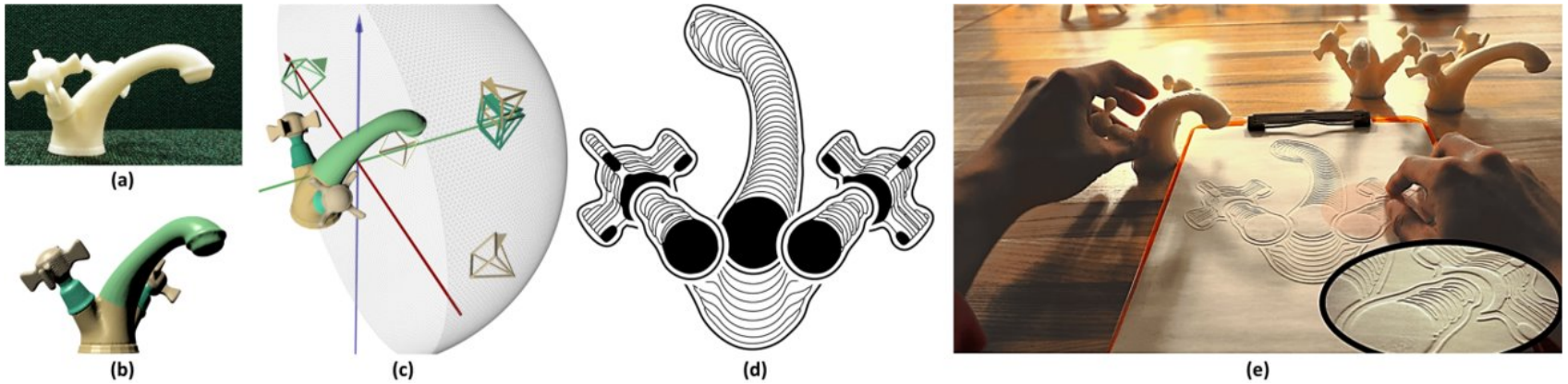
ShapeSonic: Sonifying Fingertip Interactions for Non-Visual Virtual Shape Perception

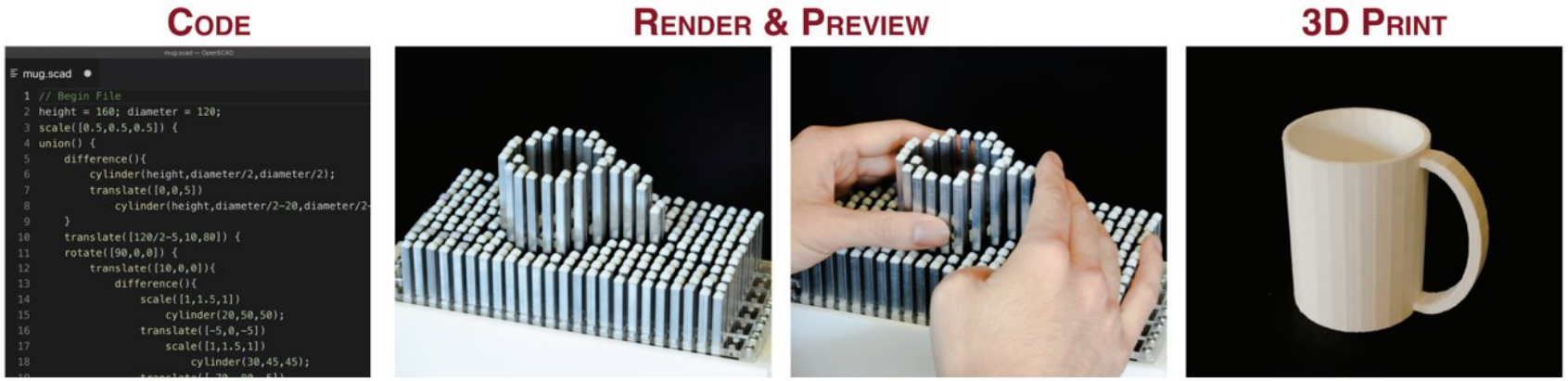
Jialin Huang George Mason University
Rana Hanocka University of Chicago
Alexa Siu Adobe Research
Yotam Gingold George Mason University

How can we create a non-visual interface for shape perception?

Tactile Approaches

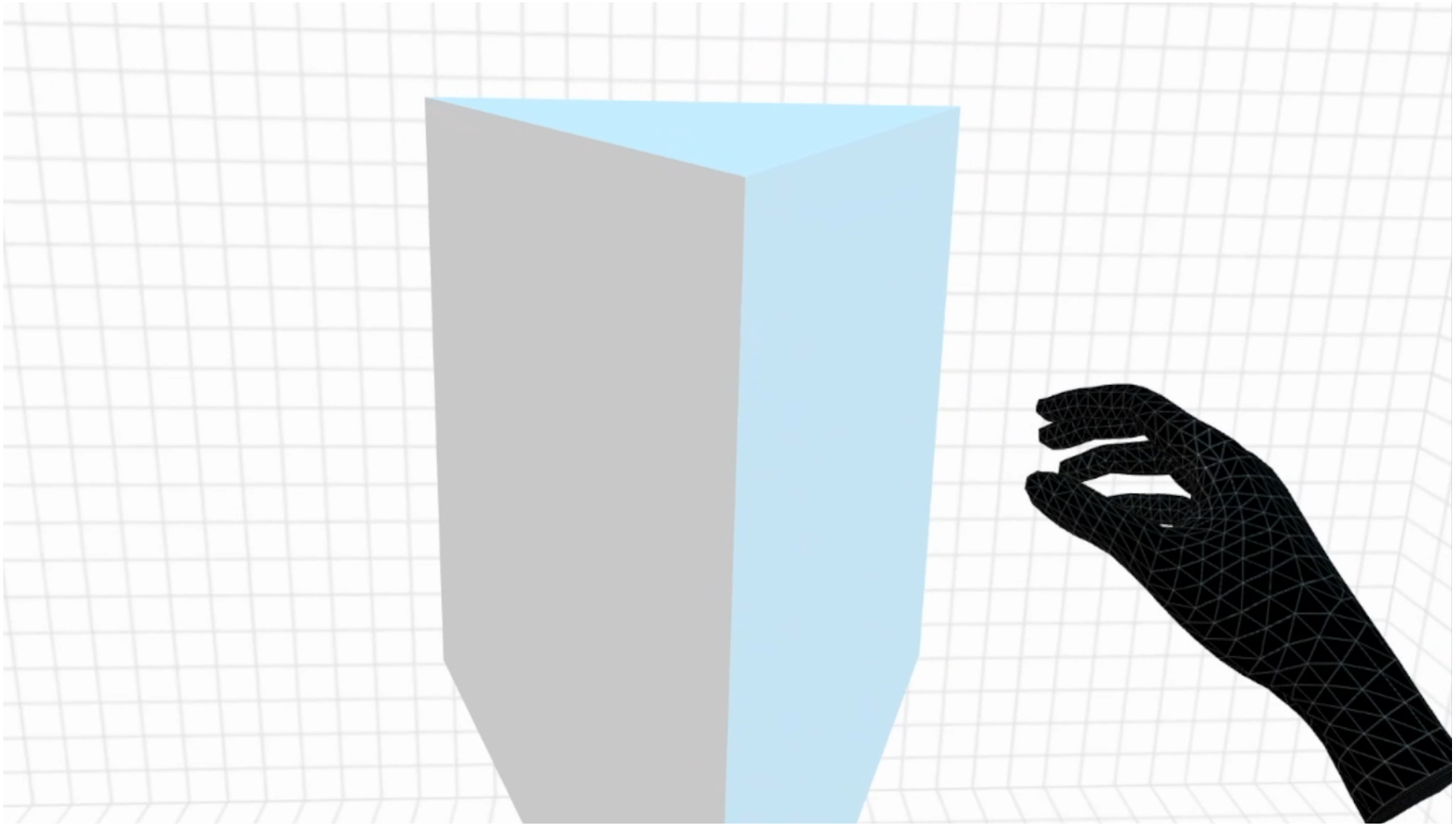


[Panotopoulou et al. 2020]

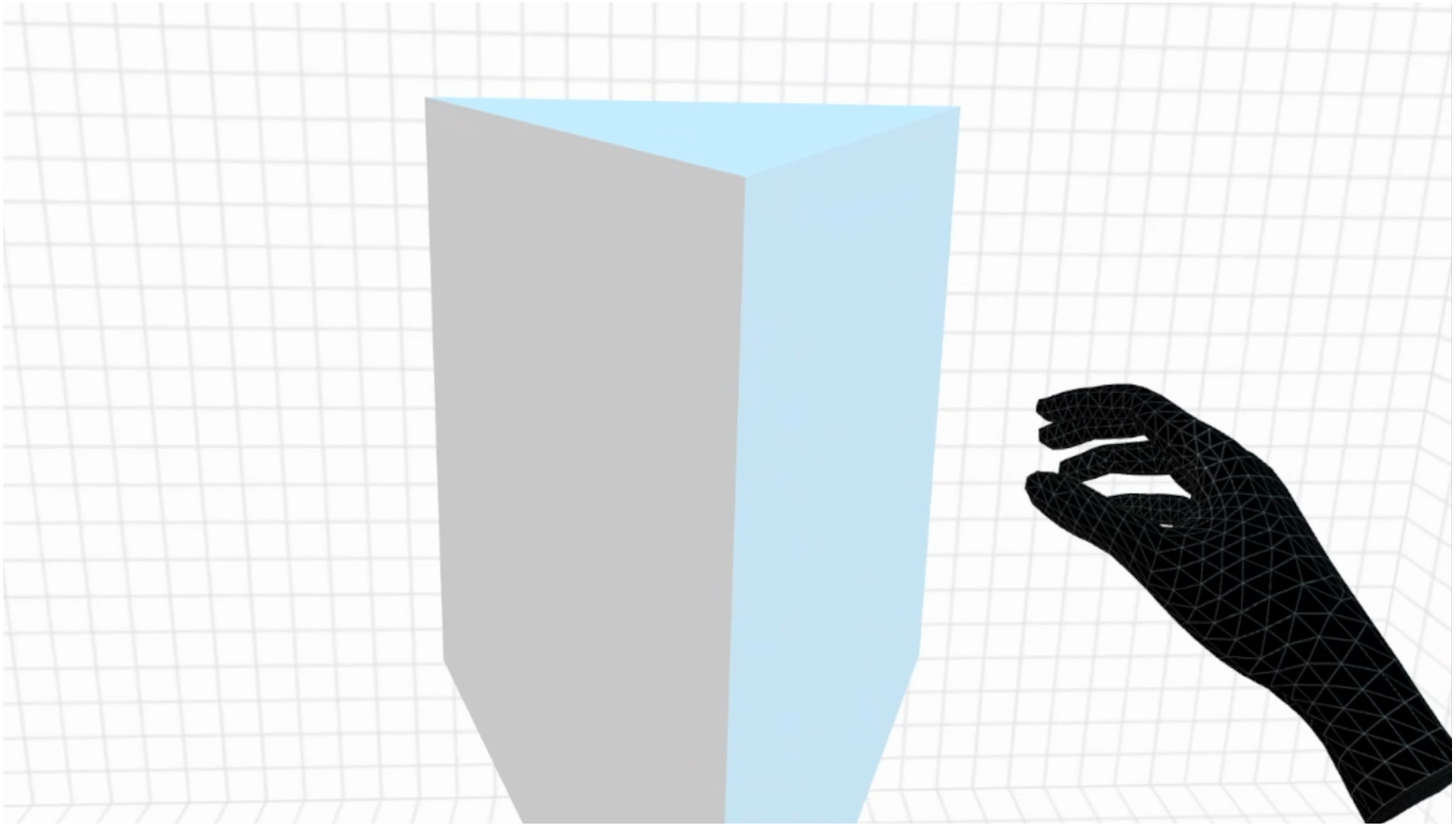


[Siu et al. 2019]

