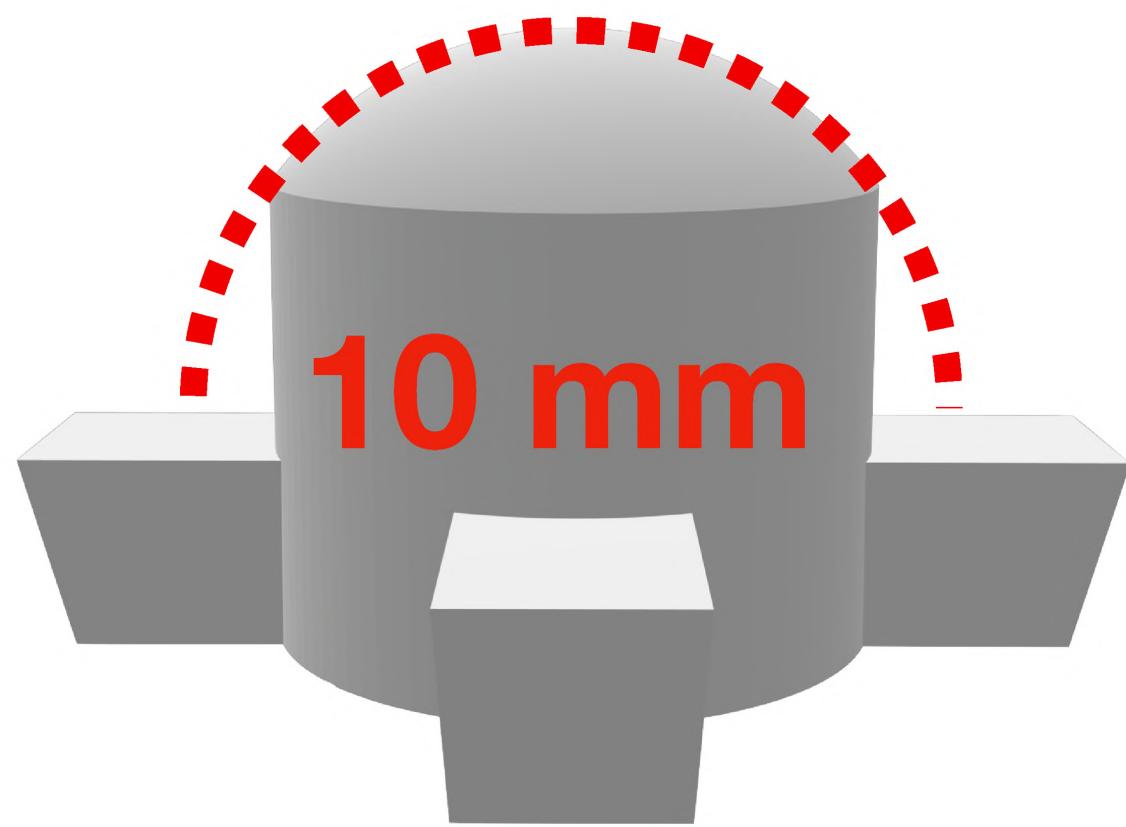
Rigid



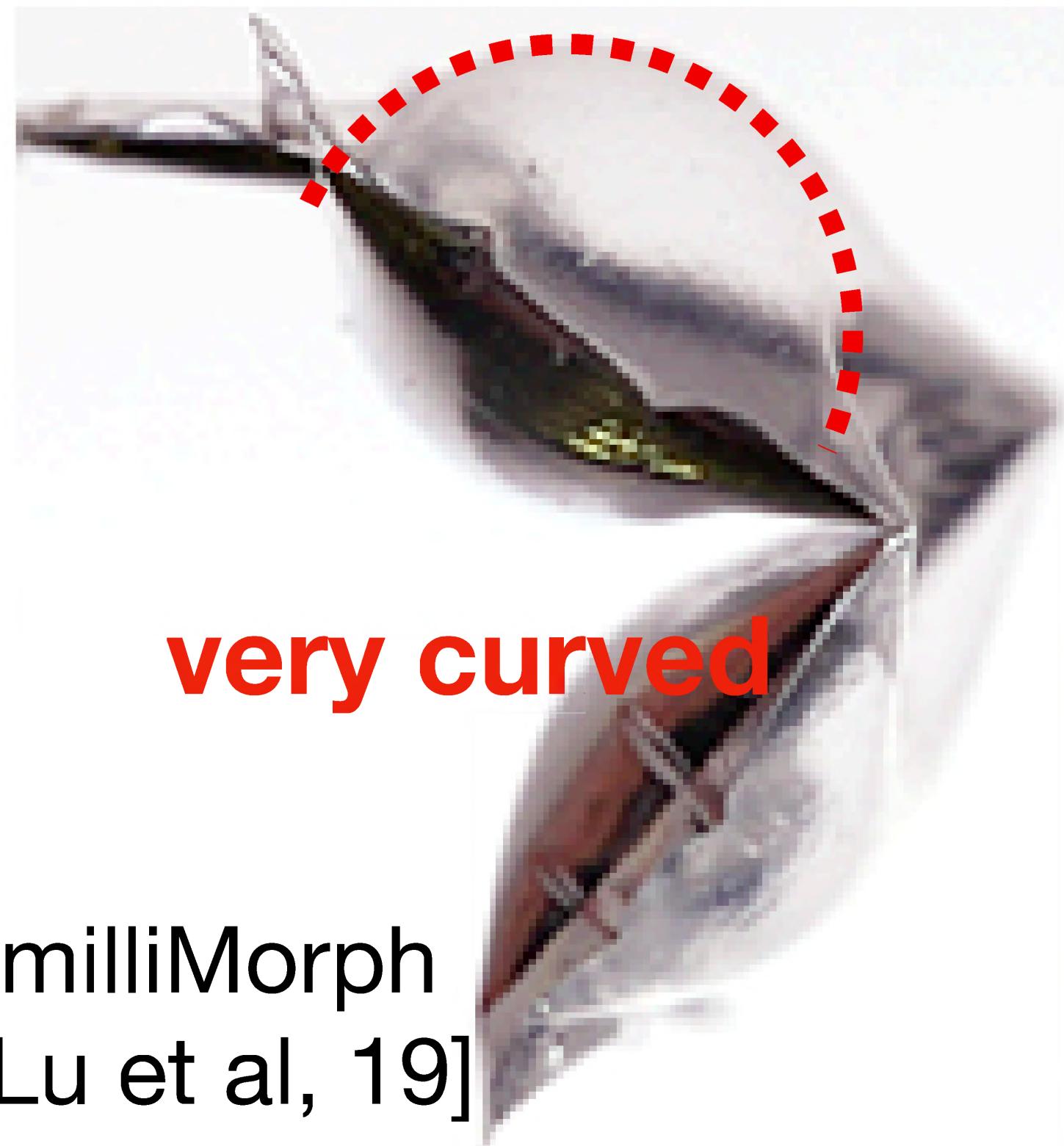
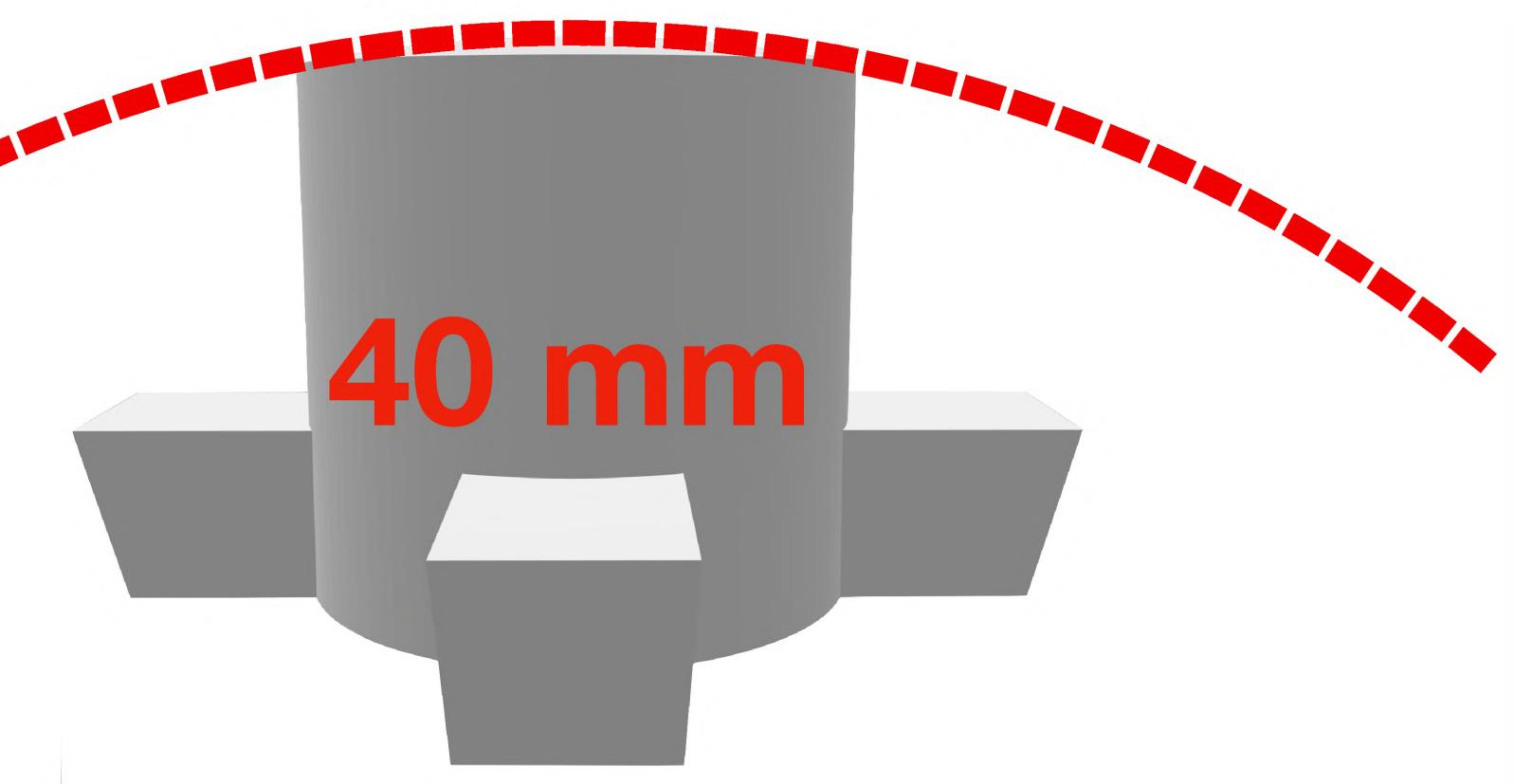
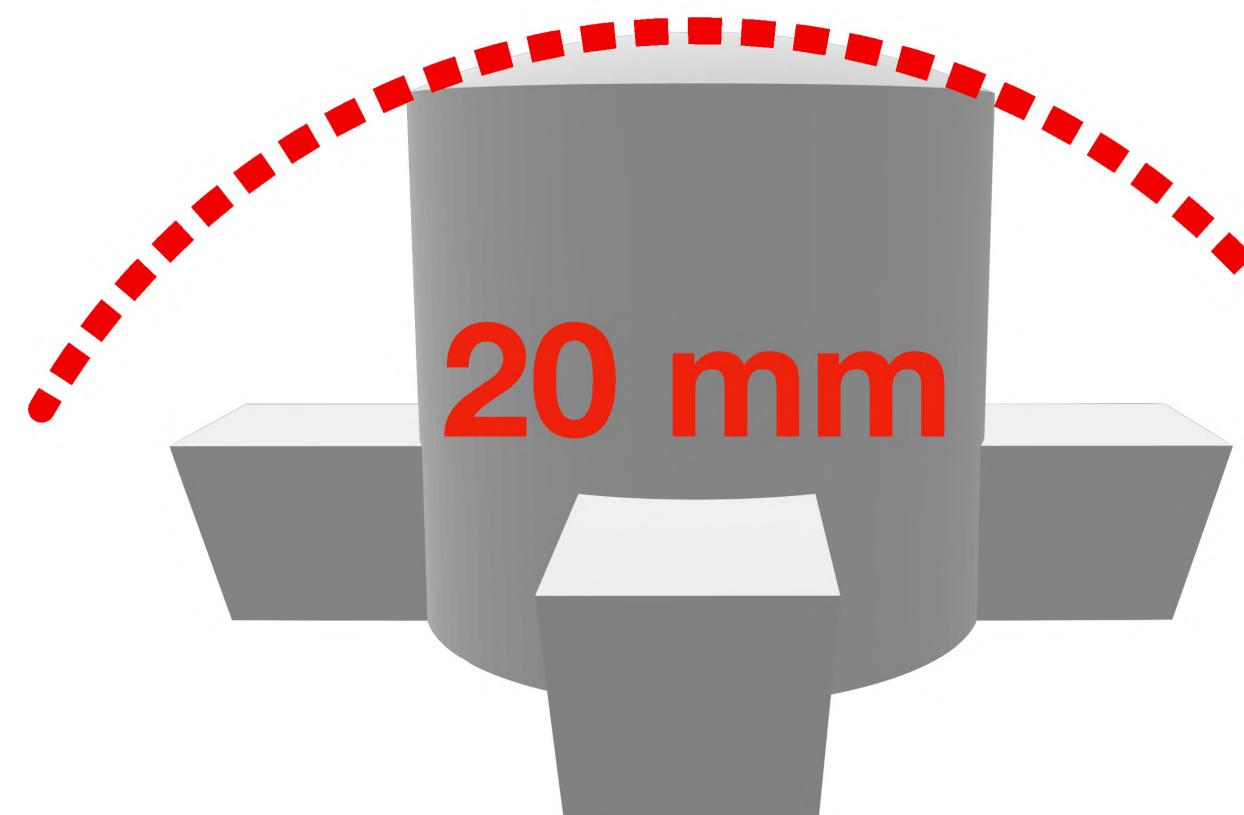
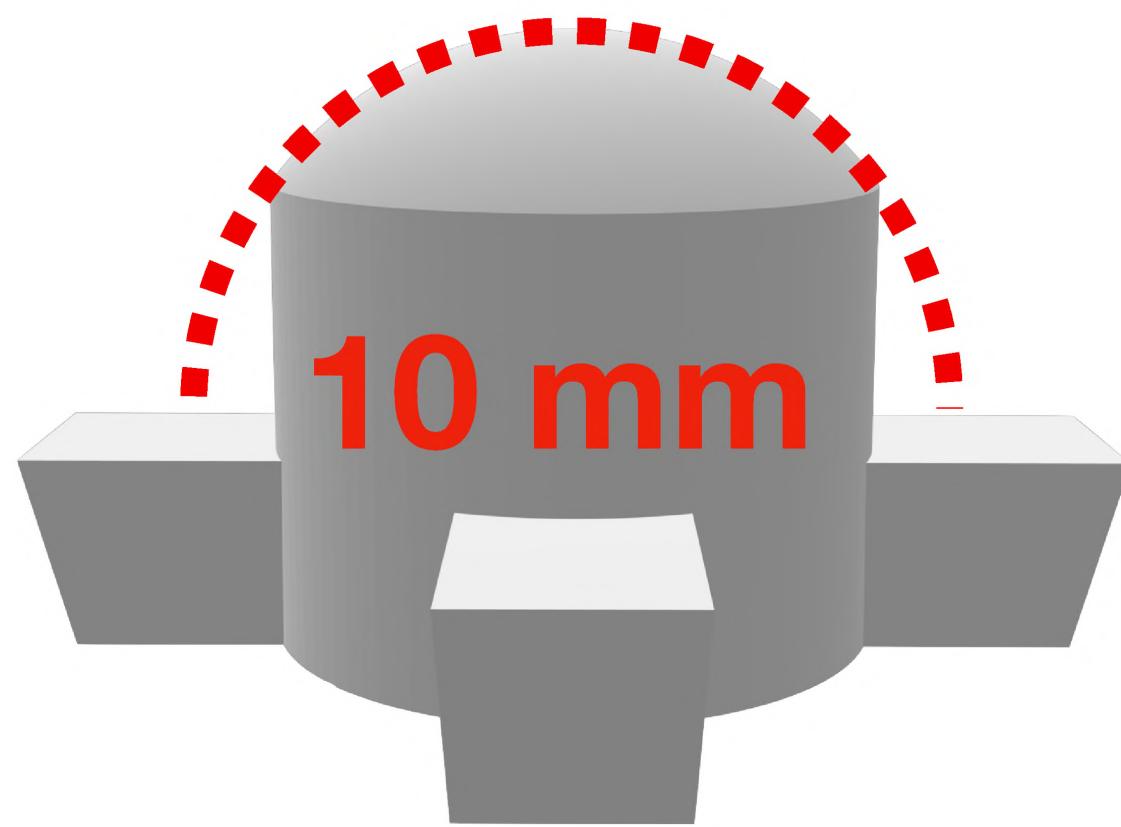
# Curvature levels