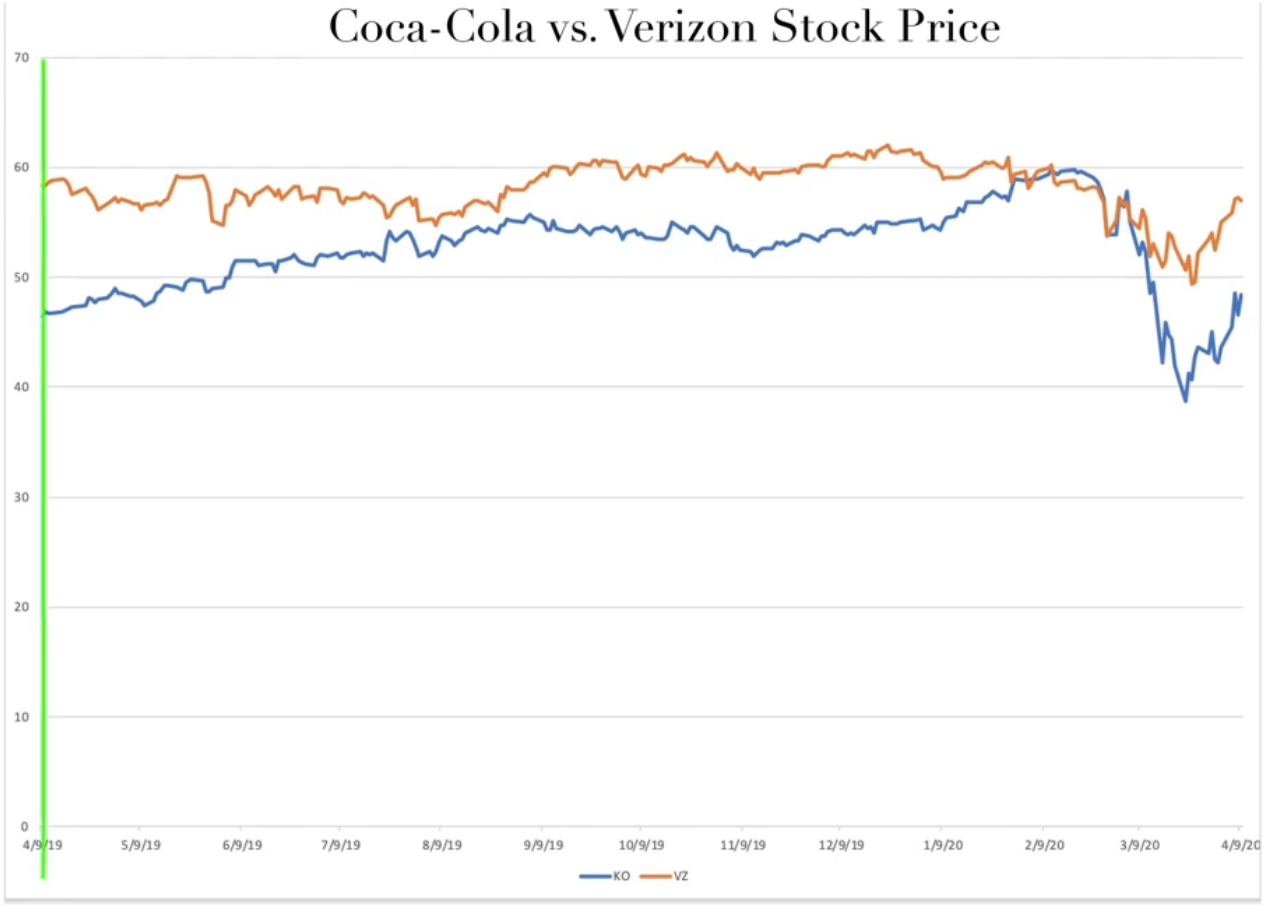
ShapeSonic is a sonification-based approach for perceiving shapes



ShapeSonic is a sonification-based approach for perceiving shapes



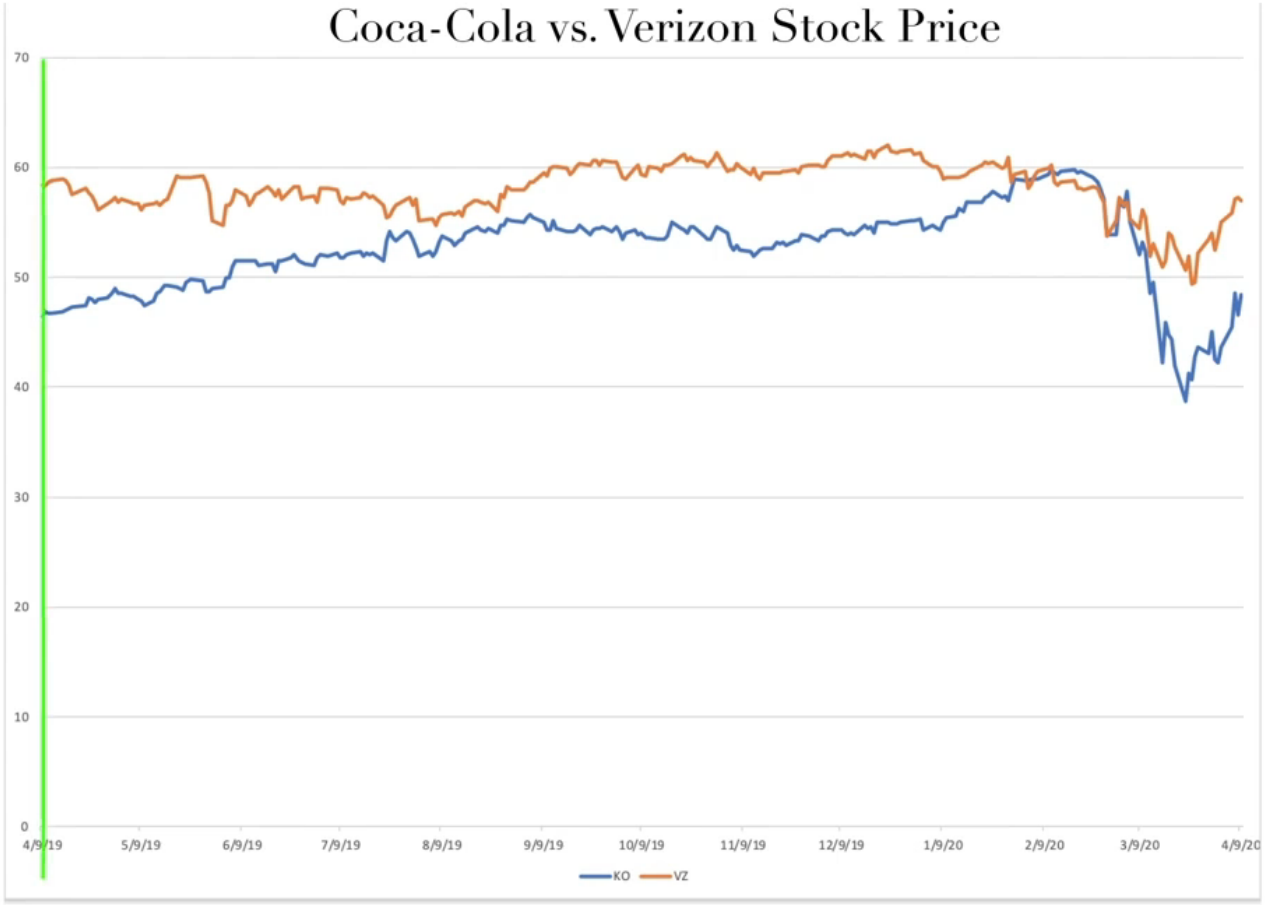
Sonification is mapping information to sound



CocaCola = Piano
Verizon = Marimba

*Stock price is still indicated by pitch.

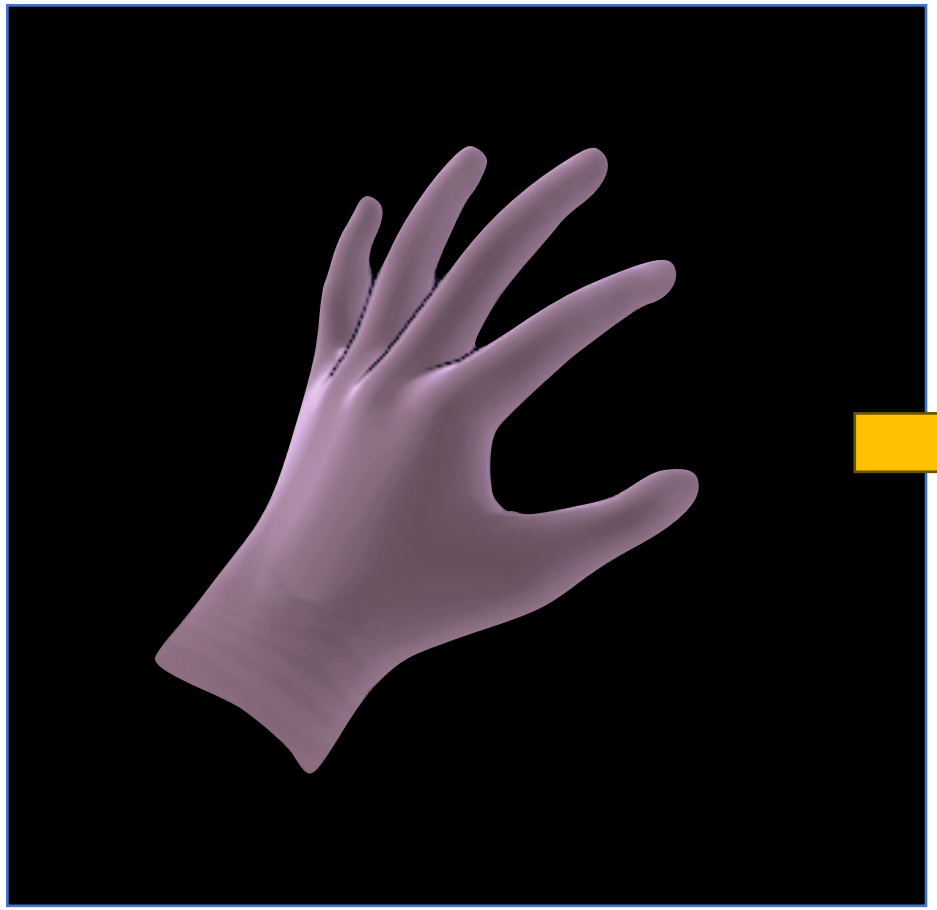
Sonification is mapping information to sound



CocaCola = Piano
Verizon = Marimba

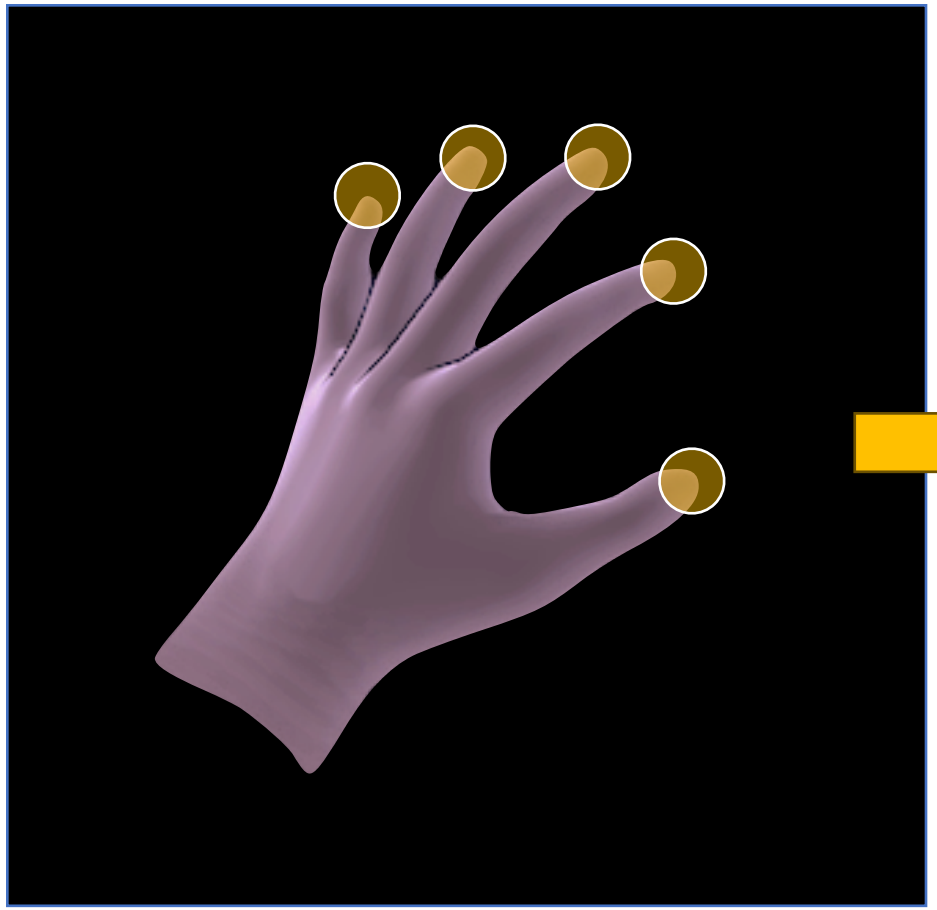
*Stock price is still indicated by pitch.

How should hands map to sound?



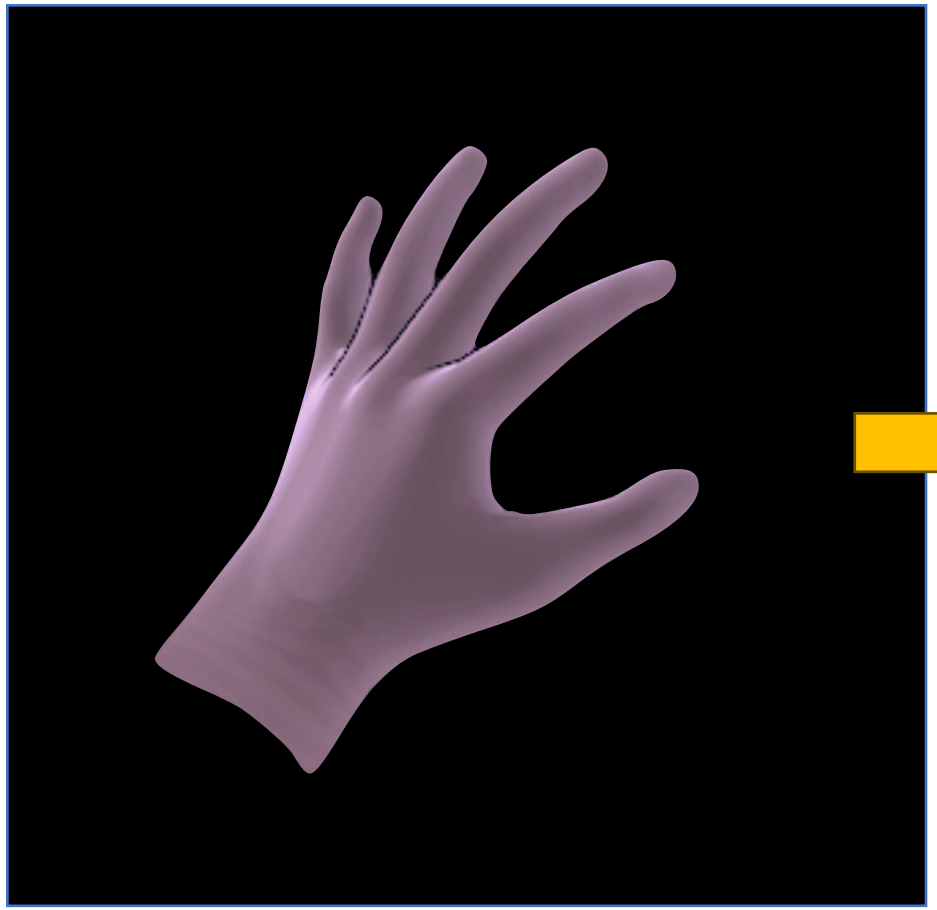
- Volume
- Pitch
- Timbre
- Spatialization
- Tempo
- …

How should hands map to sound?



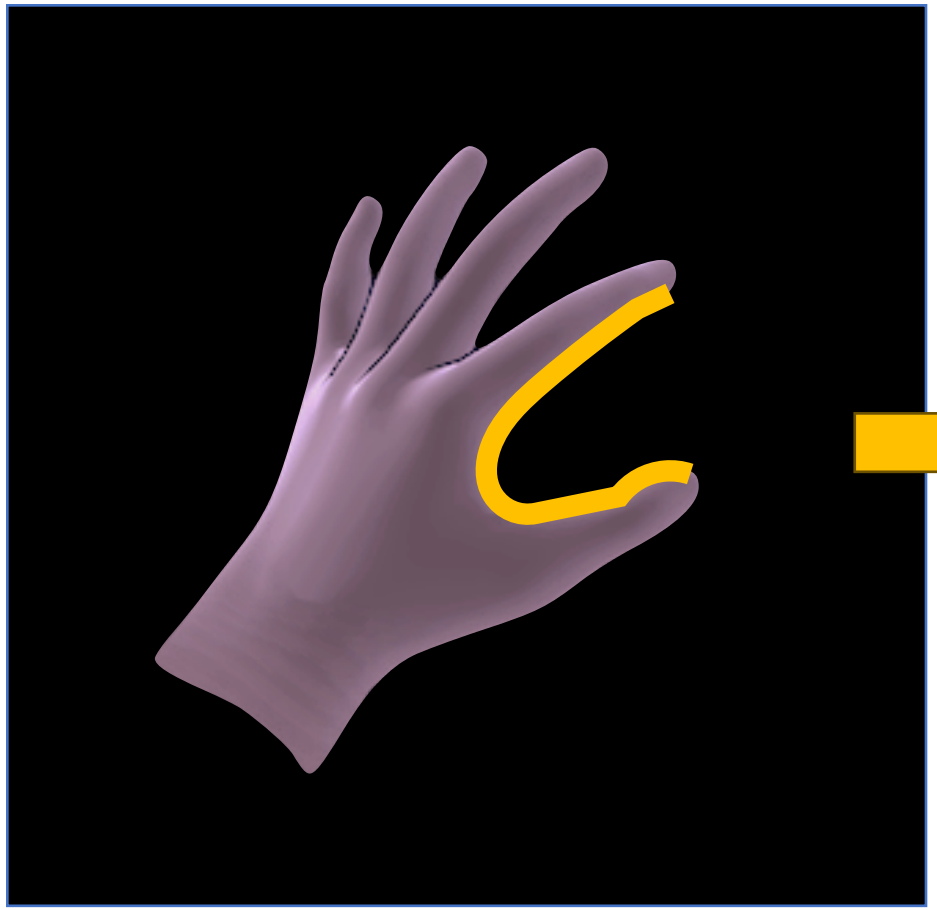
- Volume
- Pitch
- Timbre
- Spatialization
- Tempo
- …

How should hands map to sound?



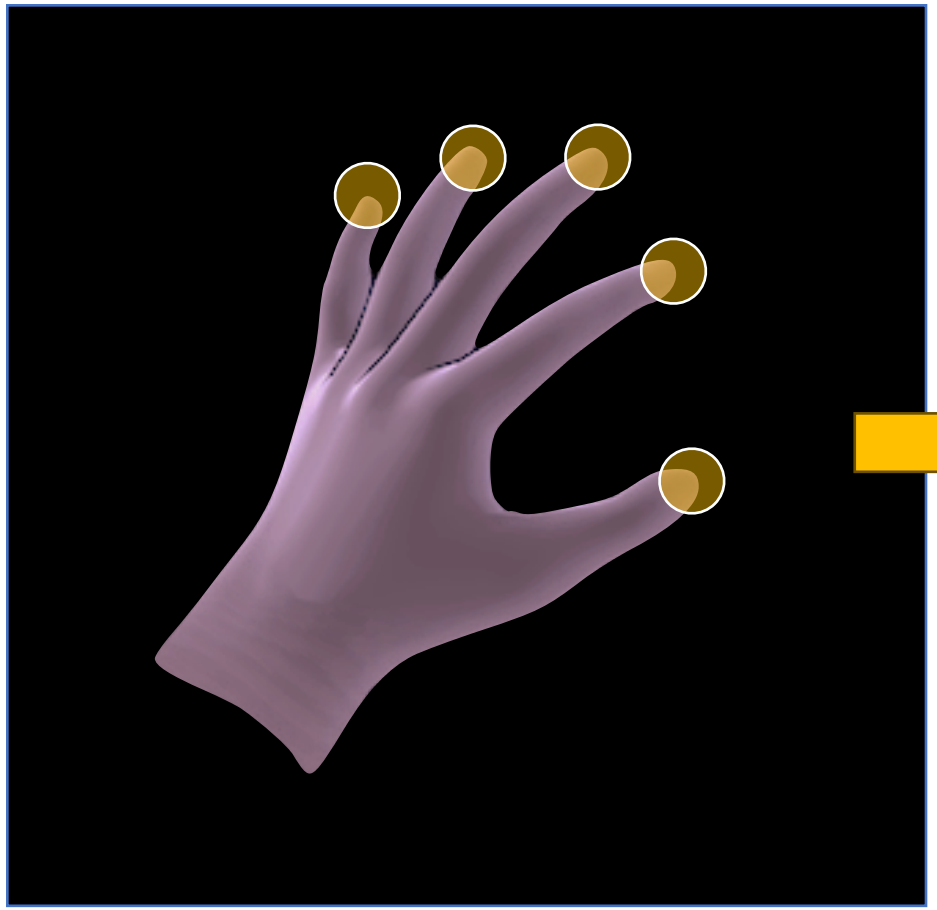
- Volume
- Pitch
- Timbre
- Spatialization
- Tempo
- …

How should hands map to sound?