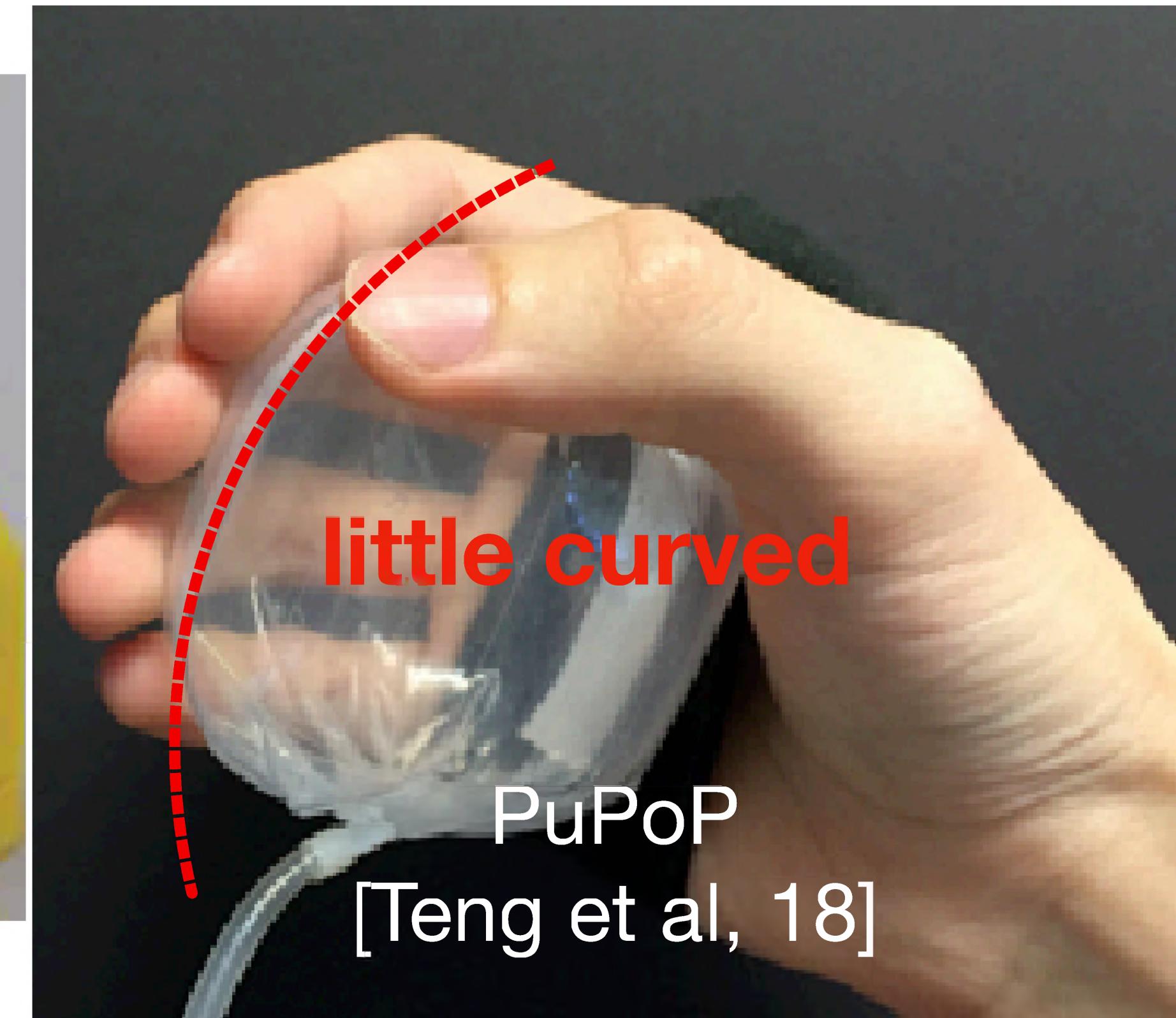
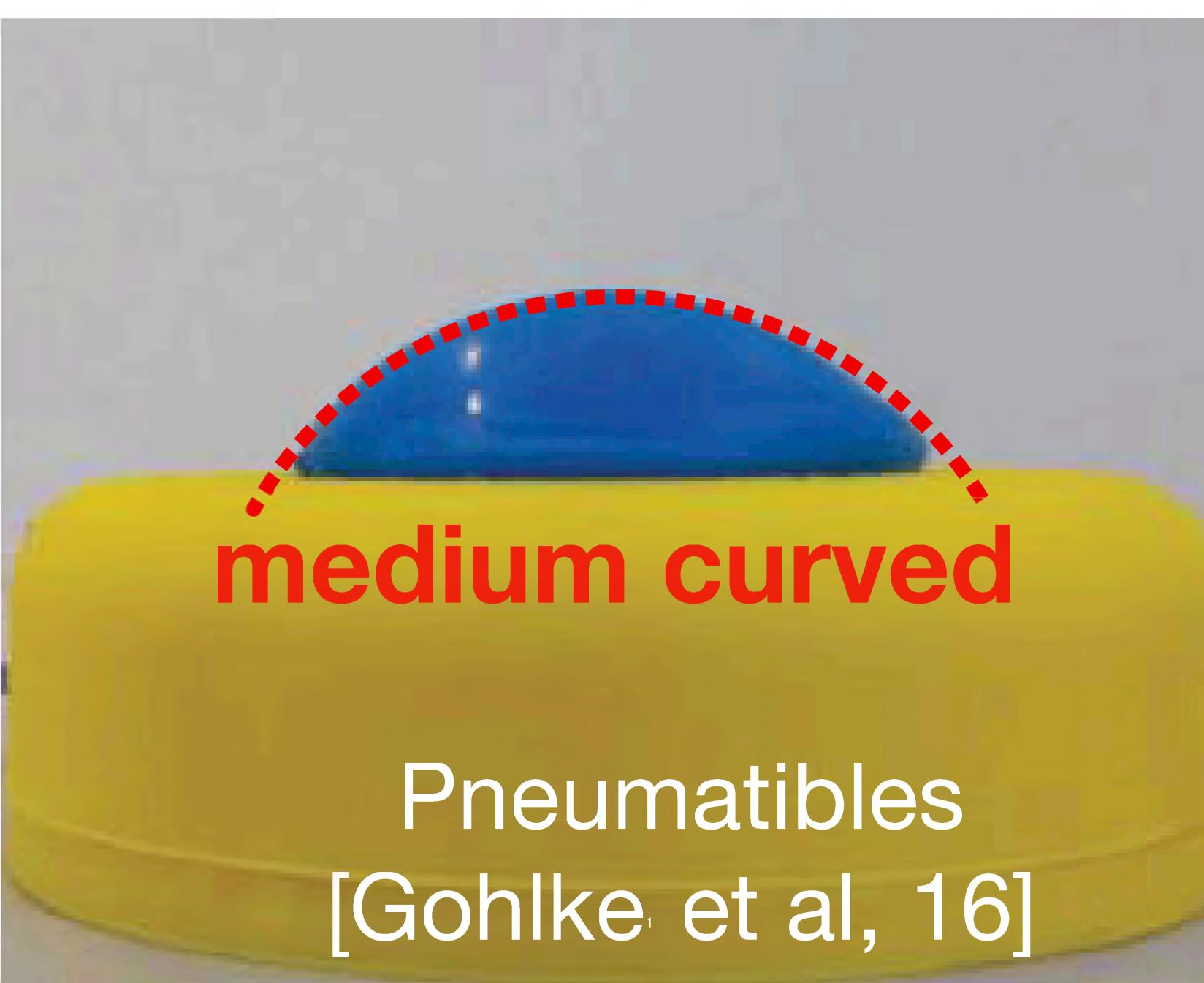
# Curvature levels



# Curvature levels



milliMorph  
[Lu et al, 19]



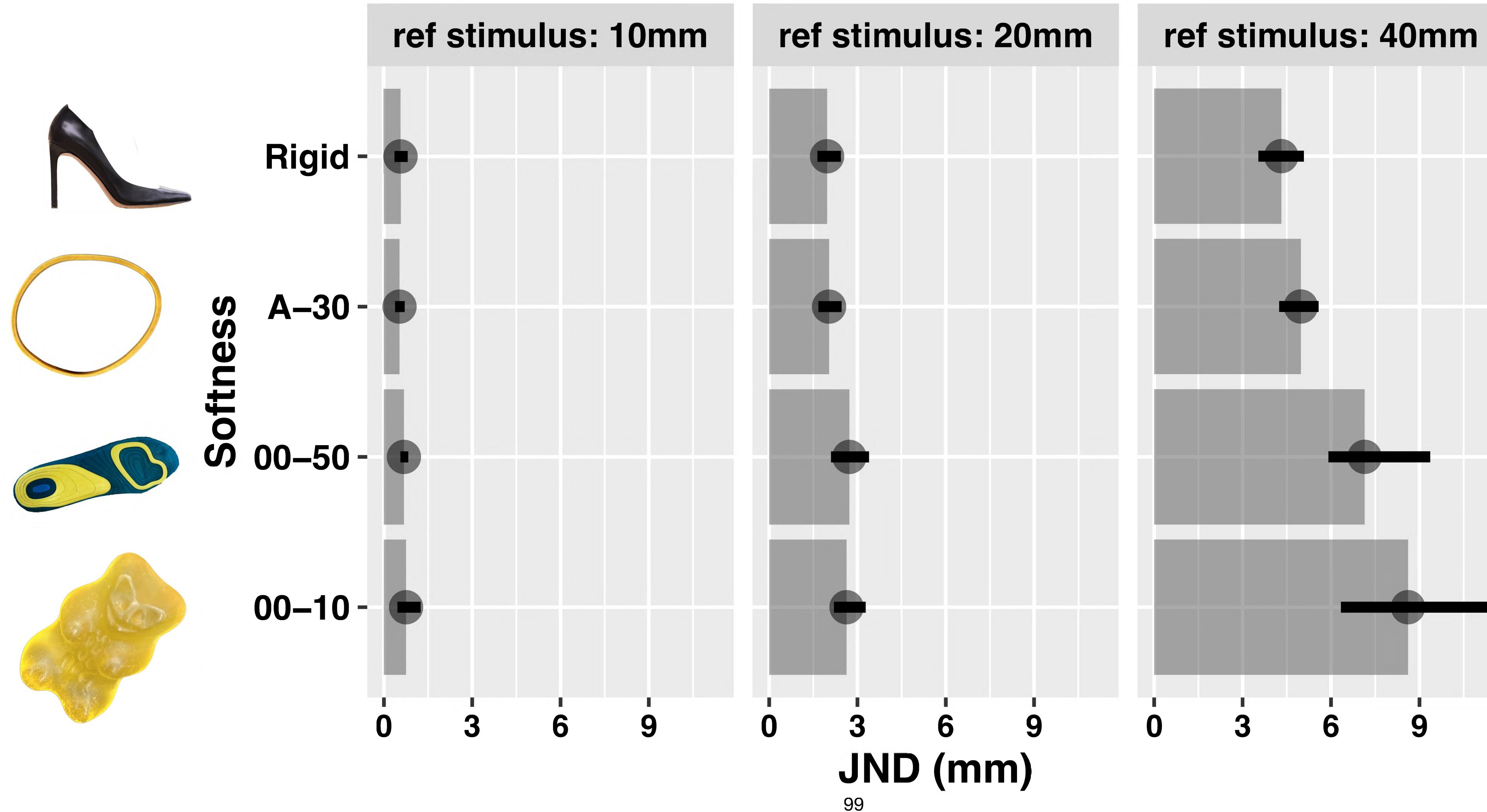
# Dependent Variables

**precision** → **Just Noticeable Difference (JND)**

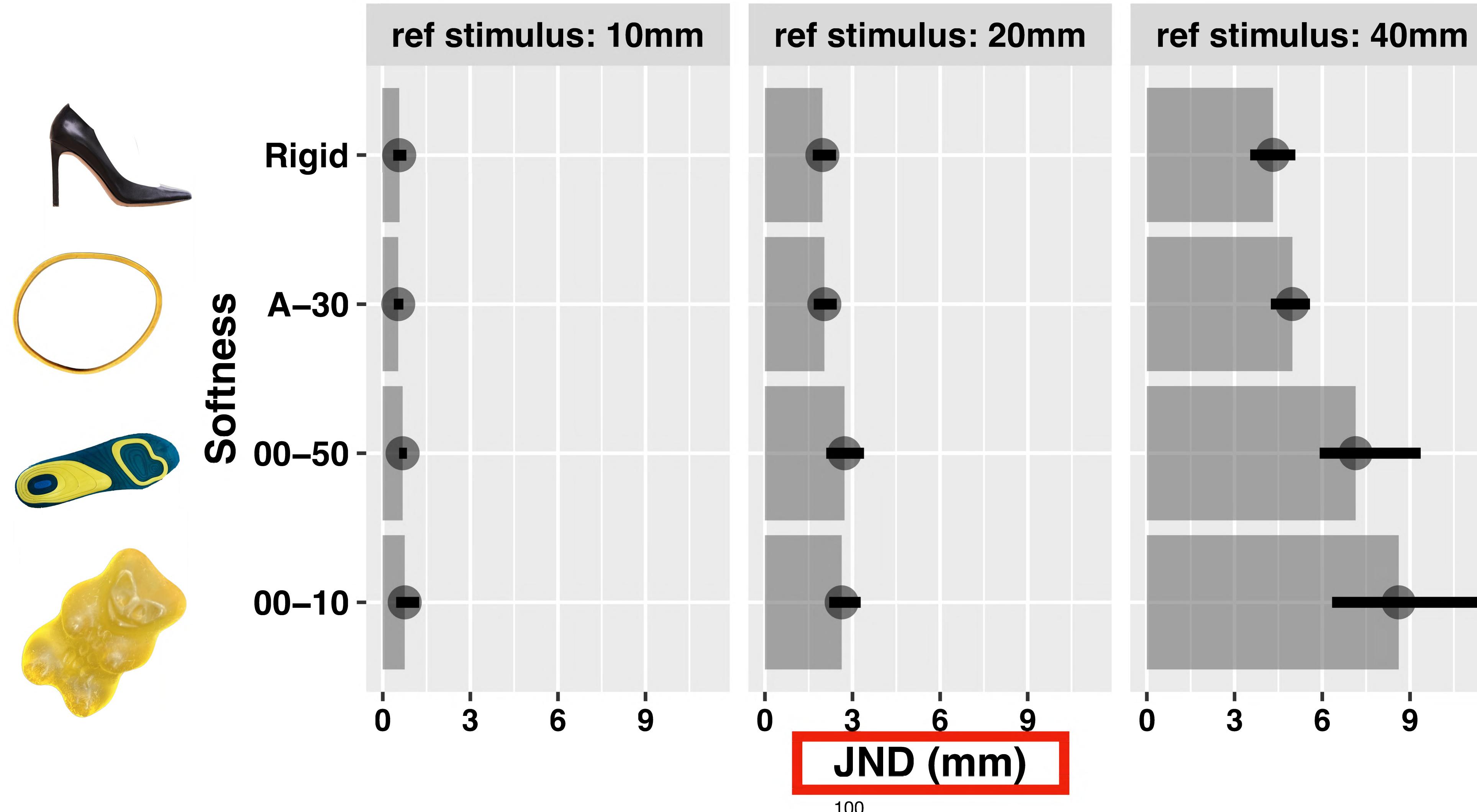
**accuracy** → **Point of Subjective Equality (PSE)**