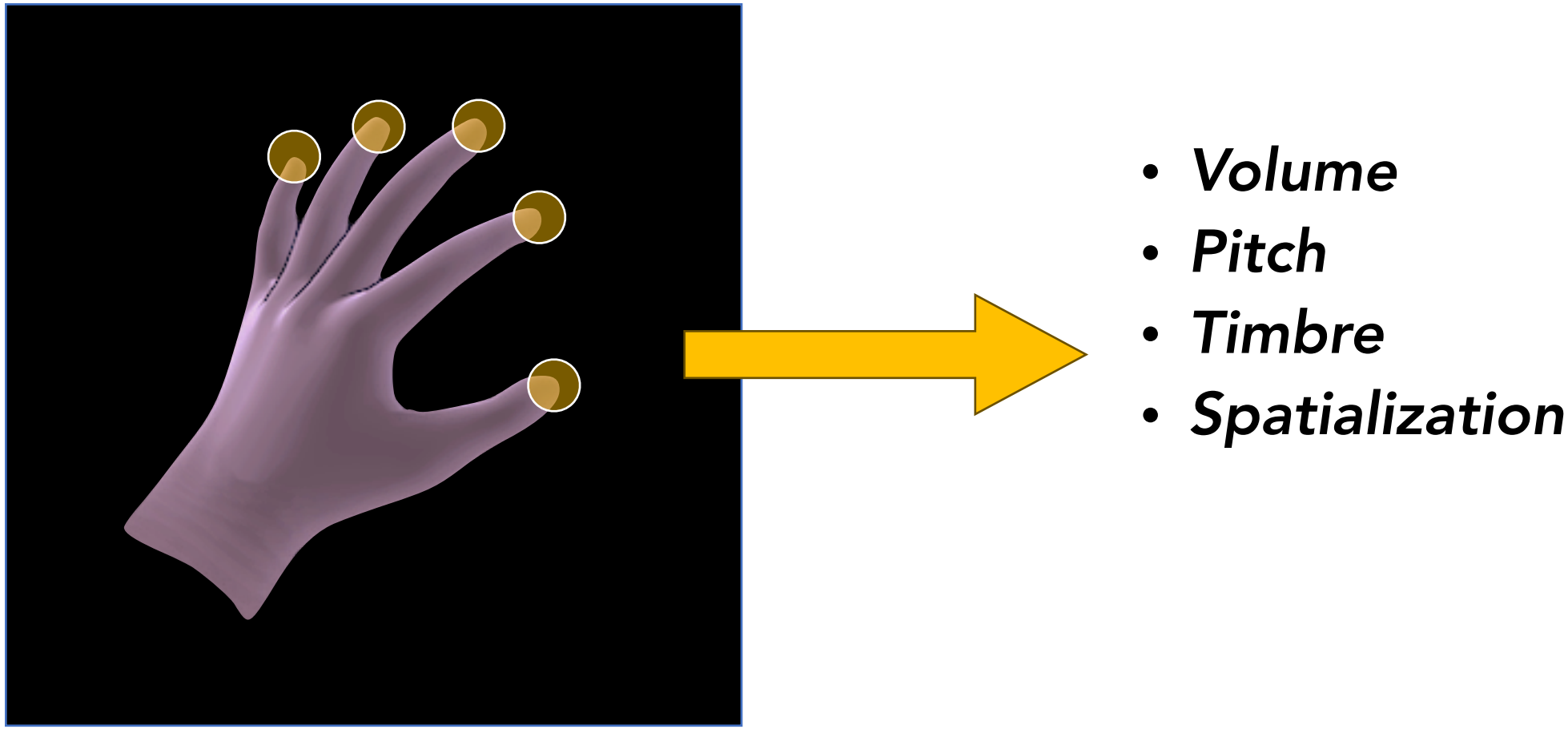
- Volume
- Pitch
- Timbre
- Spatialization
- Tempo
- …

How should hands map to sound?



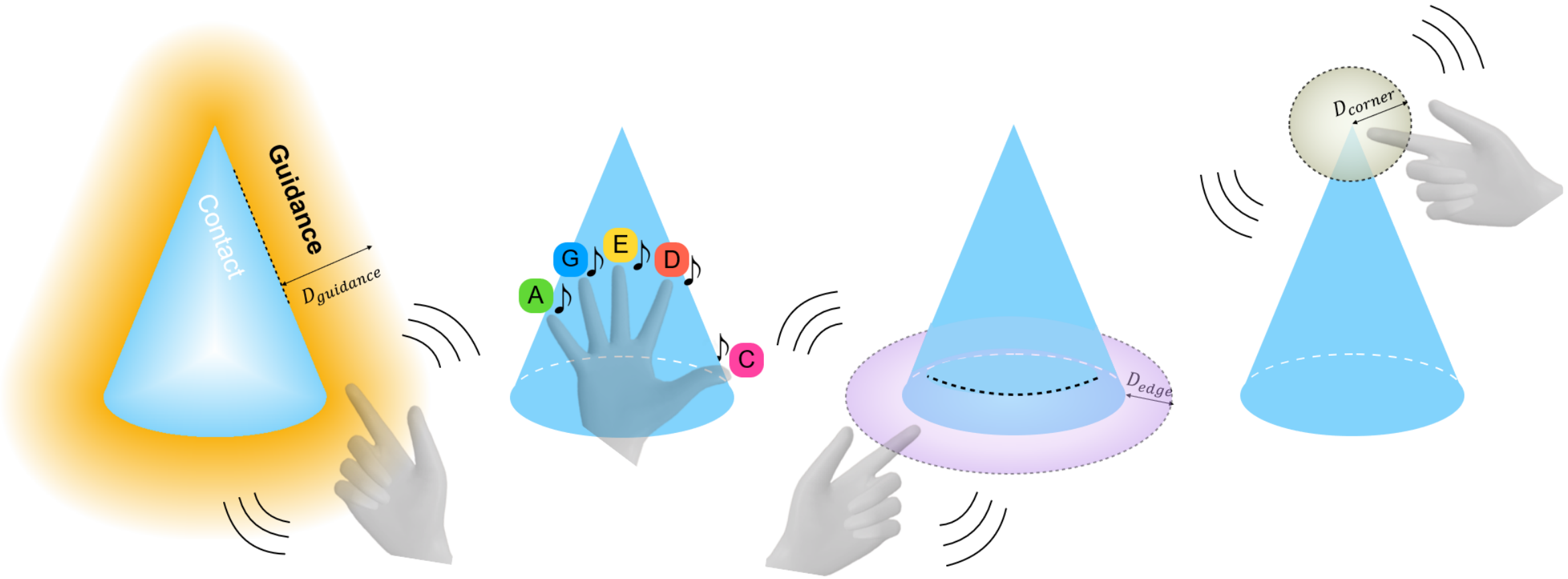
- Volume
- Pitch
- Timbre
- Spatialization
- Tempo
- …

How should hands map to sound?

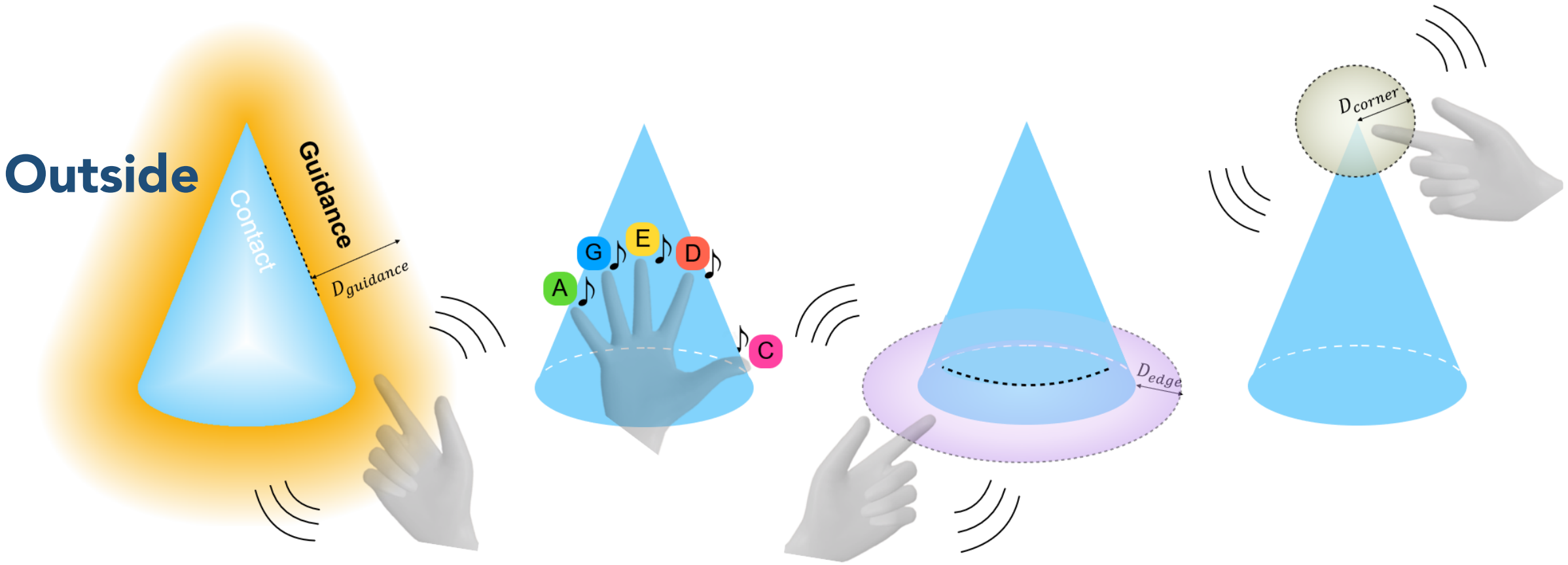


- *Volume*
- *Pitch*
- *Timbre*
- *Spatialization*

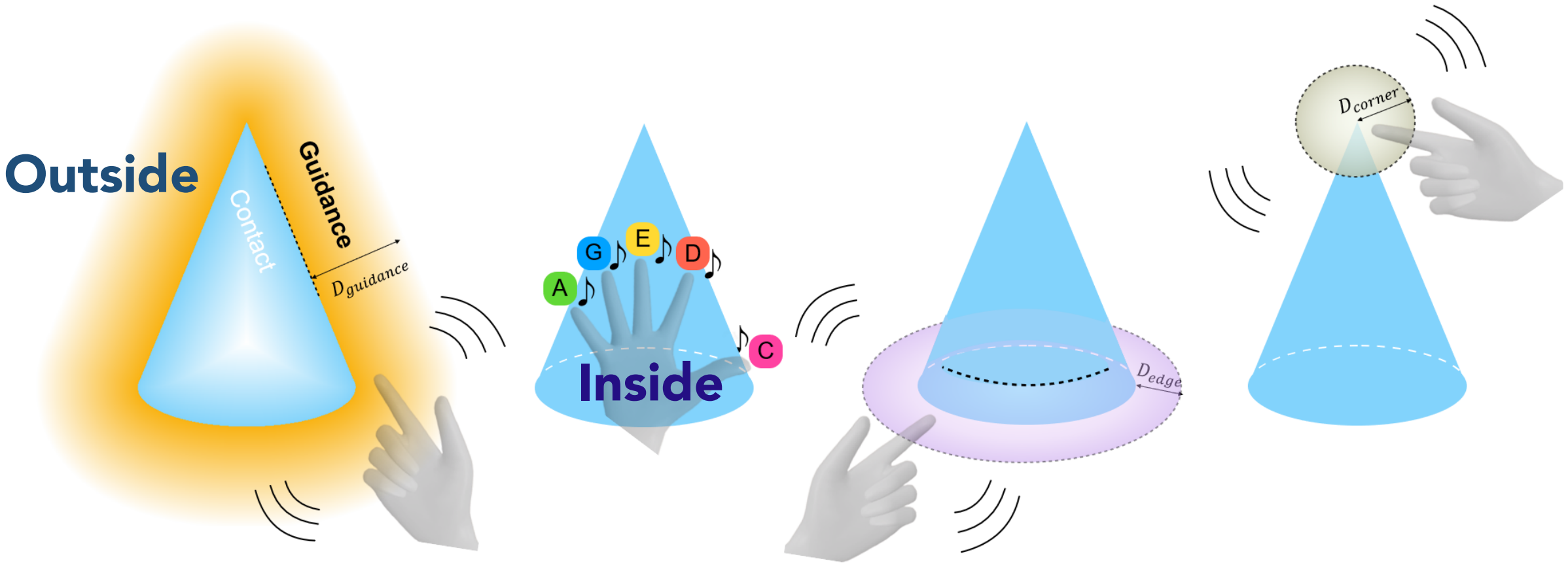
Sonification regions divide space around the shape into zones



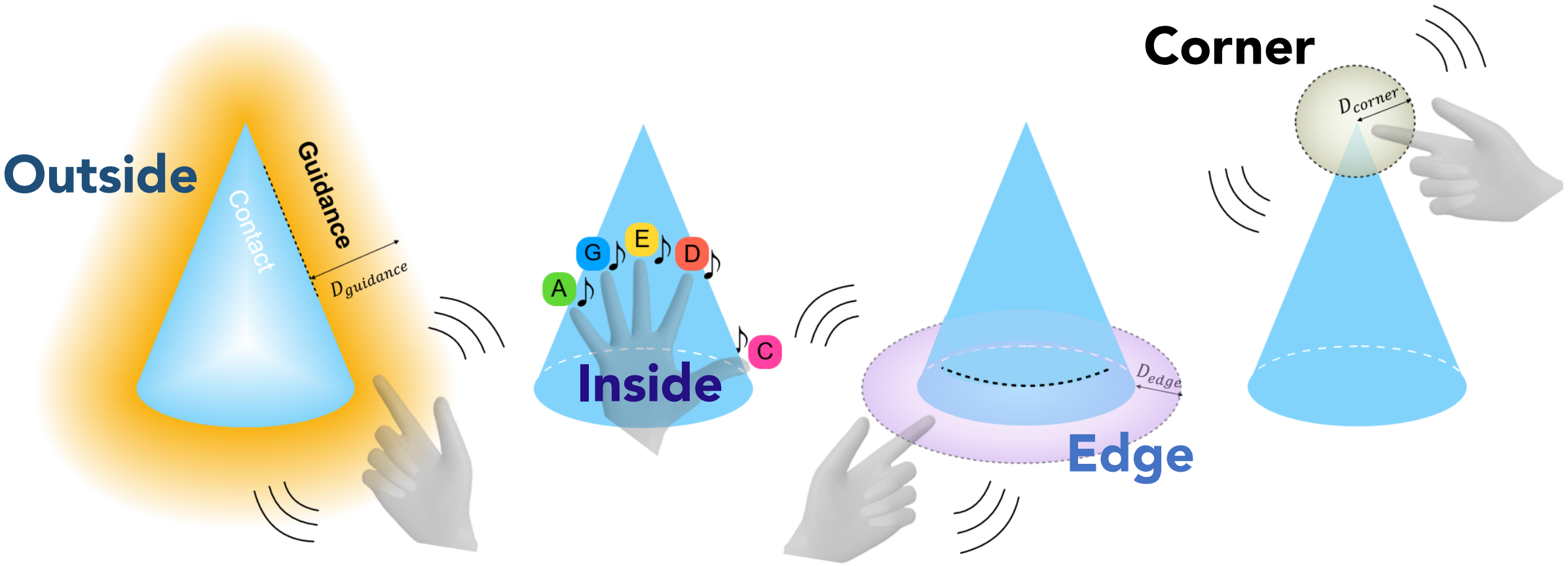
Sonification regions divide space around the shape into zones



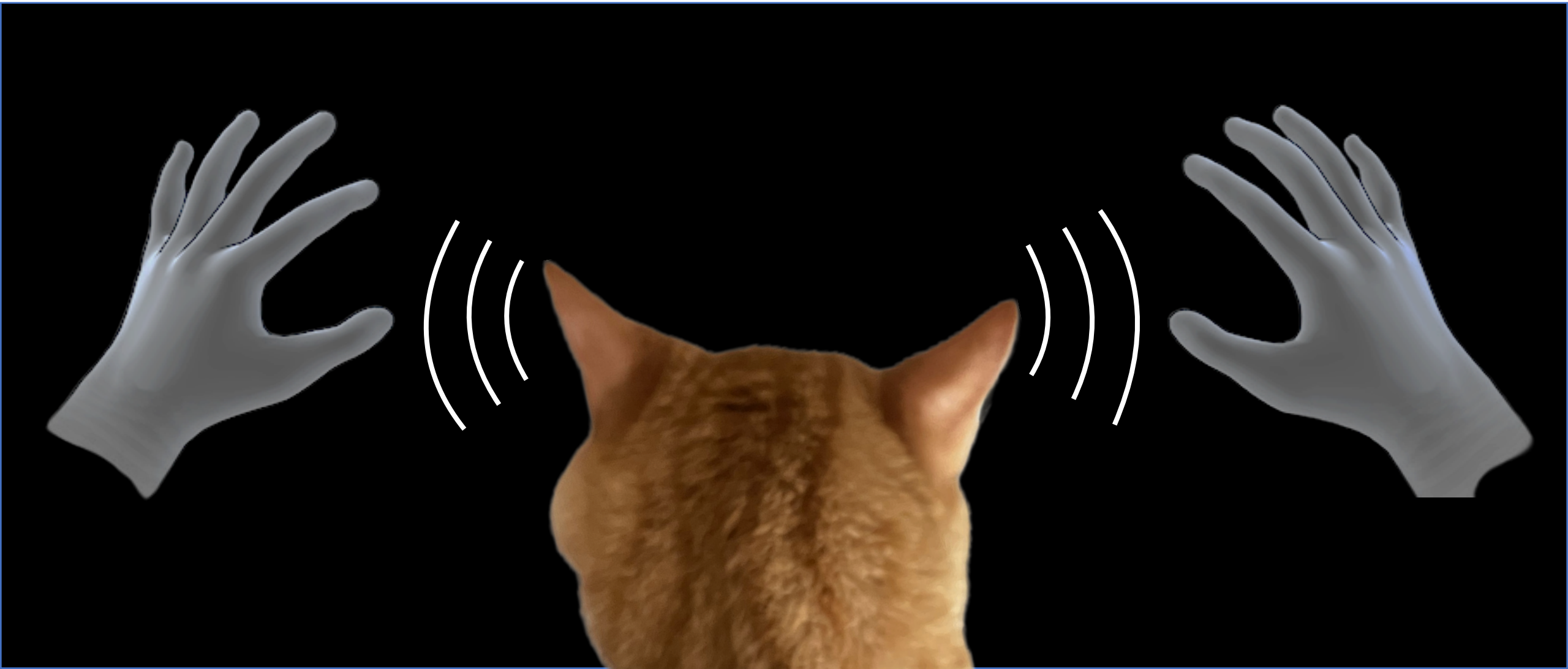
Sonification regions divide space around the shape into zones