# Curvature perception precision

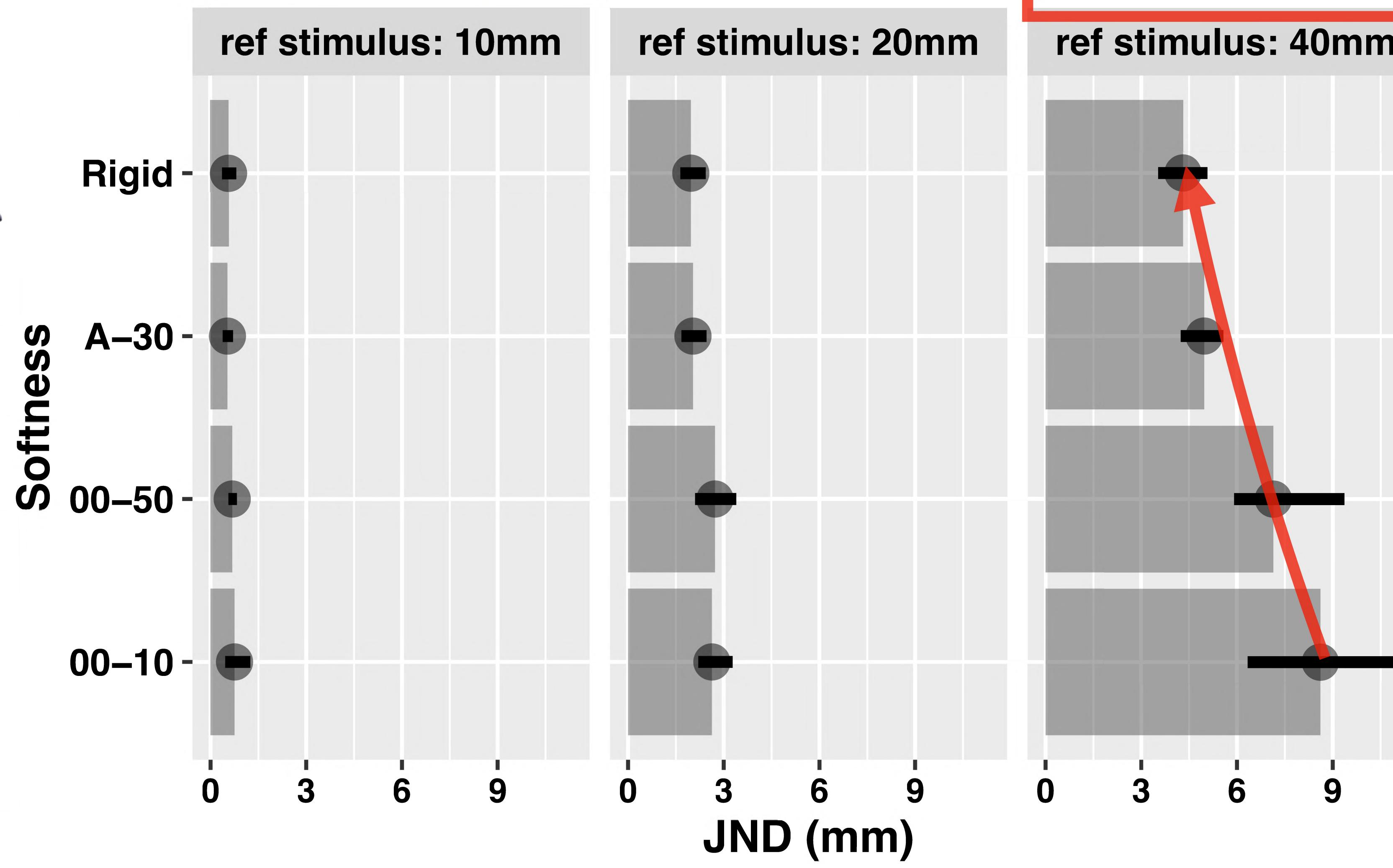
# Precision



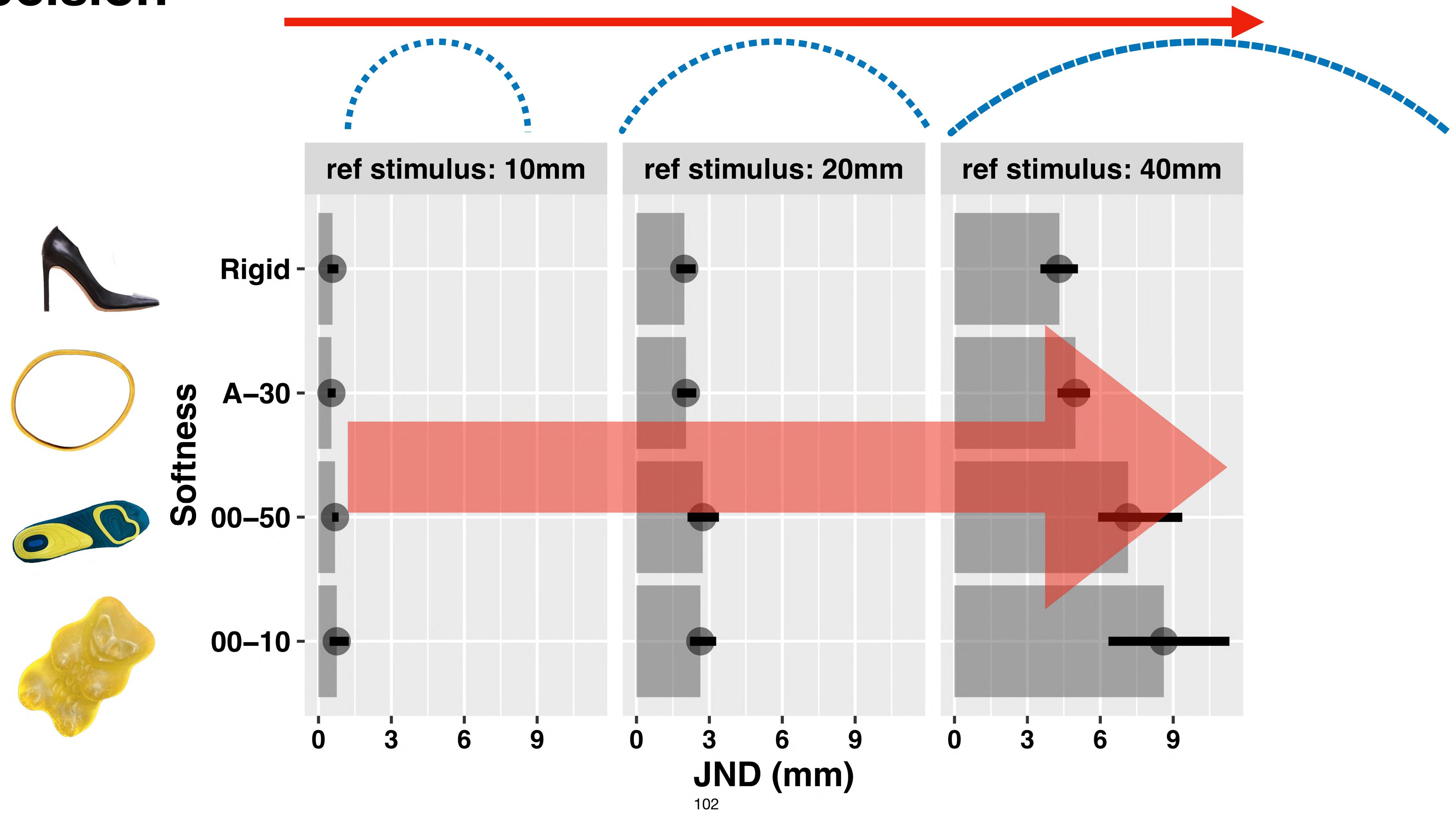
# Precision



# Precision



# Precision



# Curvature perception accuracy

# Accuracy



Softness

Rigid

A-30

00-50

00-10

ref stimulus: 10mm

ref stimulus: 20mm

ref stimulus: 40mm

Similar  
accuracy

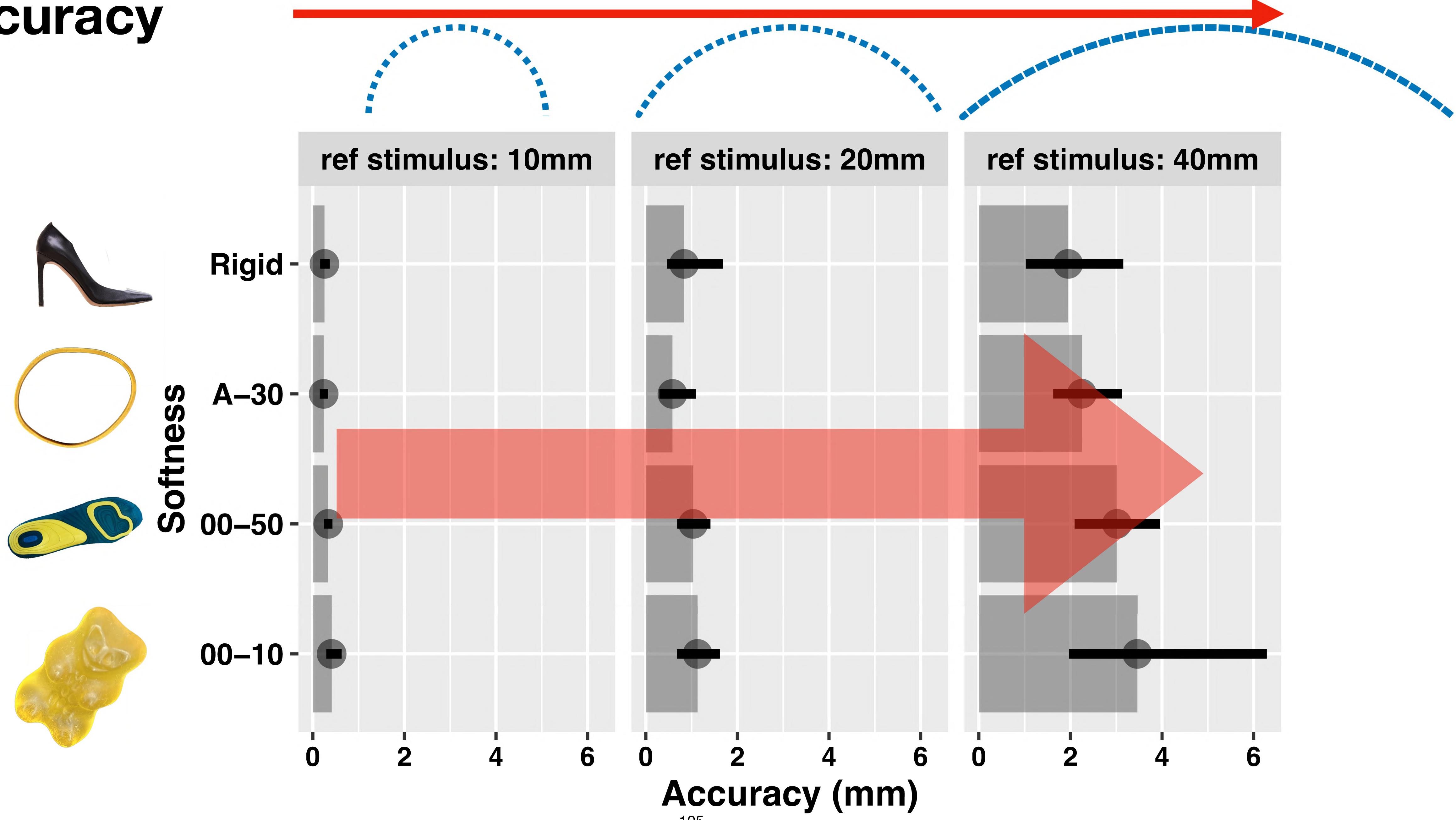
Similar  
accuracy

Similar  
accuracy

0 2 4 6

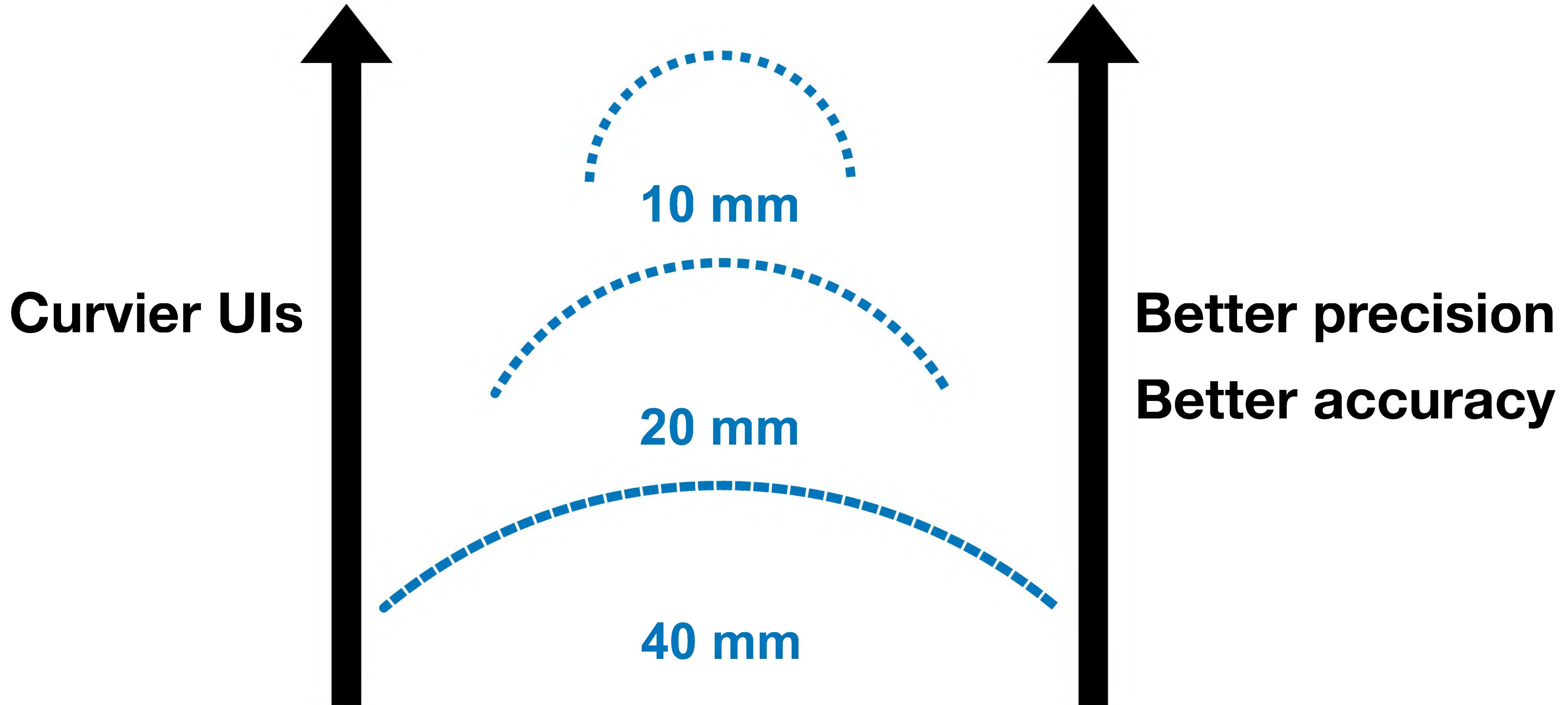
Accuracy (mm)

# Accuracy

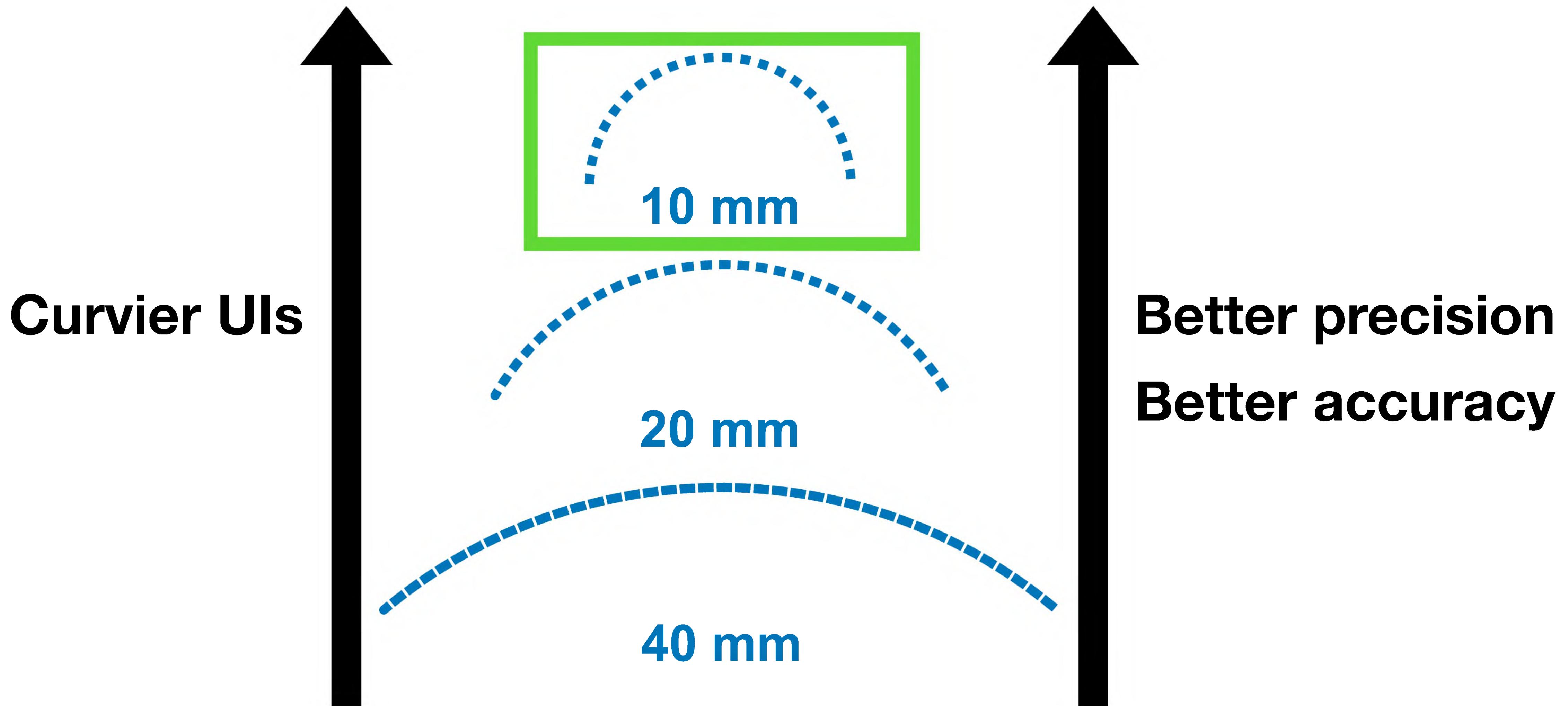


# Design guidelines

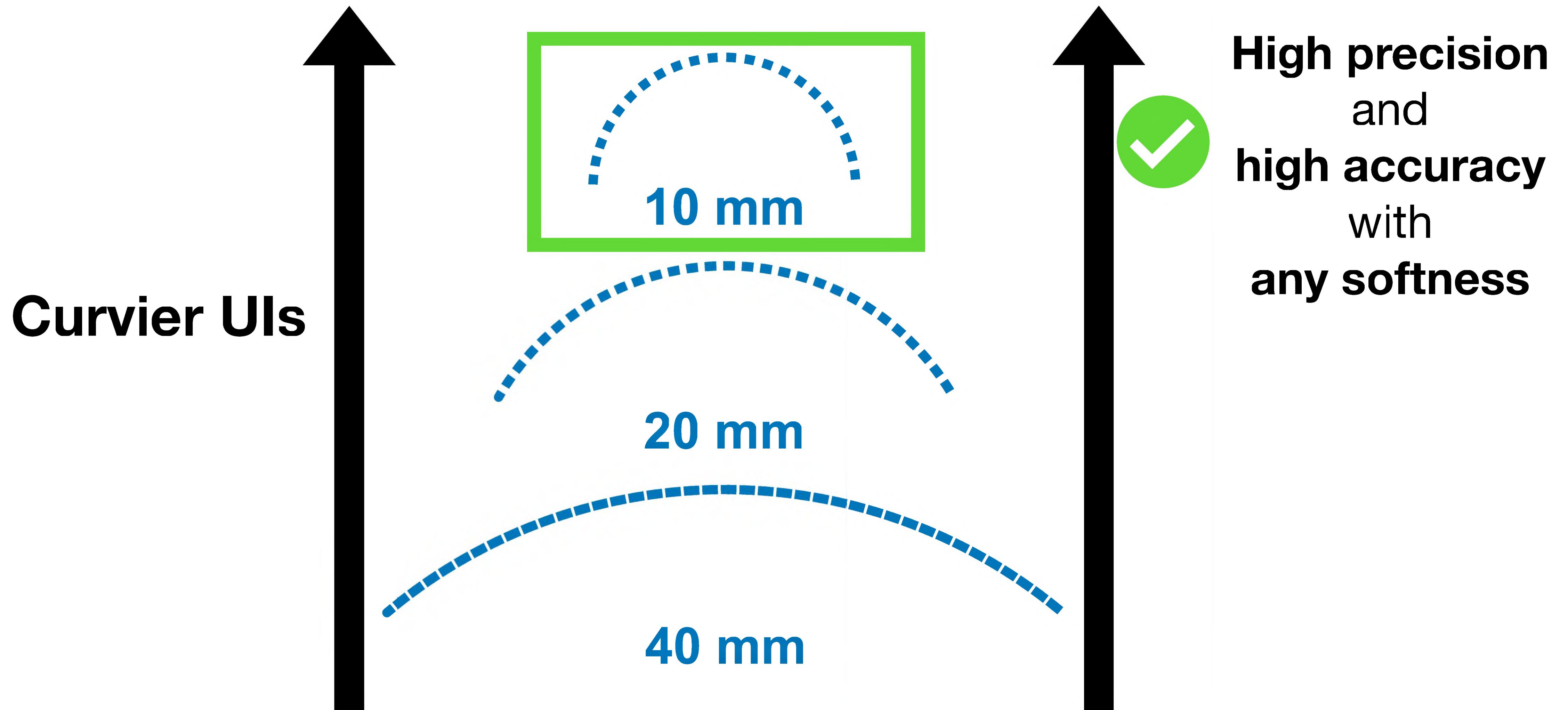
# Building precise and accurate soft curved UIs