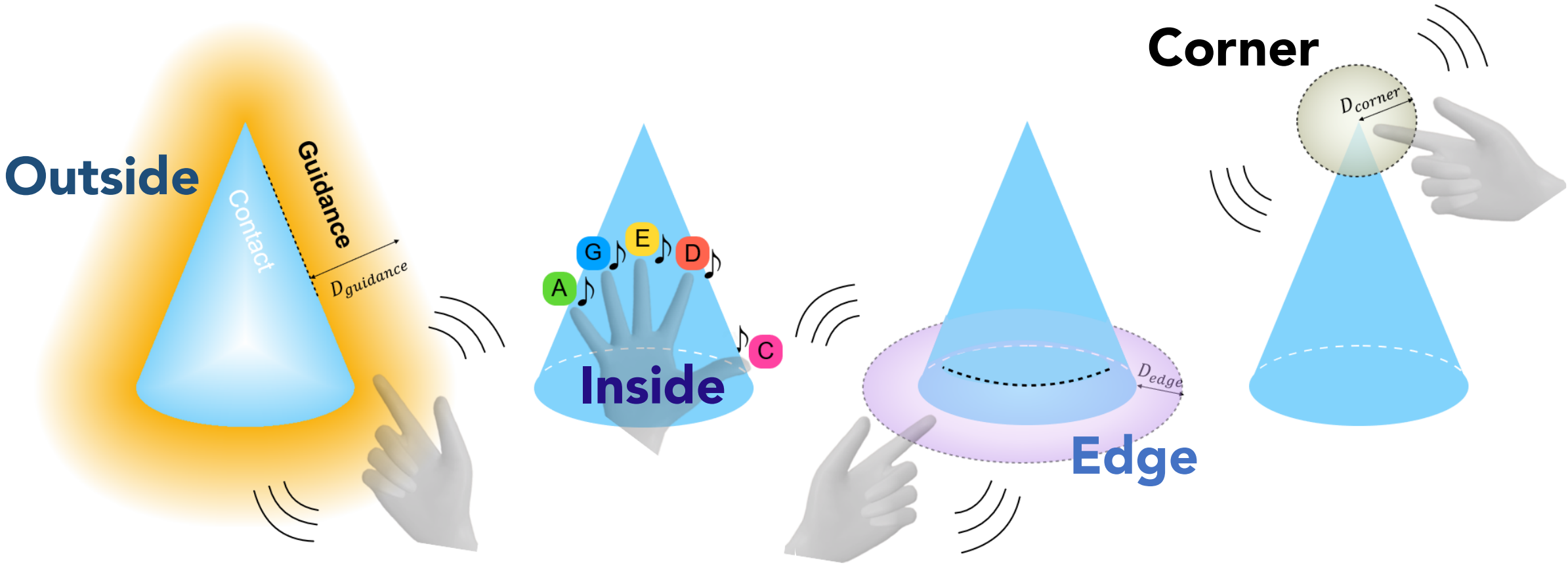


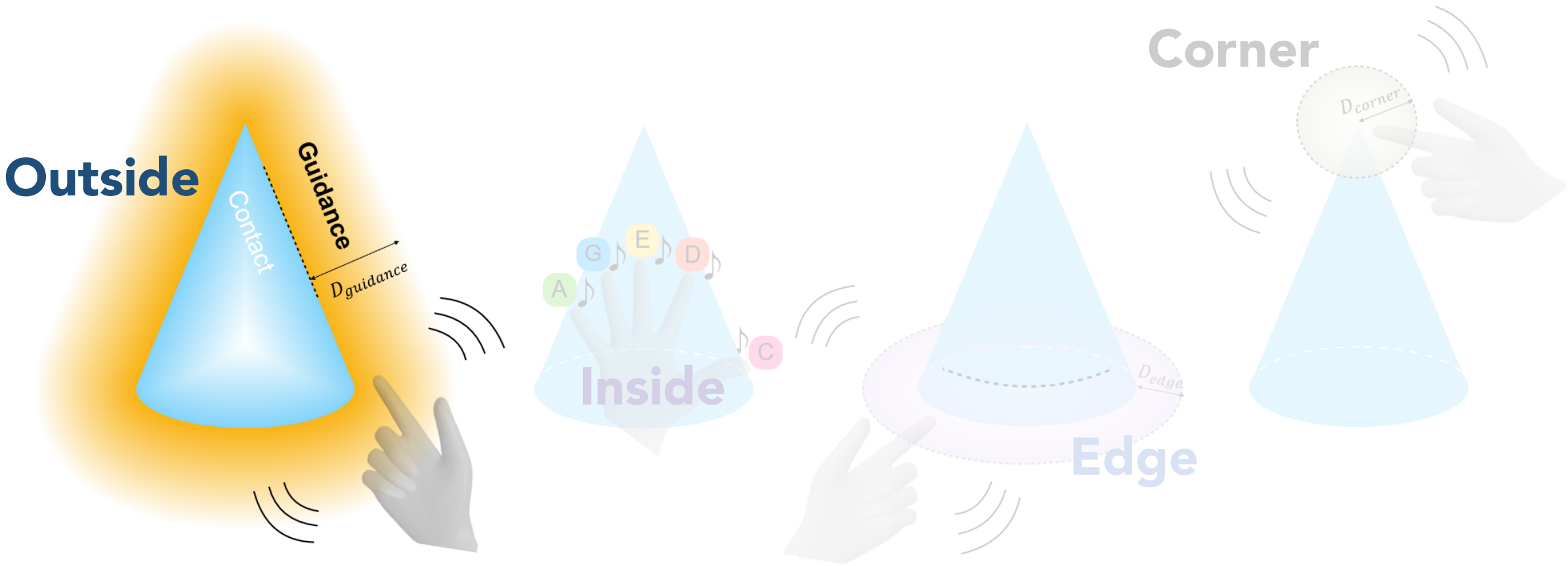
Sonification regions divide space around the shape into zones



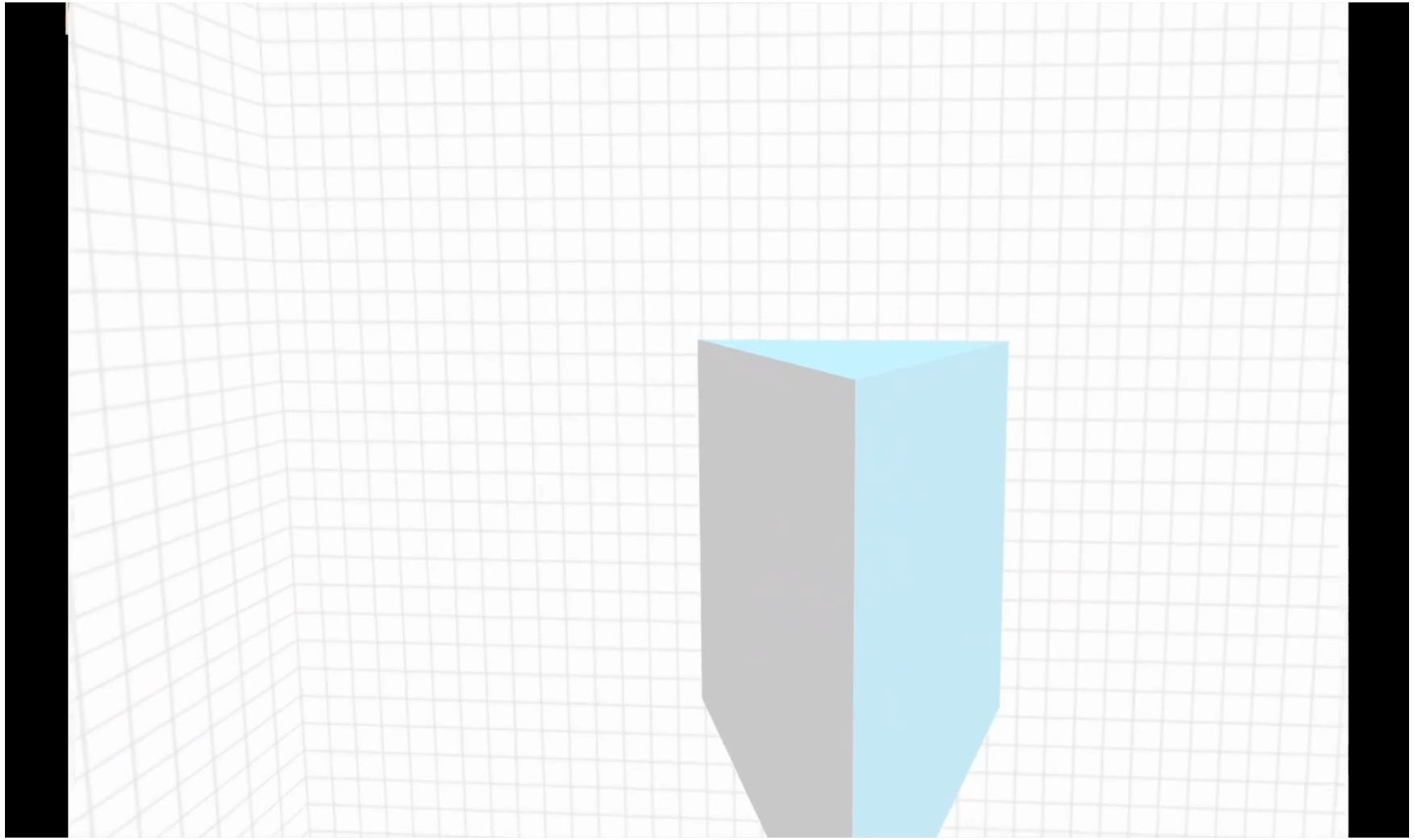
Left & right hands map to left & right ears



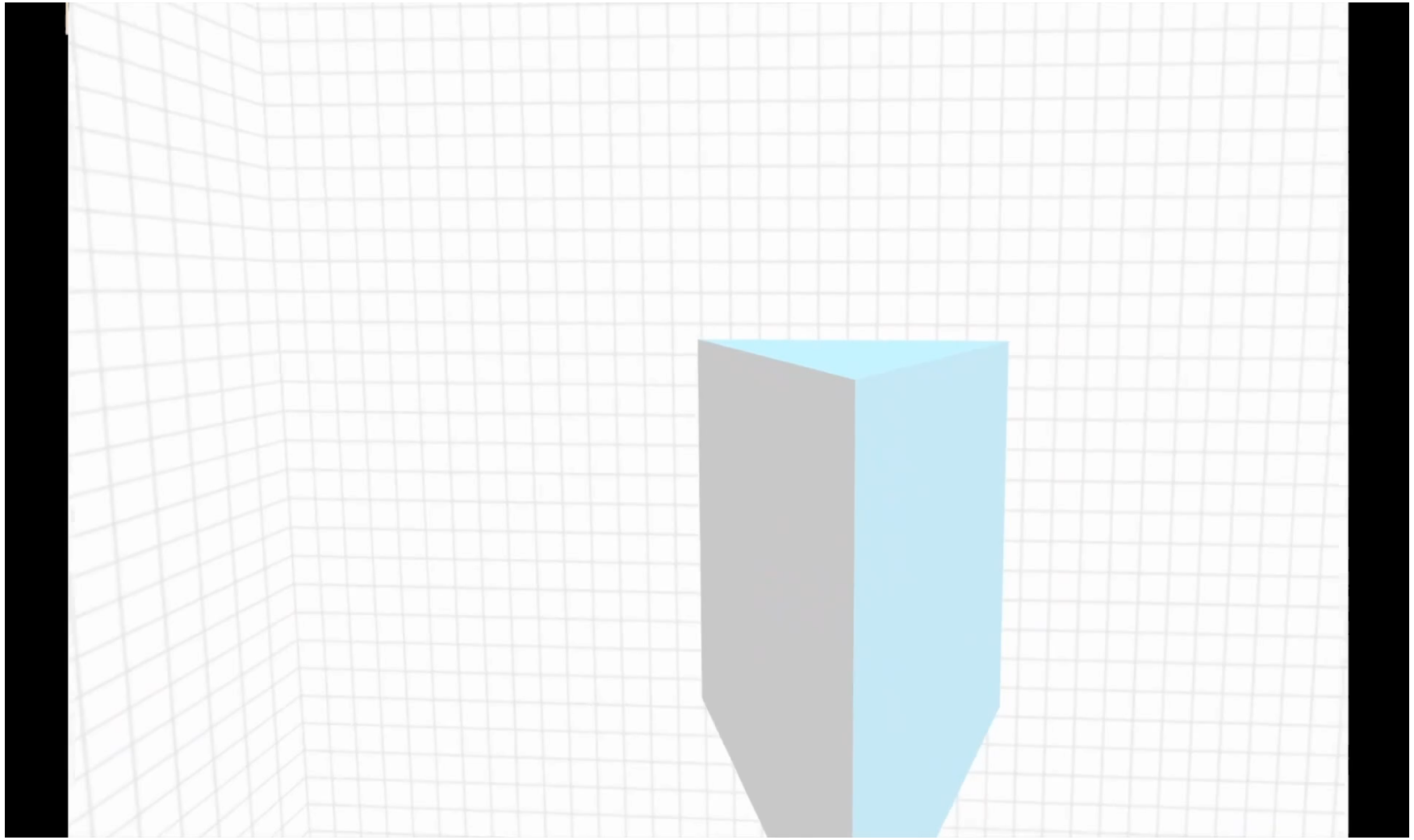

Outside
Contact
Guidance
$D_{guidance}$
G
E
D
A
C
Inside
D_{edge}
Edge
Corner
D_{corner}