# Building precise and accurate soft curved UIs



# Building precise and accurate soft curved UIs



Very curved Ultrasound probe for better precision



# Very curved Ultrasound probe for better precision



Radius  $\approx$  10 mm

gy Consumption,

Sustainability

Policy and Ethics

Ownership

y and Compliance

SOCIETAL

Security

Isolating

**Technological explorations**

**User perception study**

Toolkits

DESIGN

Public engagement

eness

Platforms

Designing for

Application and Content

Instru

End-user programming

Configurations

**New device design**

Affordances

Appropriateness

Aesthetics

Meaning

Semantics

Hedonics

Configurations

Meaning

Semantics

Hedonics

New device design



Interaction beyond shapes

Challenges and future work

# New device design

TECHNOLOGICAL

ization and Resolution

Toolkits

Platforms

End-user programming

Designing for Temporality

Integrating Artefact and Interaction

## Design of

**a novel shape-changing wearable device**

**providing users with novel haptic feedback**

Theory Development

USER BEHAVIOUR

In-situ Evaluations

Com

Public engagement

Affect

Application and Content

Instru

Semantics

Hedonics

Configurations

Aesthetics

Meaning

Configurations

Aesthetics

Meaning

Semantics

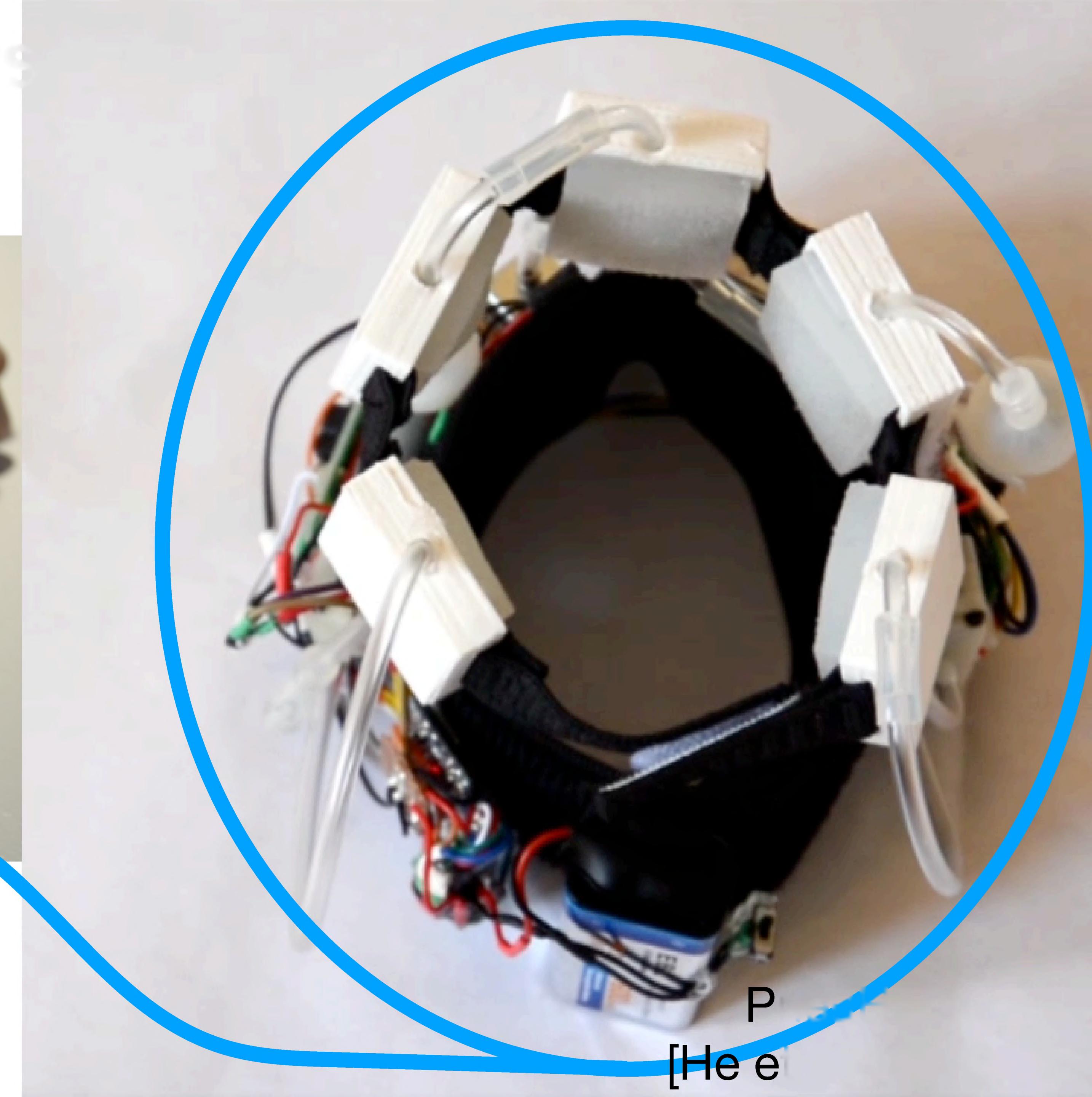
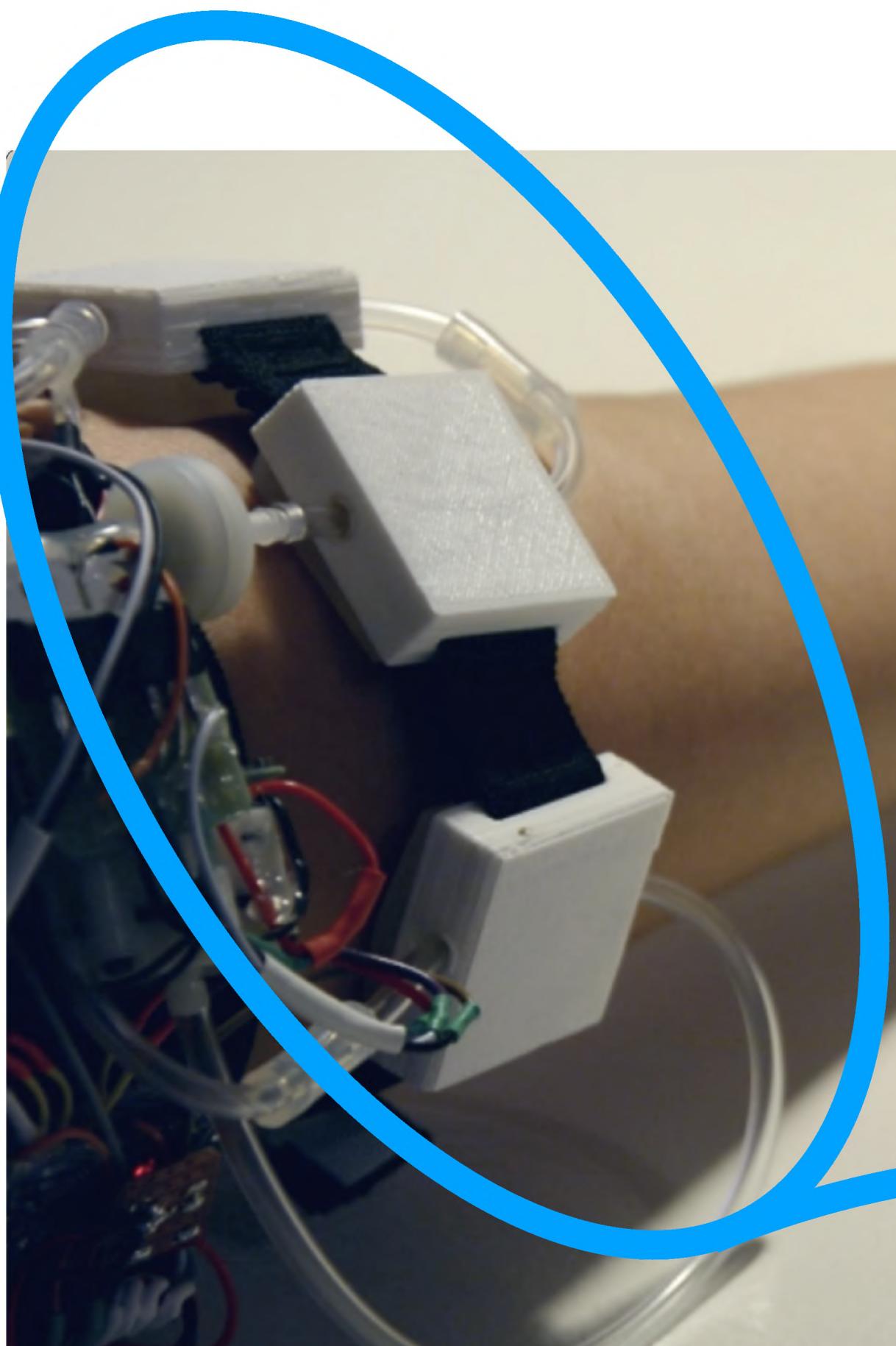
Hedonics



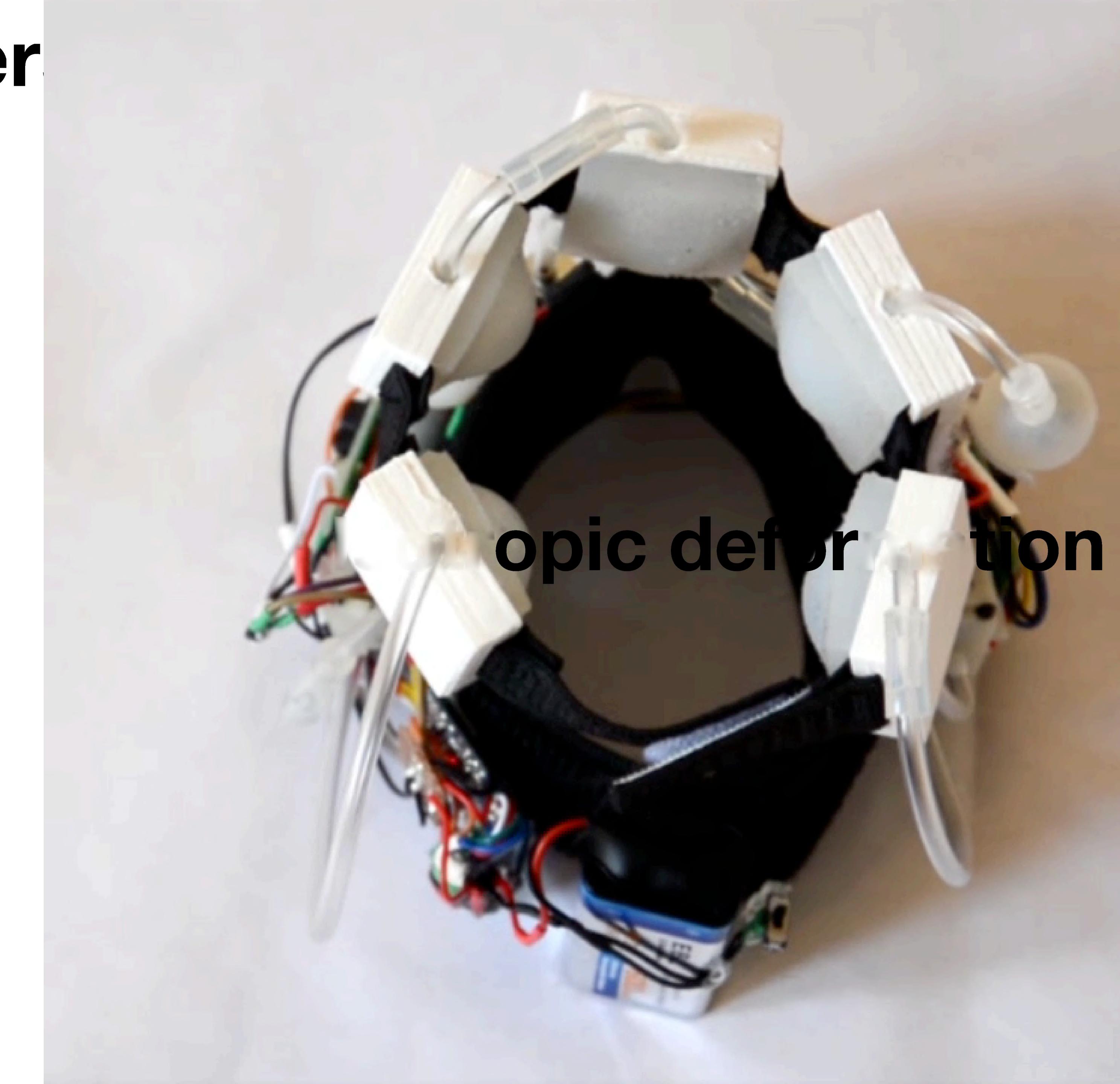
# Commonly-used notifications



**Feedback  
by  
shape change**



# Inflatable air chamber

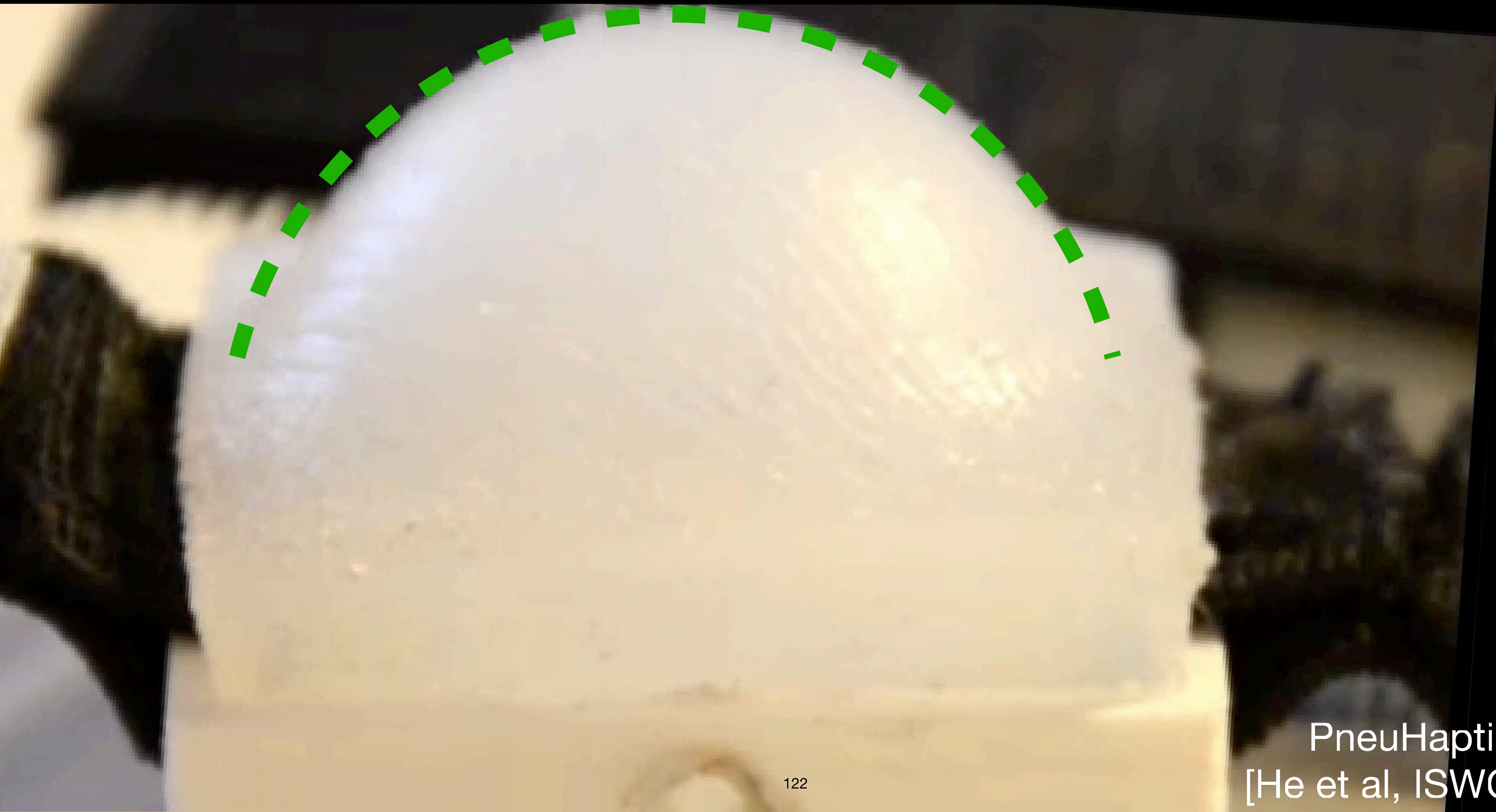


opic defor tio





# Creates only a spherical shape



PneuHaptic  
[He et al, ISWC'15]

**Curvature is important**  
for the perception of the shape of soft surfaces

# SoftMorphees



Size



Porosity



Curvature



Closure

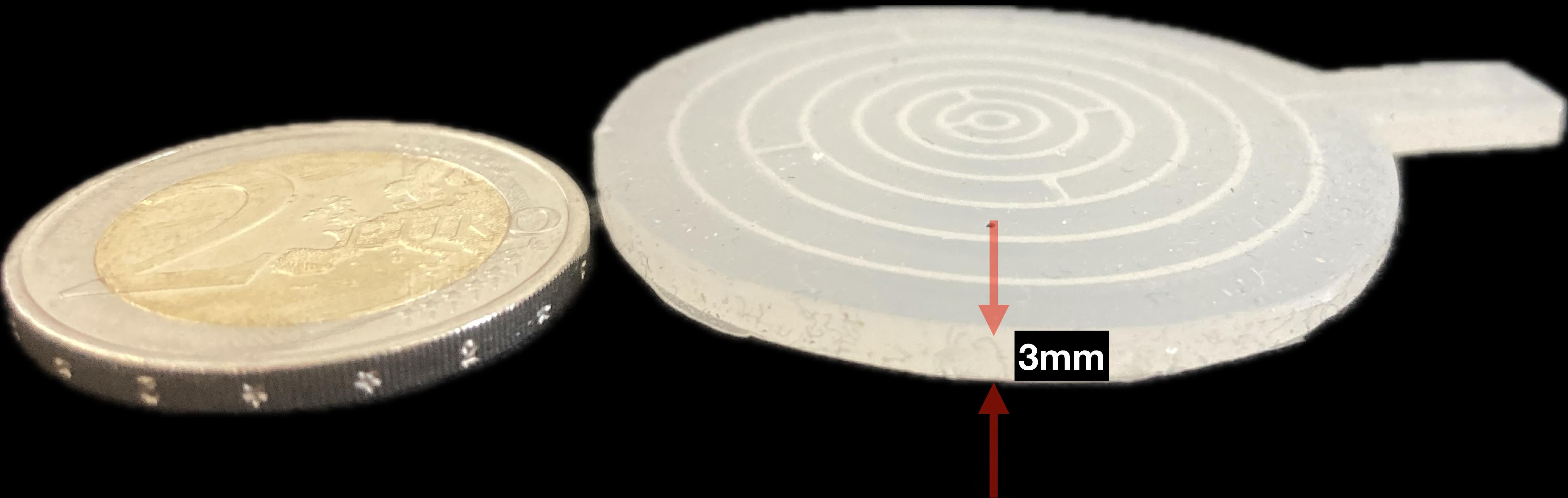


Amplitude

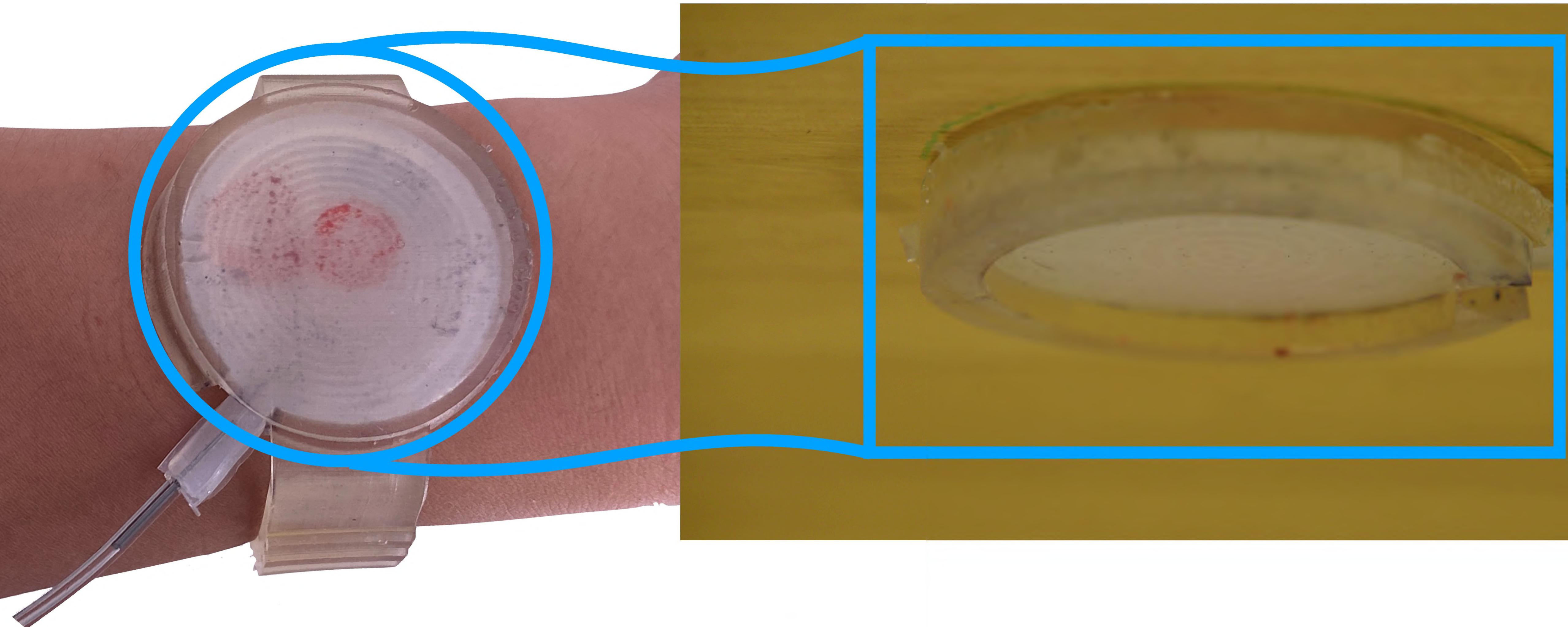


Zero-crossing

# Thin surface

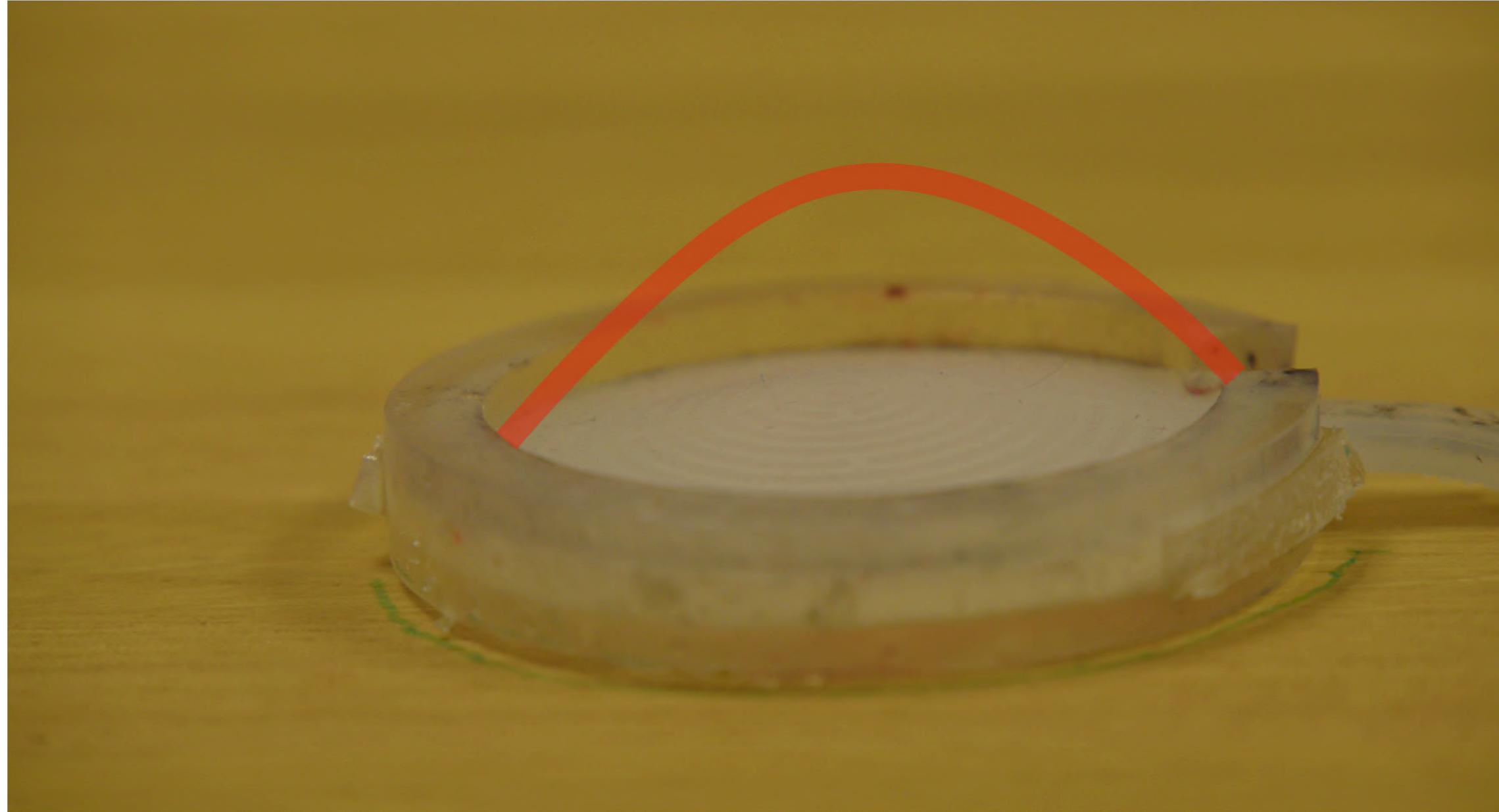


3mm

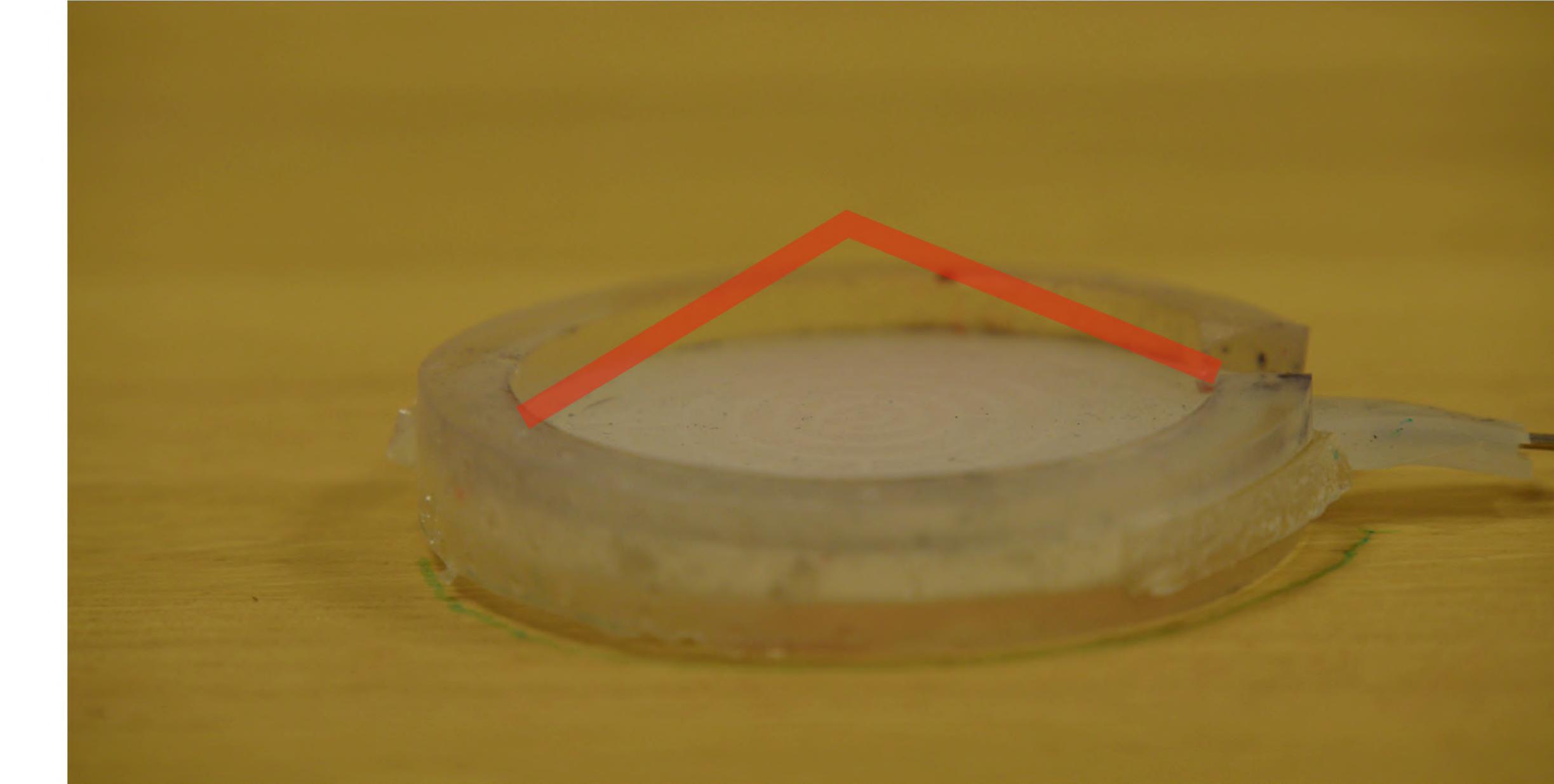


**Which shape change makes the deformation more noticeable?**

# Surfaces with different shape changes



Round



Pointy

# **Psychophysical experiment to measure the absolute detection threshold**

12 Participants (6 women, 6 men, median = 27 years)

Registration on [osf.io/cqv7f](https://osf.io/cqv7f)