Outside
Contact
Guidance
$D_{guidance}$
G
E
D
A
C
Inside
D_{edge}
Edge
Corner
D_{corner}

Guidance sounds play outside the shape

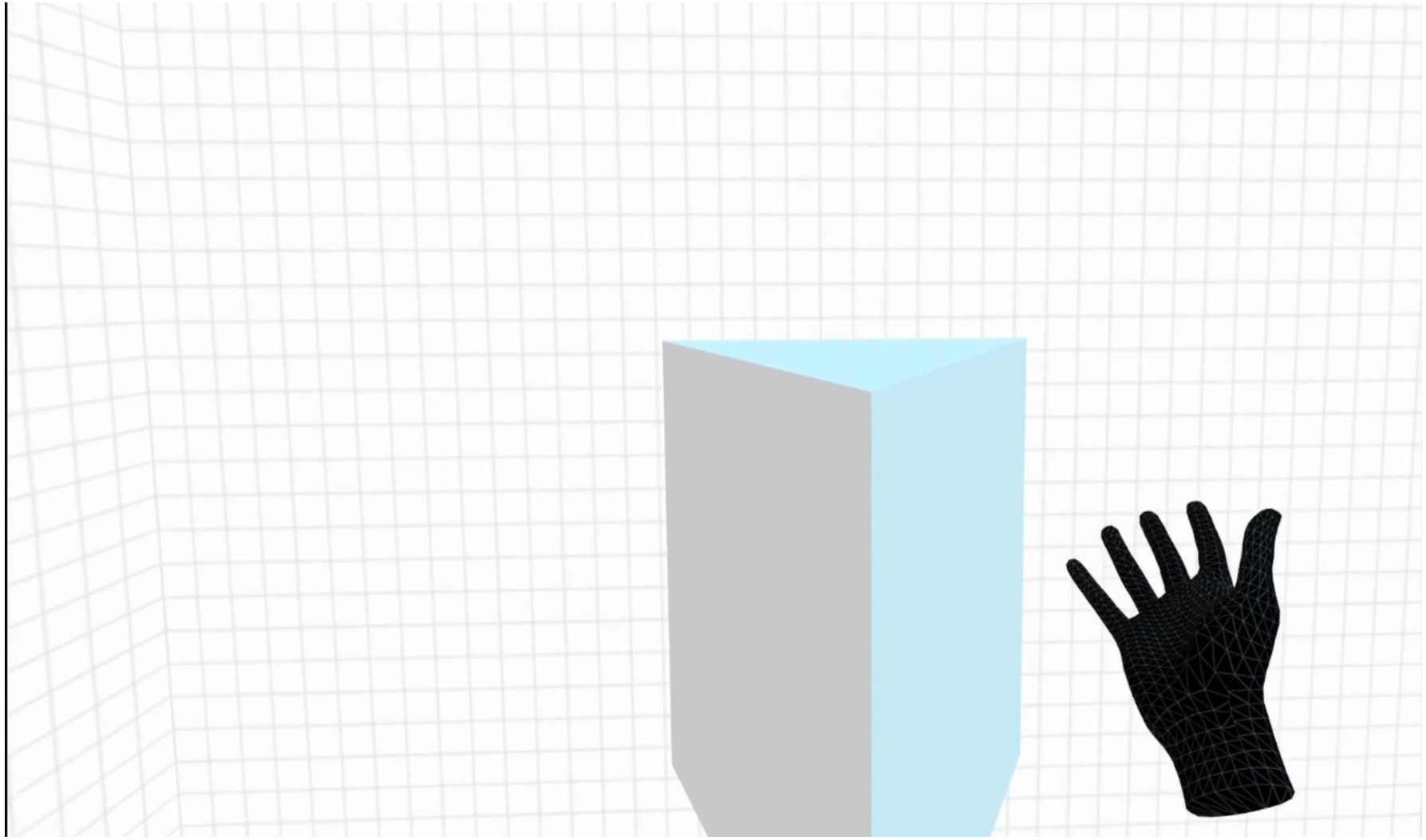


Guidance sounds play outside the shape

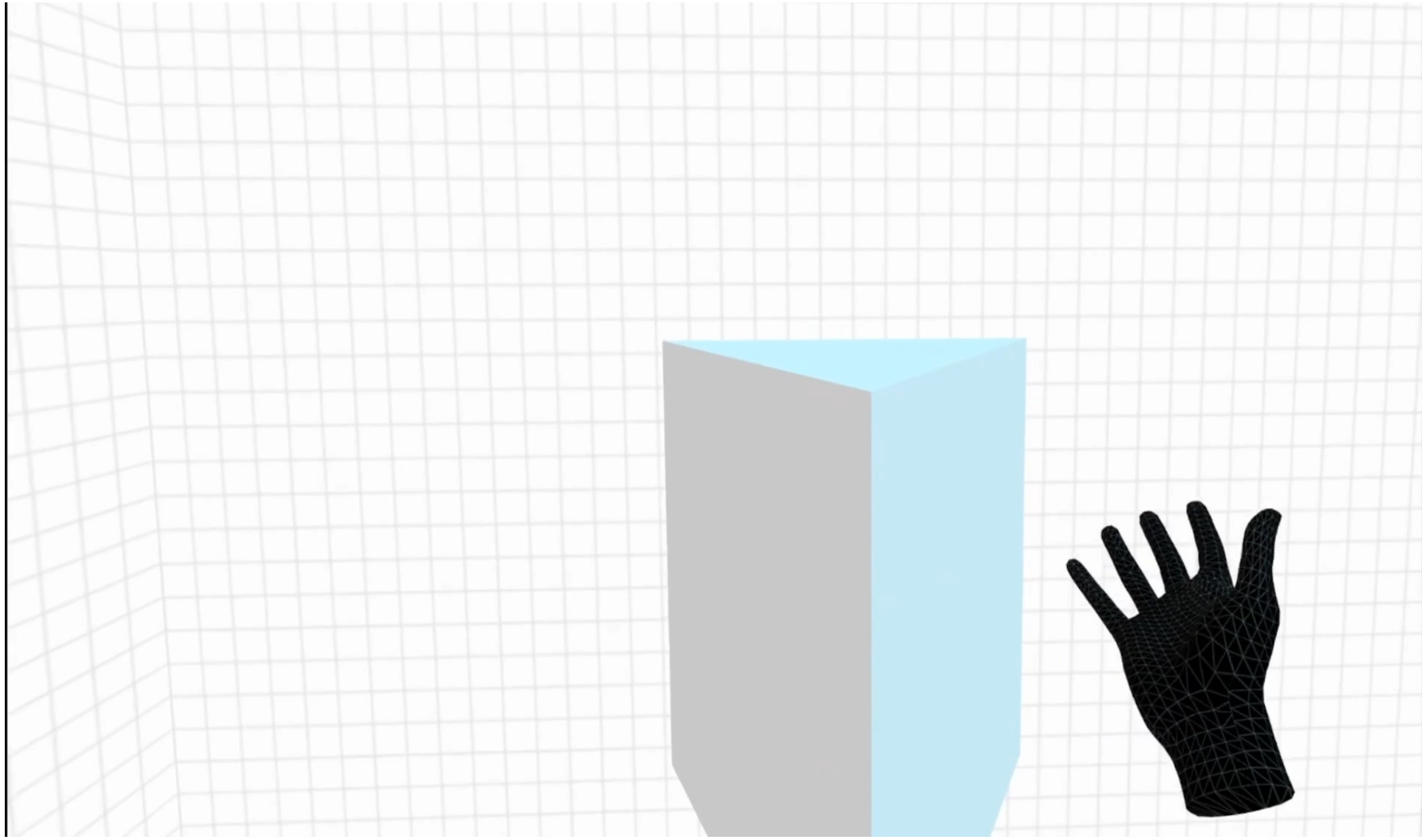


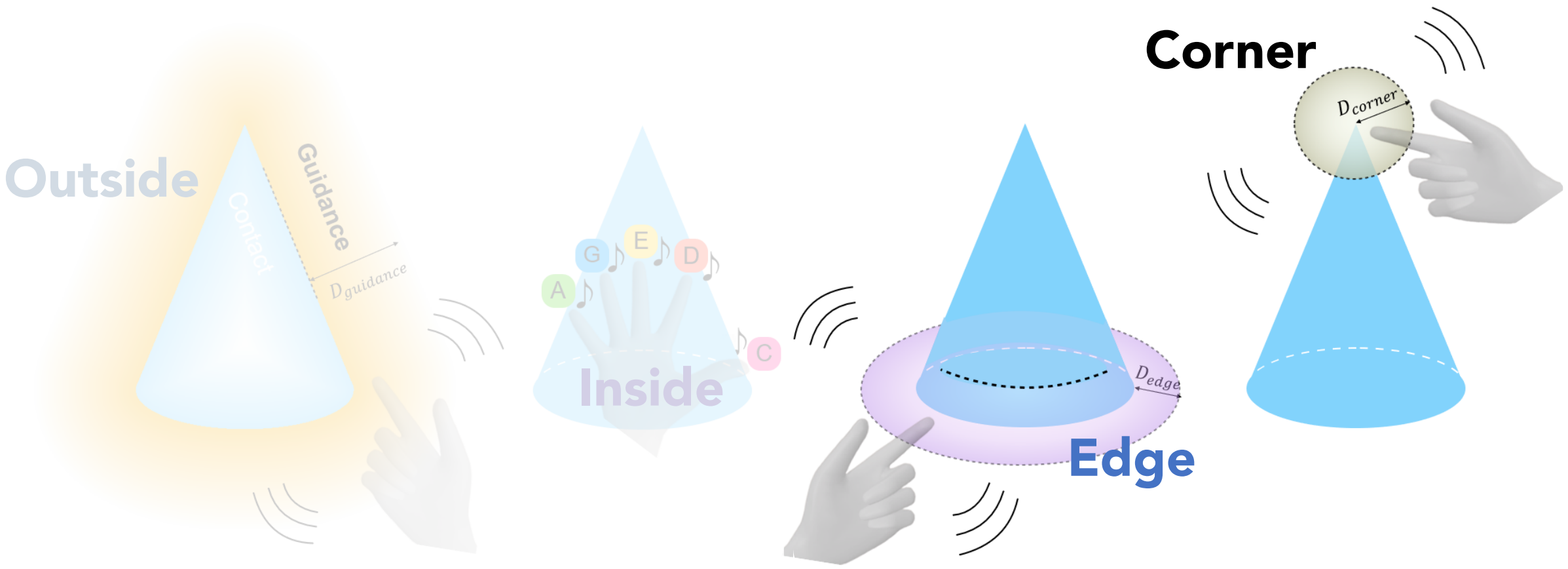
Outside
Contact
Guidance
$D_{guidance}$
G
E
D
A
C
Inside
Corner
D_{corner}
D_{edge}
Edge