# Independent variable

**Round**

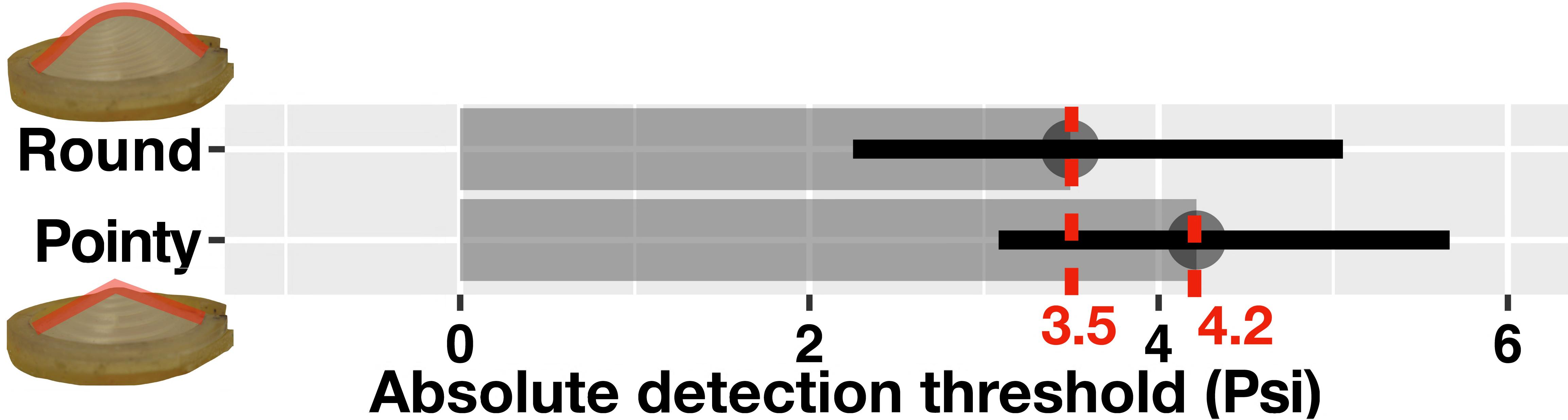


**Pointy**



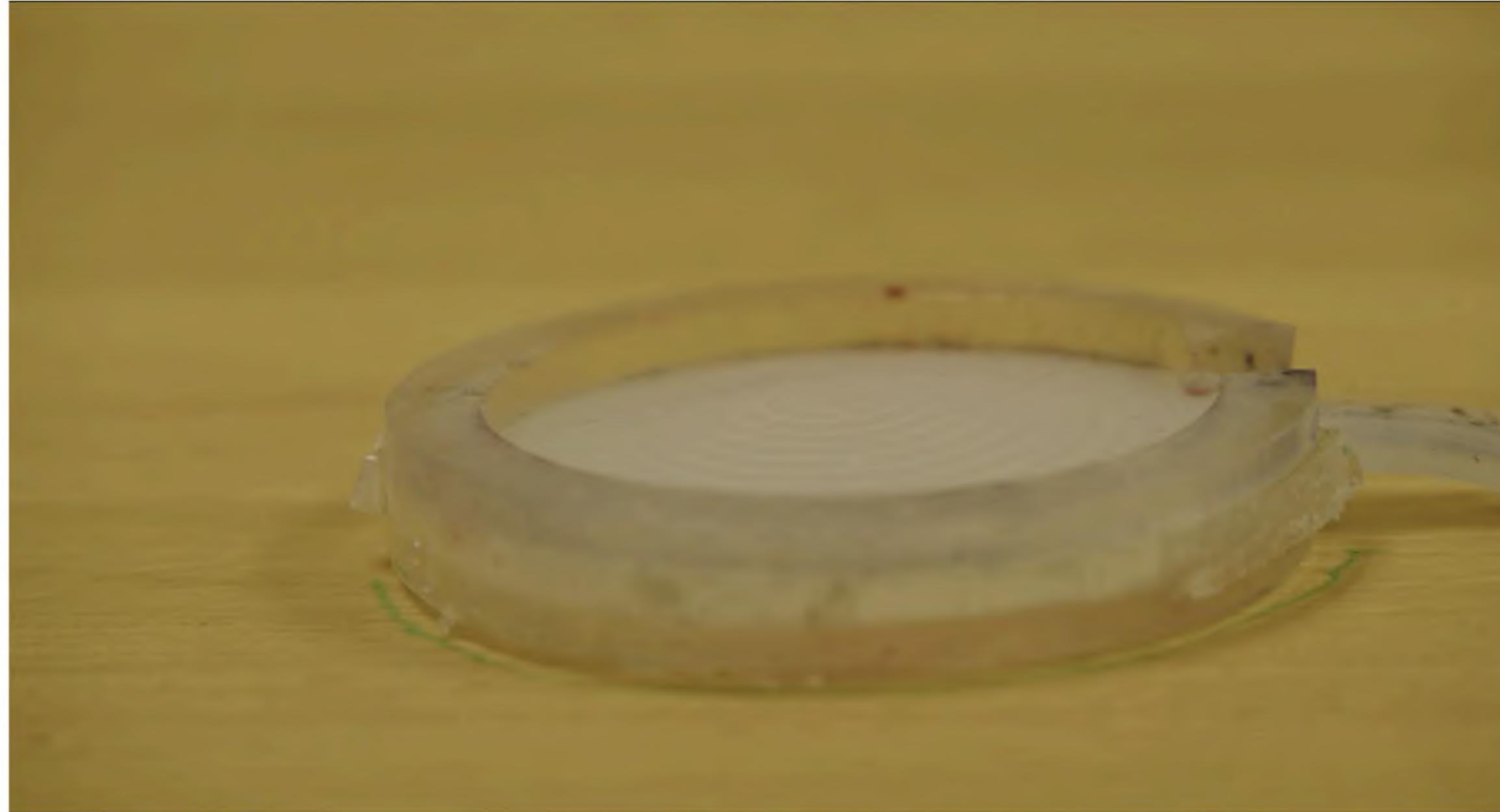
# Absolute detection threshold

# Low detection threshold

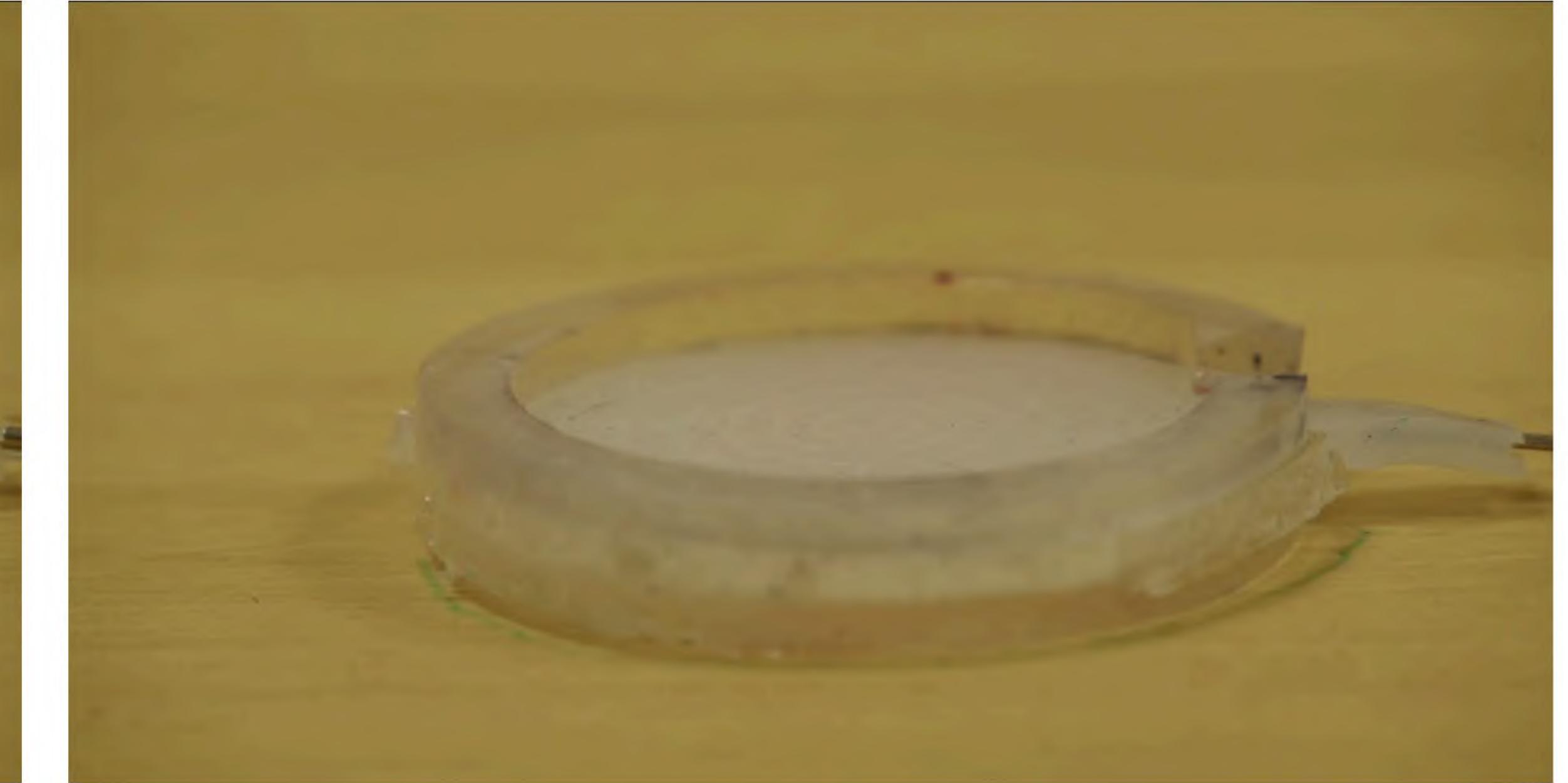


# **Efficient haptic feedback**

# Efficient haptic feedback

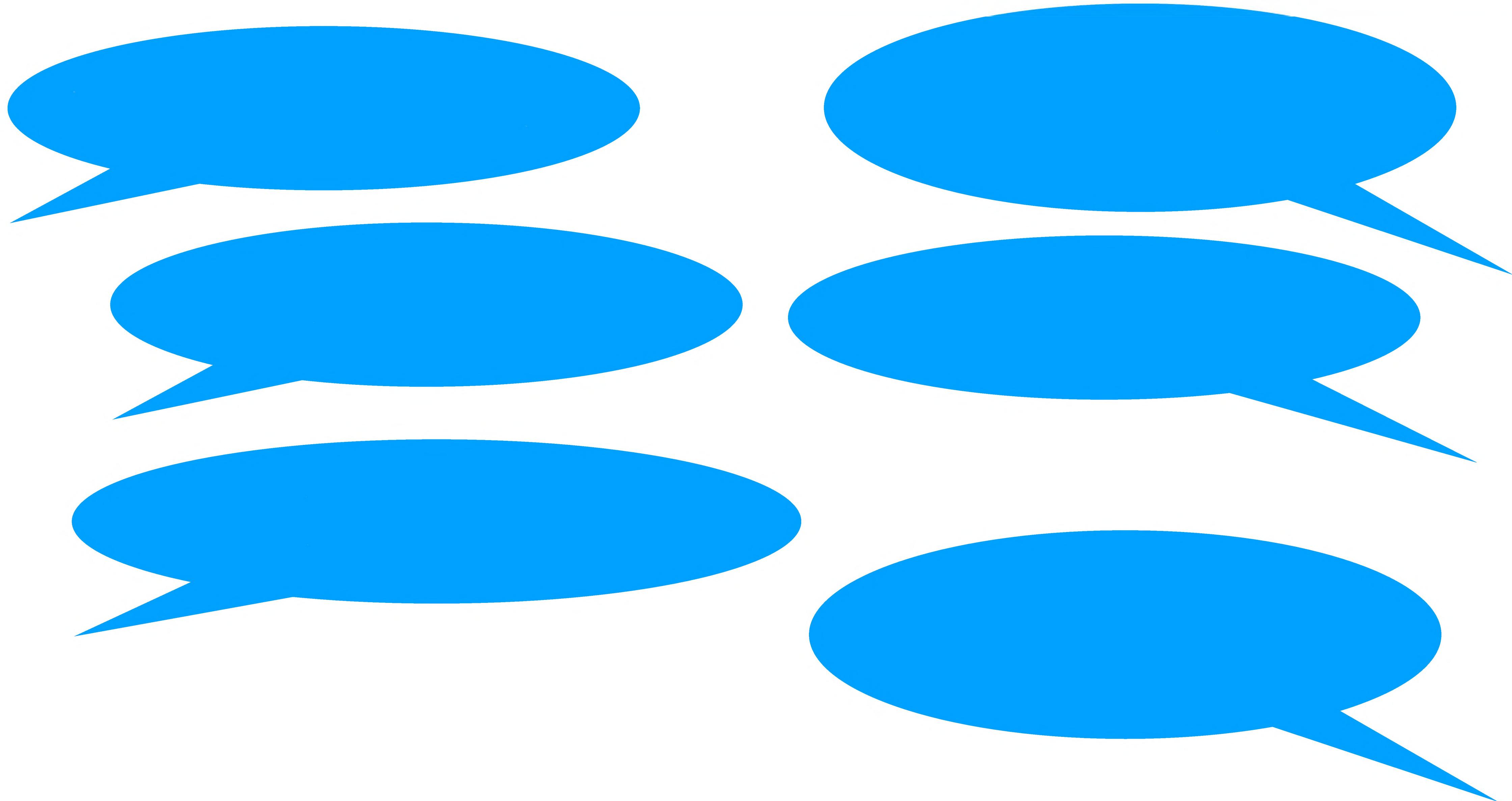


Round

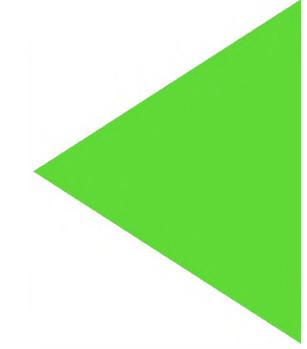


Pointy

# Qualitative feedback



New device design



Interaction beyond shapes

Challenges and future work

Interaction beyond shapes



Challenges and future work

Robustness

Stability

Modality Integration

TECHNOLOGICAL

Miniaturization and Resolution

Theory Development

Perception studies

USER BEHAVIOUR

User experience

In-situ Evaluations

Comparative Studies

# Developing shape-changing surfaces

Responsiveness

Platforms

Designing for Temporality

Application and Content

Instrumentation

End-user programming

Integrating Artefact and Interaction

Affordances

Appropriateness

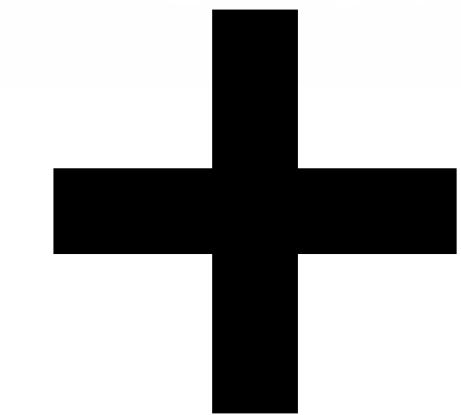
Configurations

Aesthetics

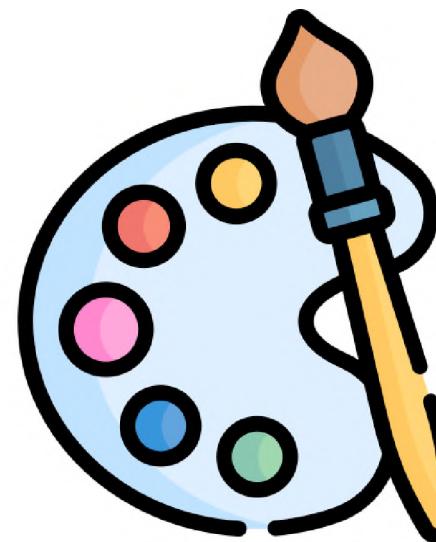
Meaning

Semantics

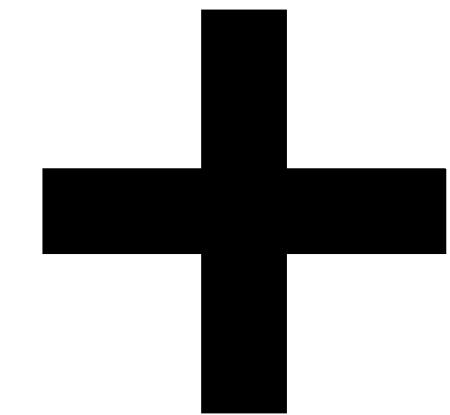
Hedonics



## Other interaction information beyond shapes?



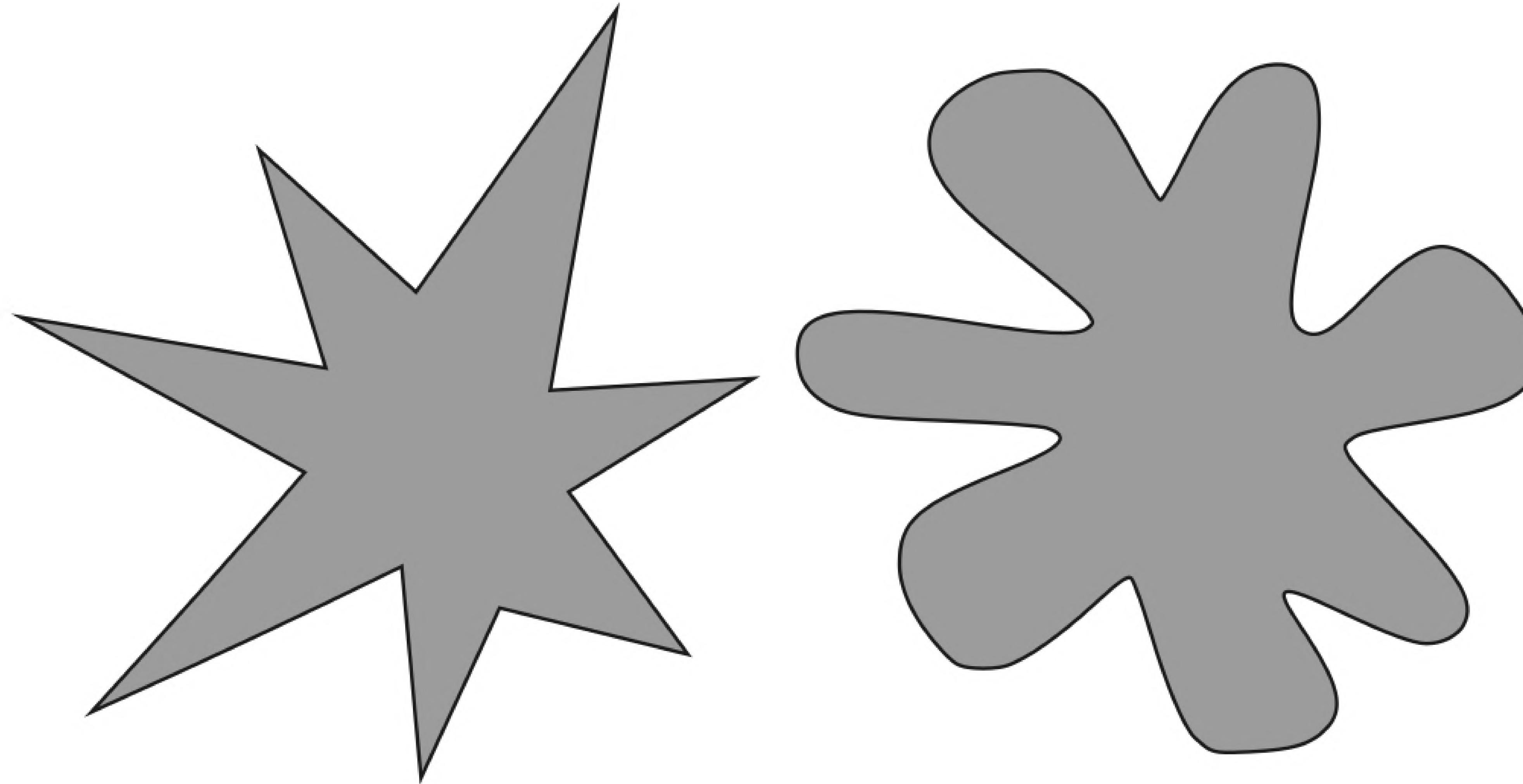
# Which shapes



# Which other interaction information

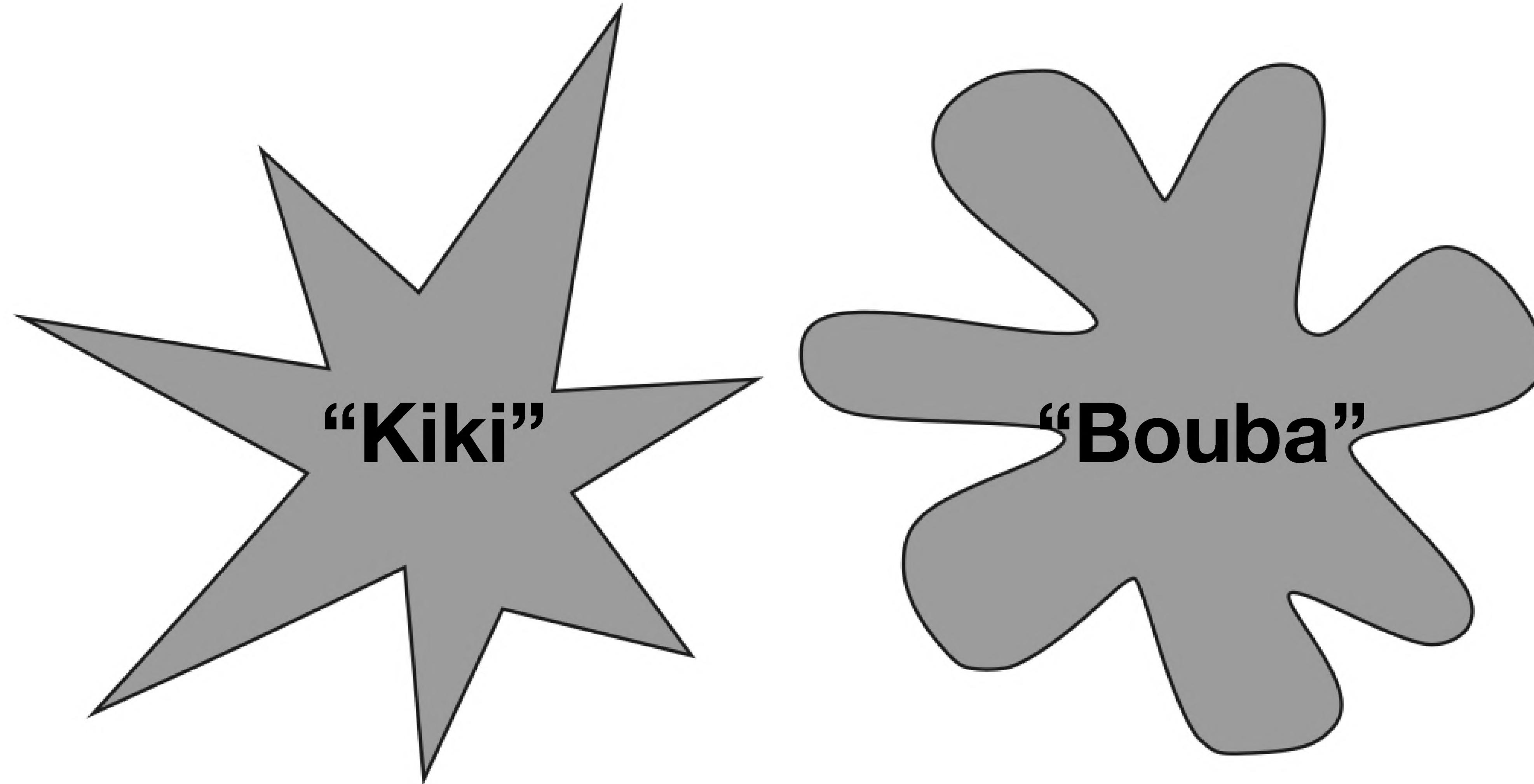
# **Cross-sensory correspondences**

# Auditory-visual association



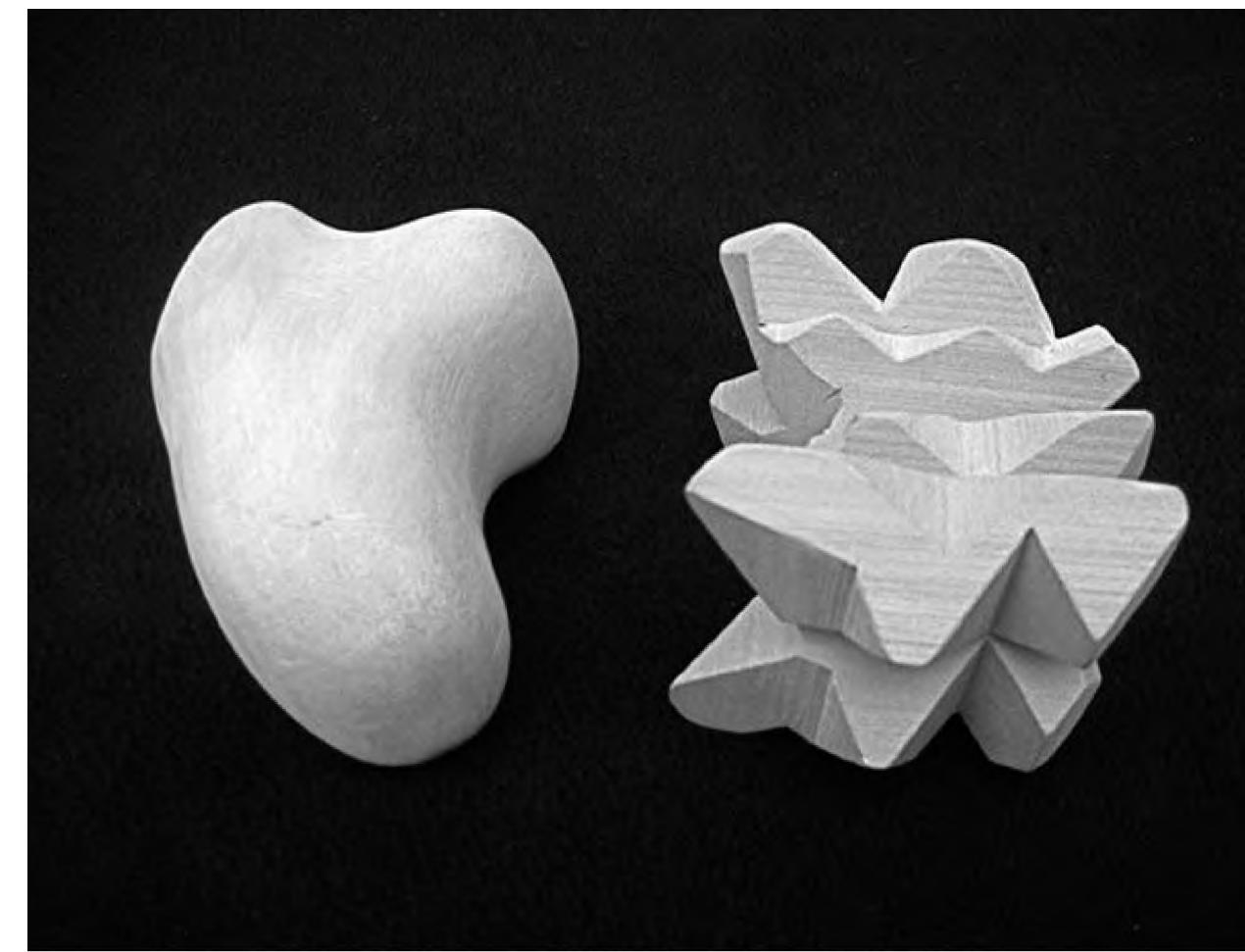
(Köhler, 1929)  
(Ramachandran & Hubbard, 2001)

# Auditory-visual association

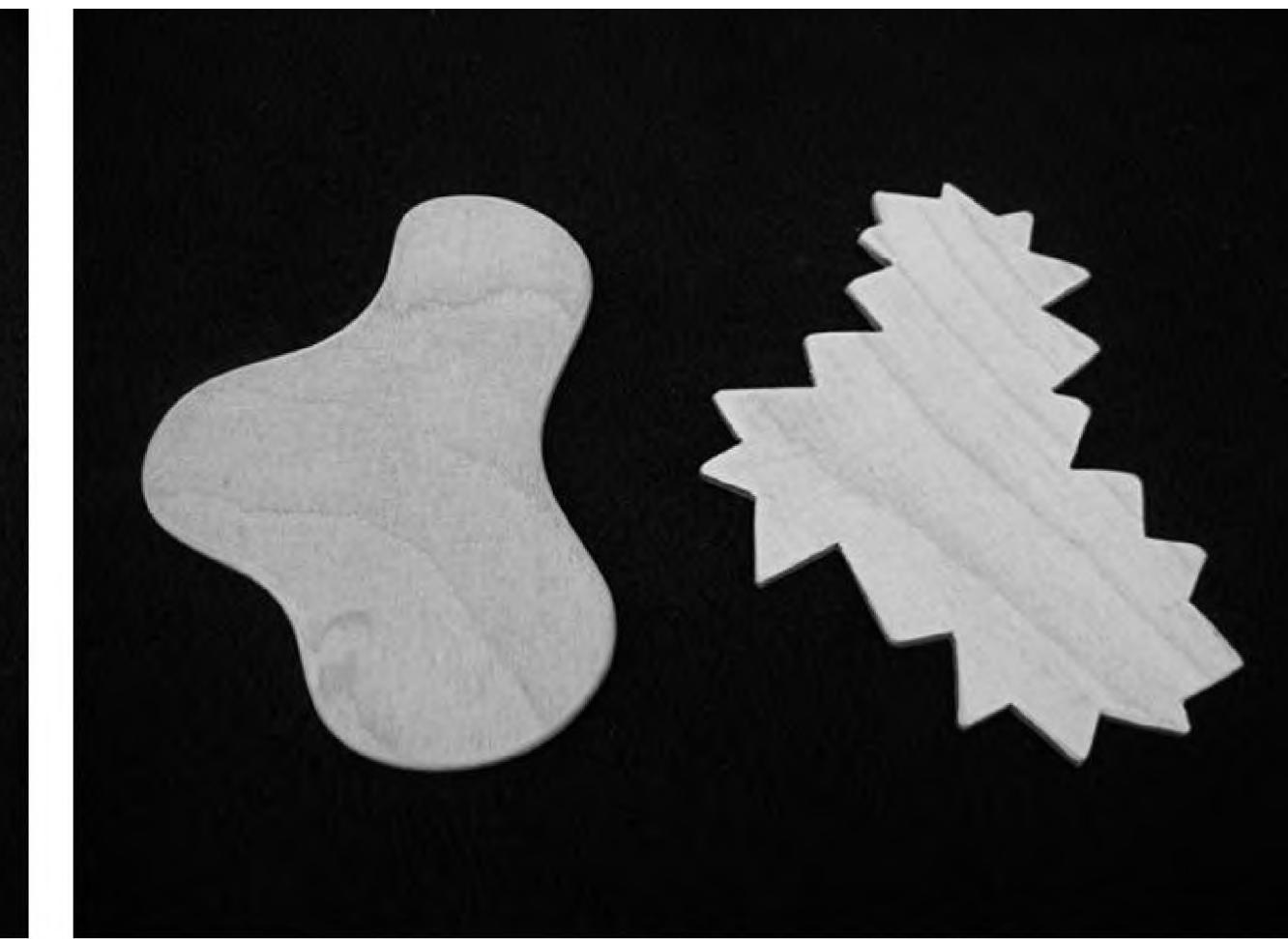


(Köhler, 1929)  
(Ramachandran & Hubbard, 2001)

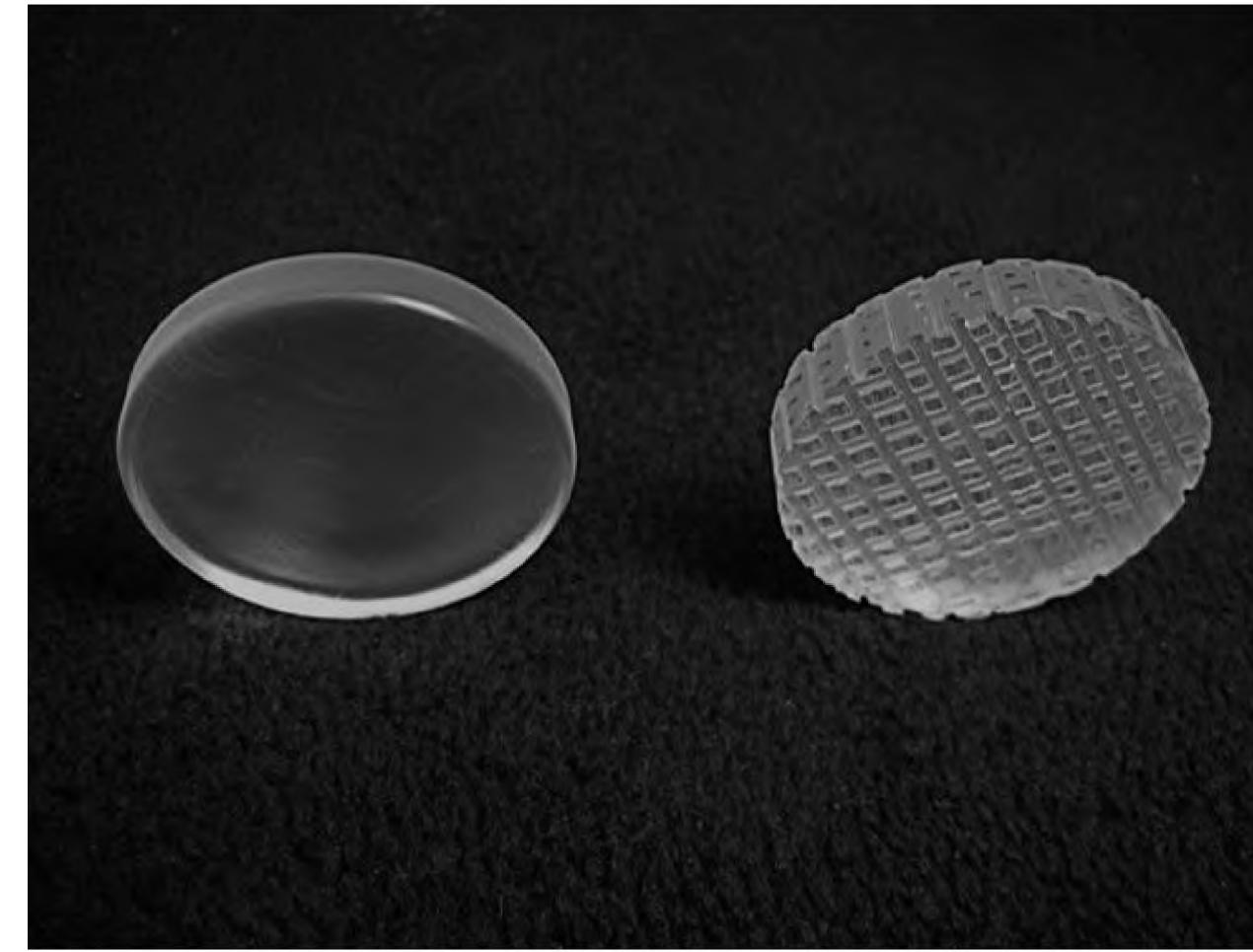
# Auditory-haptic association



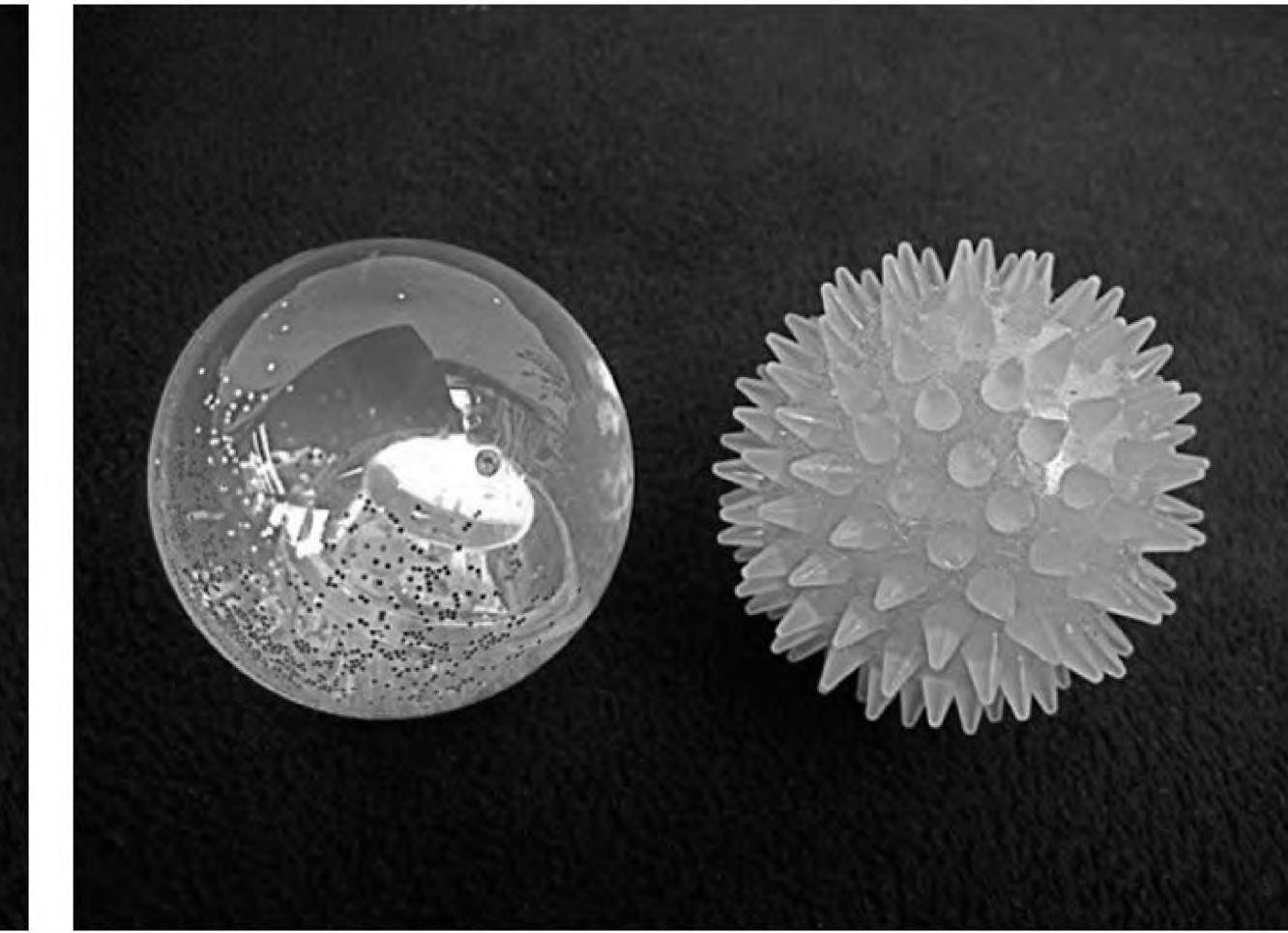
A



B



C



D

(Fryer et al., 2014)

# Auditory-haptic association

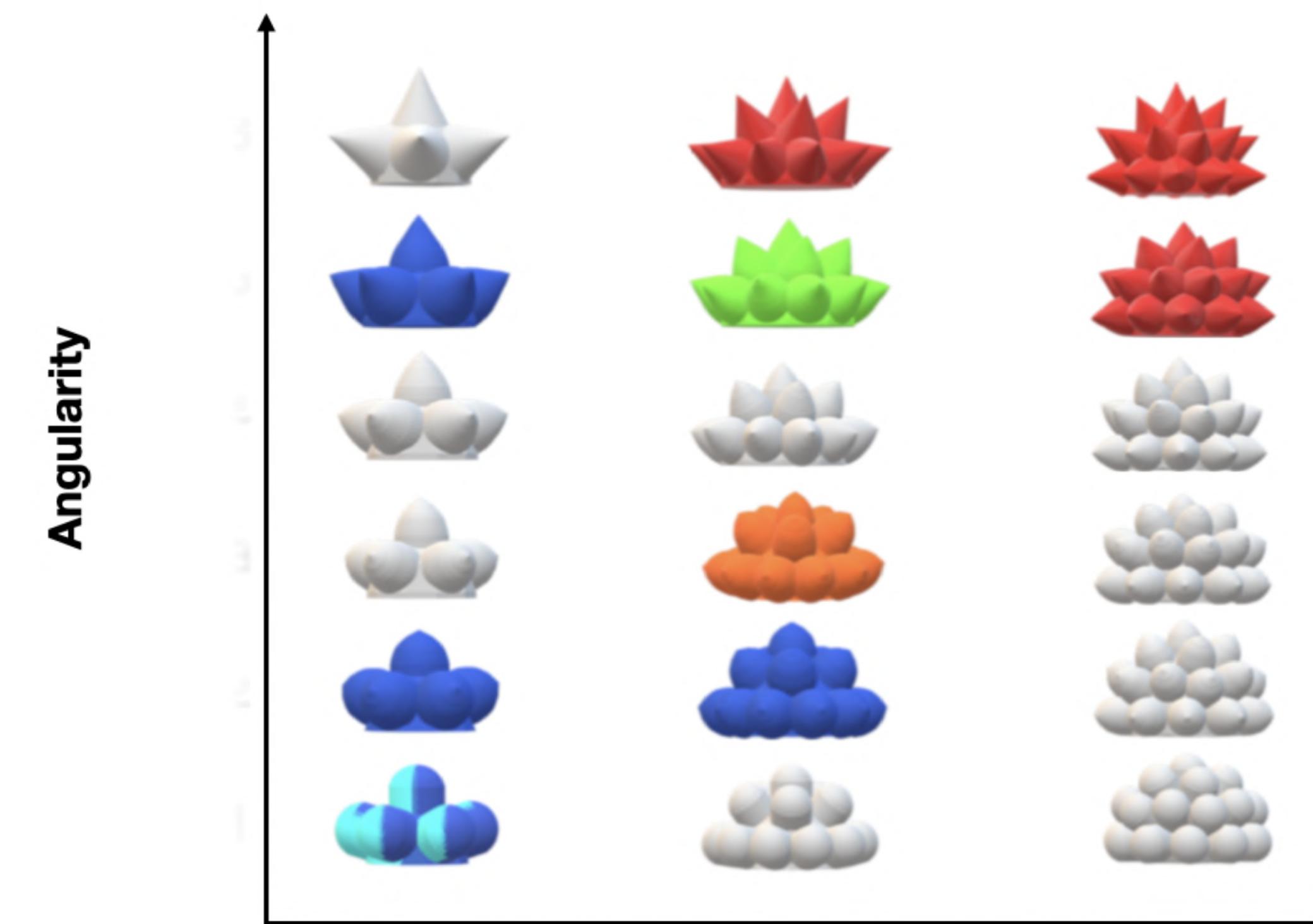


(Fryer et al., 2014)

# Haptic-olfactory association

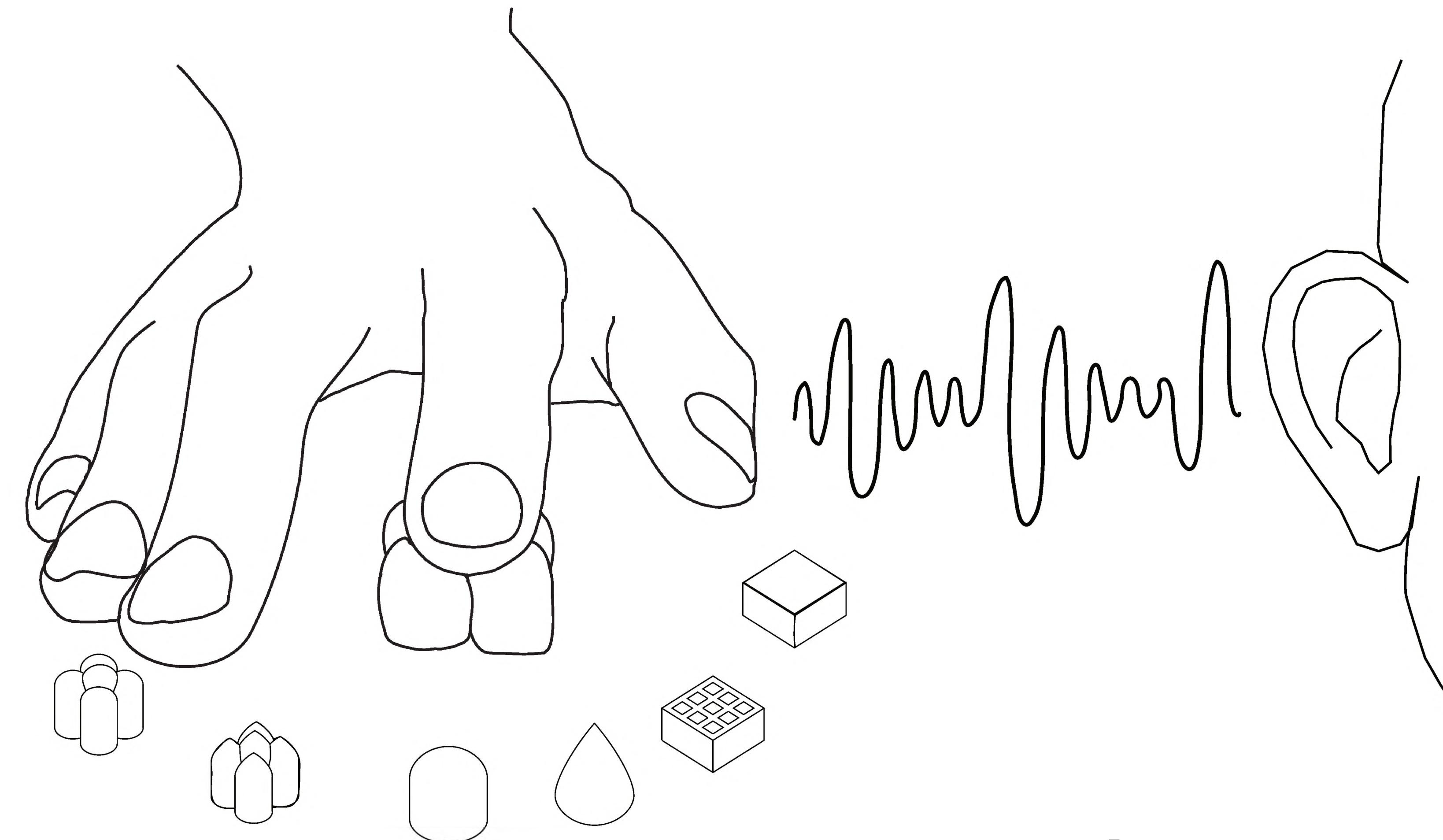


# Haptic-visual association

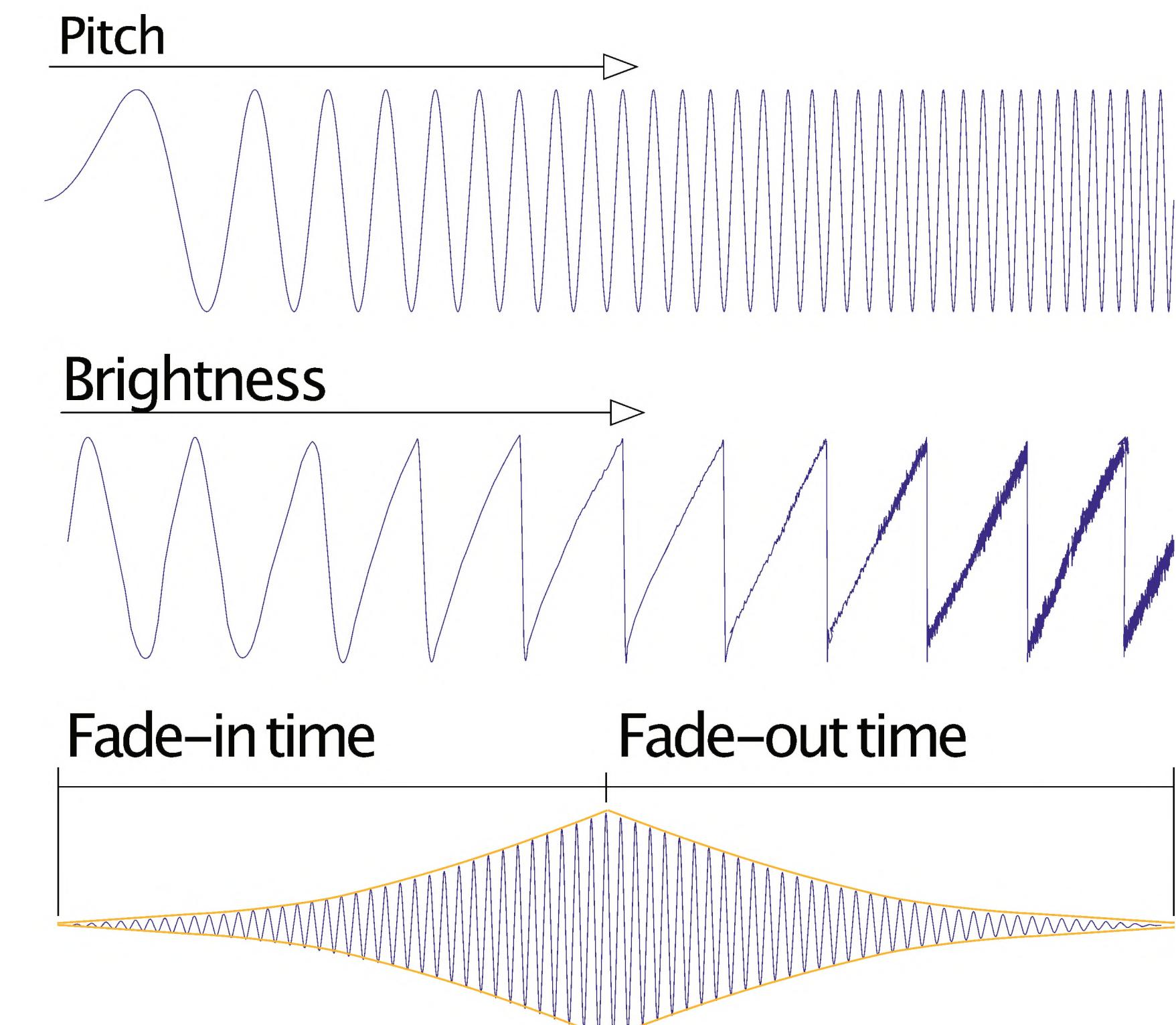


“Feeling Colours” [Lin et al. CHI’21]

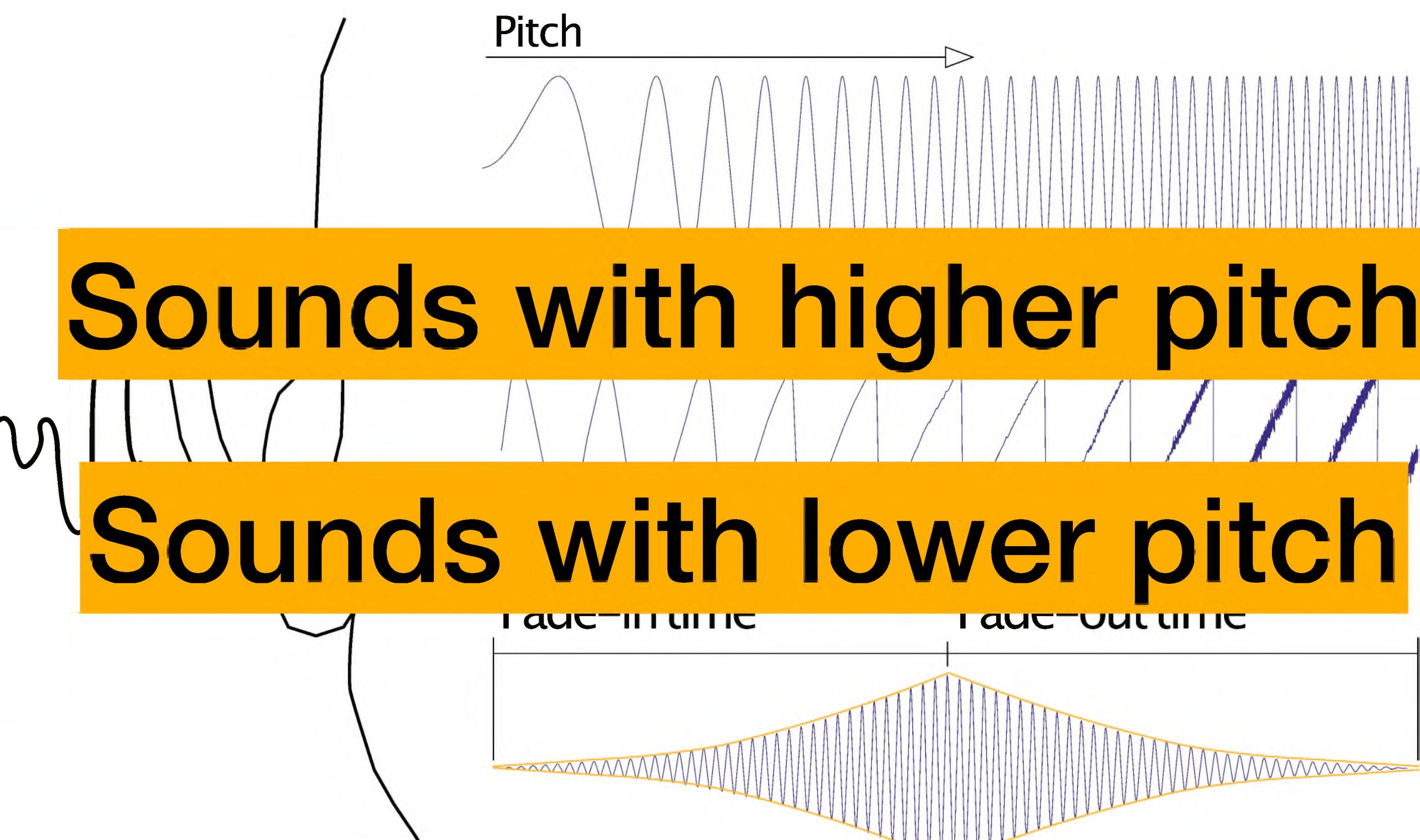
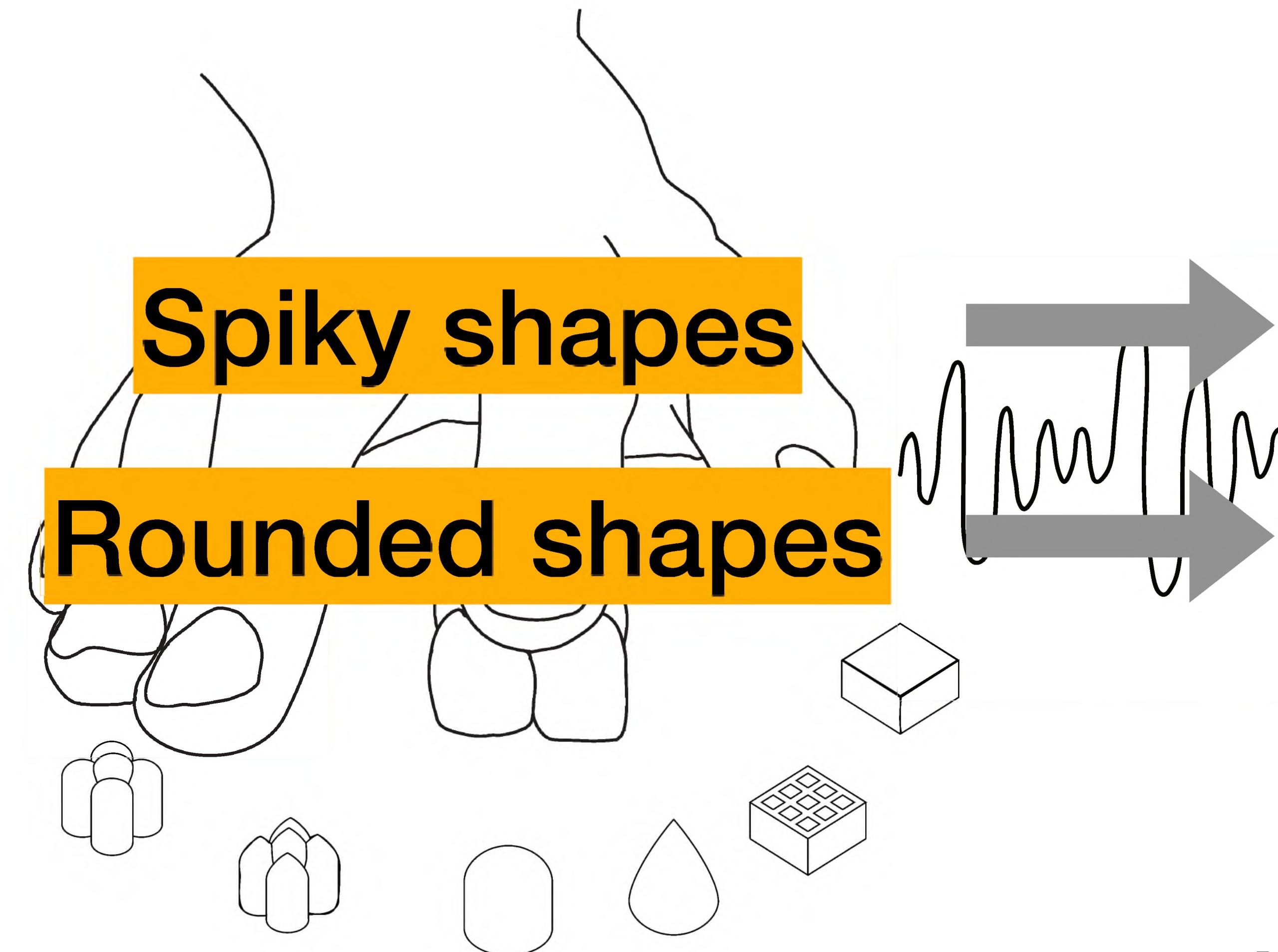
# Haptic-auditory association



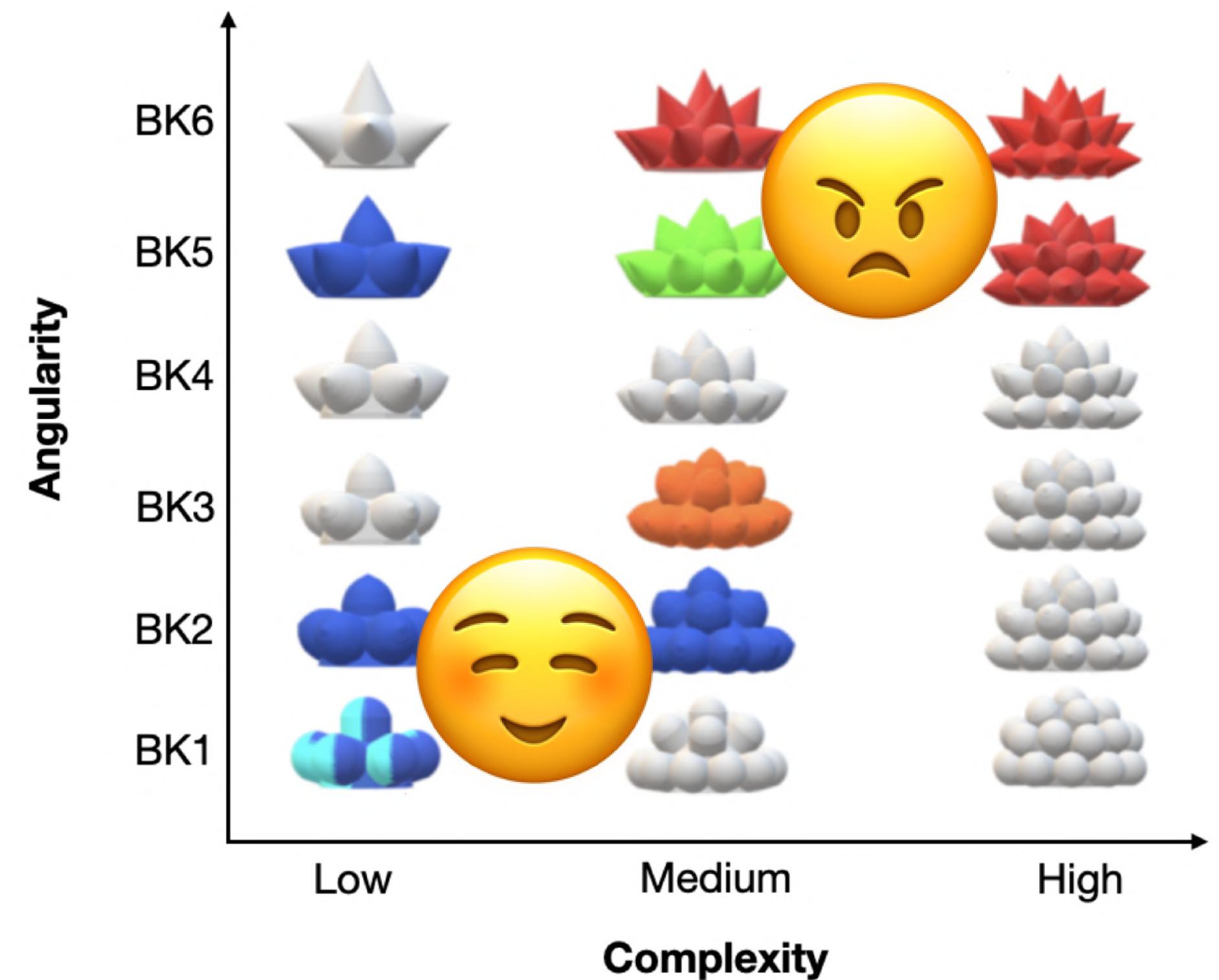
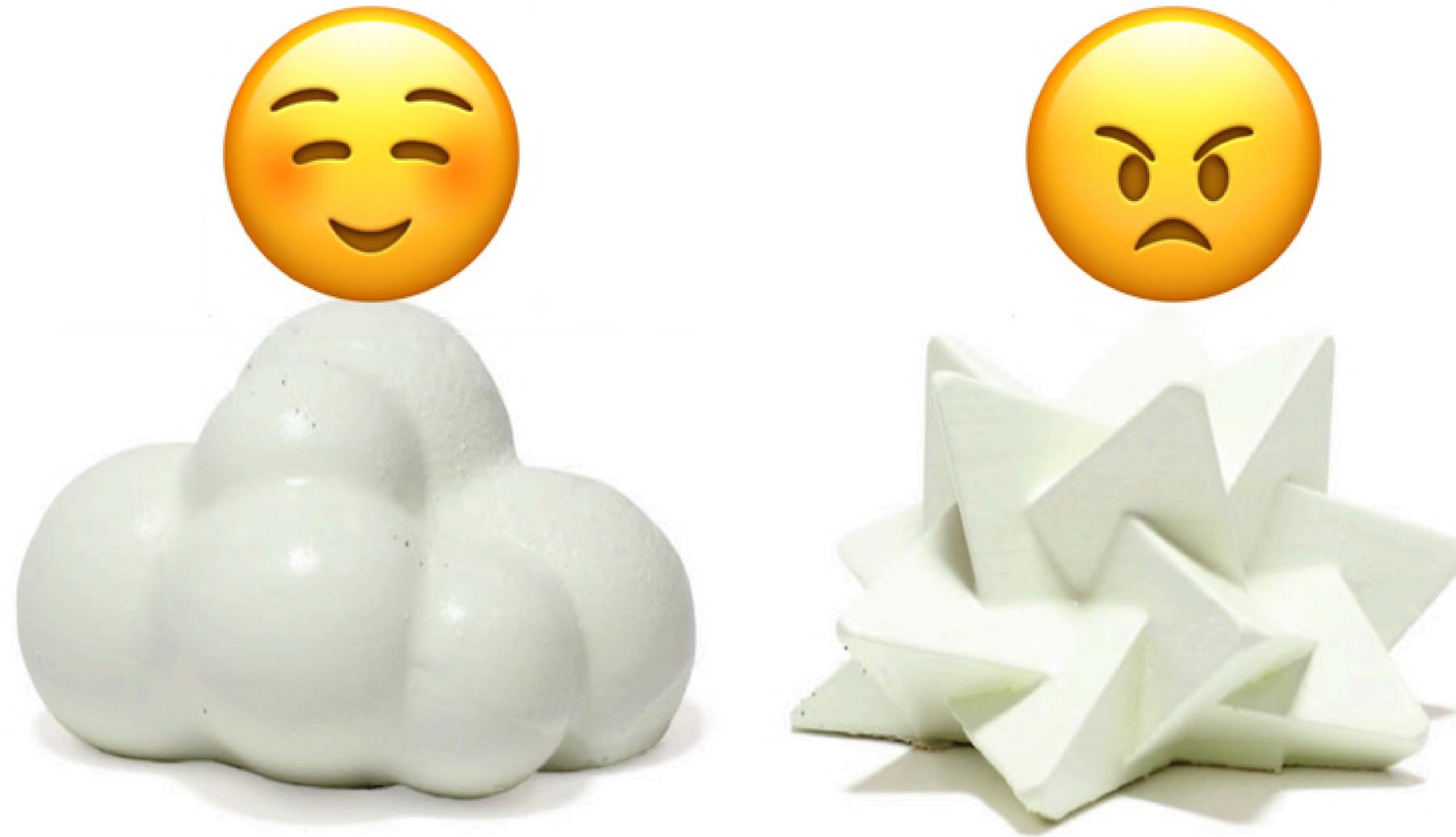
“It sounds squishy” [Palmer et al. DIS’25]



# Haptic-auditory association



# Haptic-emotion association



“Like Popcorn” [Metatla et al. CHI’19]

“Feeling Colours” [Lin et al. CHI’21]

Robustness

Stability

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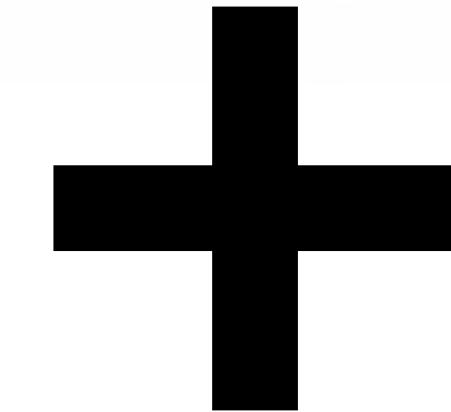
Configurations

Aesthetics

Meaning

Semantics

Hedonics



## Other interaction information beyond shapes?



## Interaction beyond shapes



## Challenges and future work

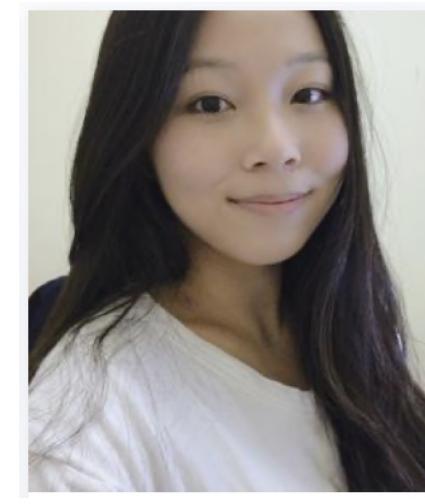
# Interaction through shape-changing surfaces



Main contributors:



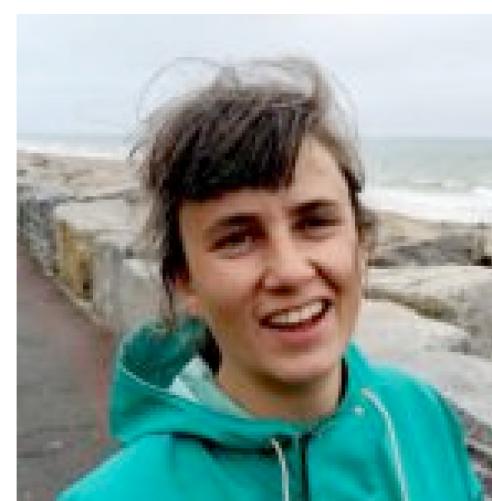
Zhuzhi Fan



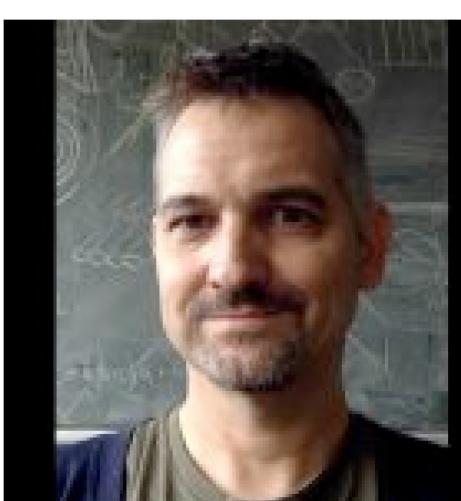
Susan Min Li



Tegan Roberts-Morgan



Céline Coutrix



Benoît Roman



Oussama Metatla

Funding projects:

CNRS 80 Prime MeMorl

ANR SecondSkin

ERC inclusive cross-sensory social play