Contact sounds play on the surface and inside the shape

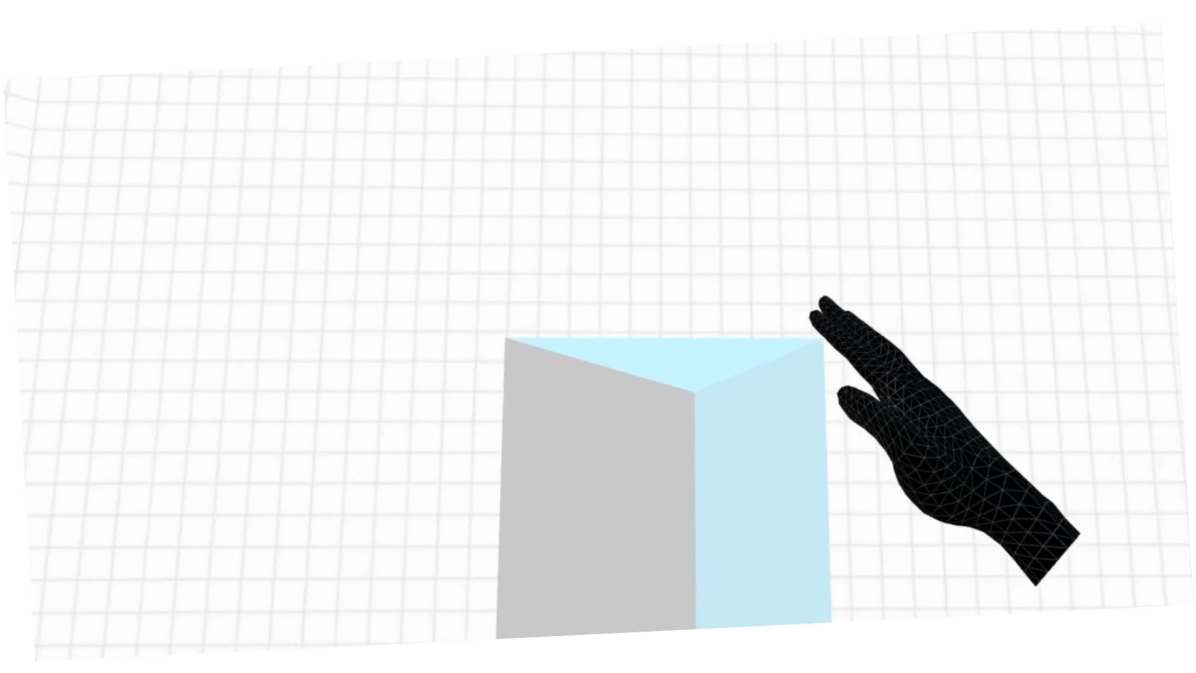


Contact sounds play on the surface and inside the shape

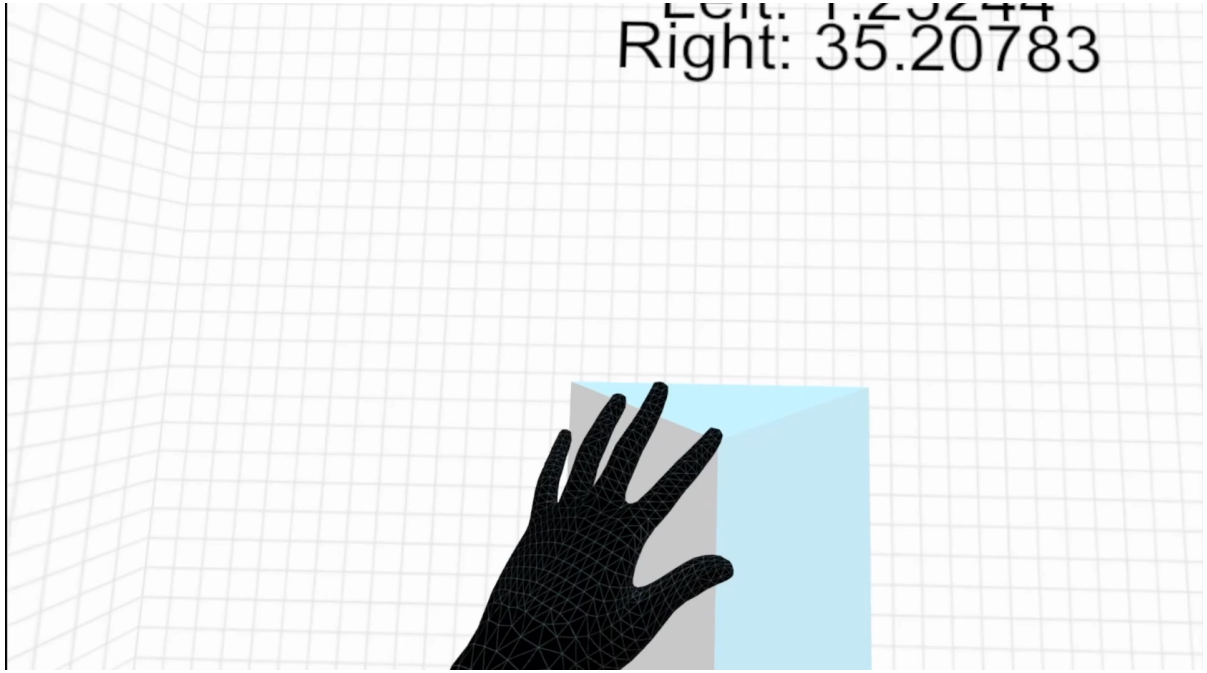



Outside
Contact
Guidance
$D_{guidance}$
G
E
D
A
C
Inside
D_{edge}
Edge
Corner
D_{corner}

Edges and corners trigger earcons

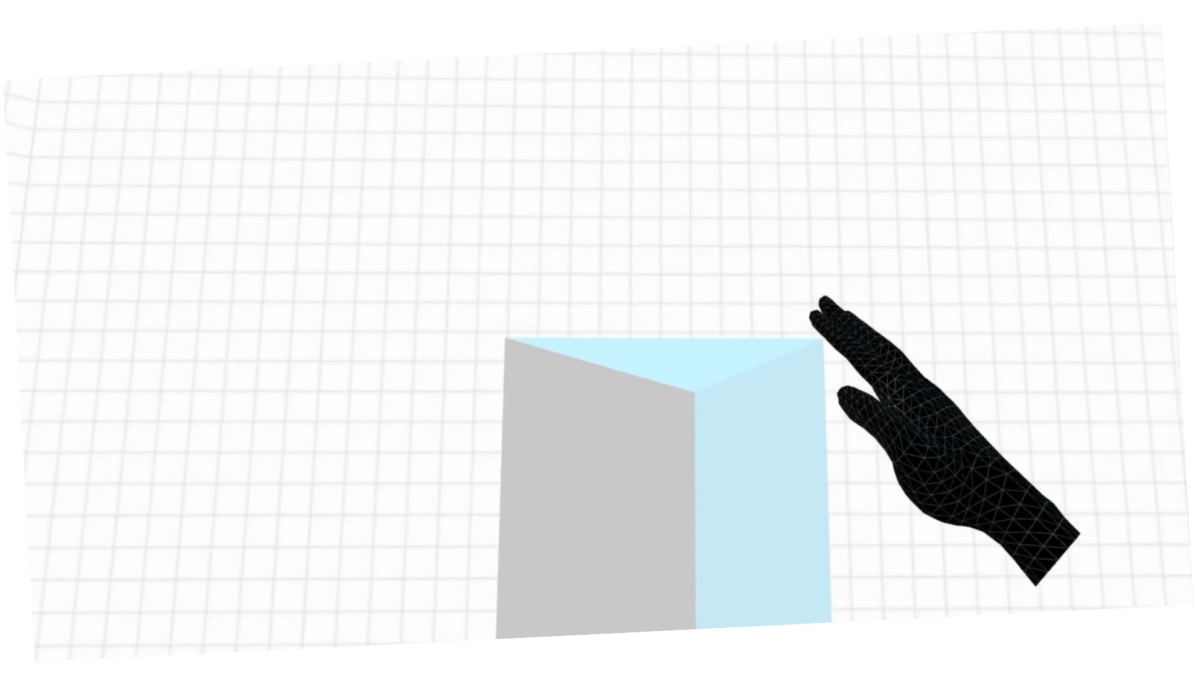


Edge Sound (right)

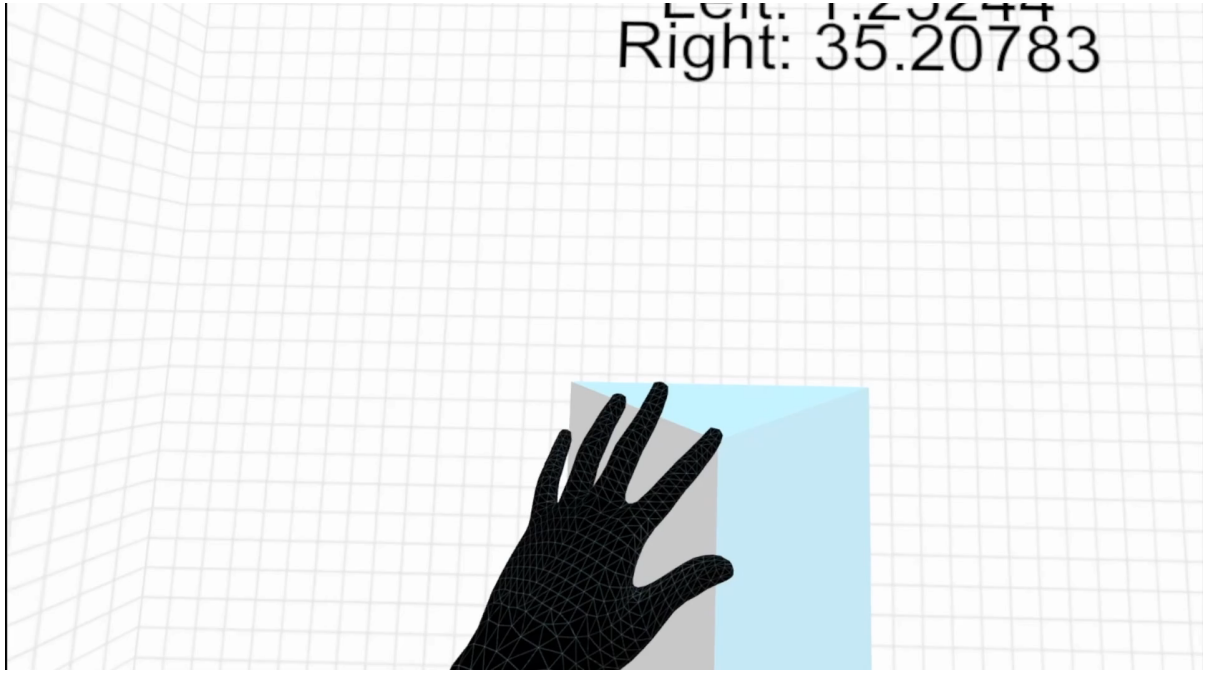


Corner Sound (left)

Edges and corners trigger earcons

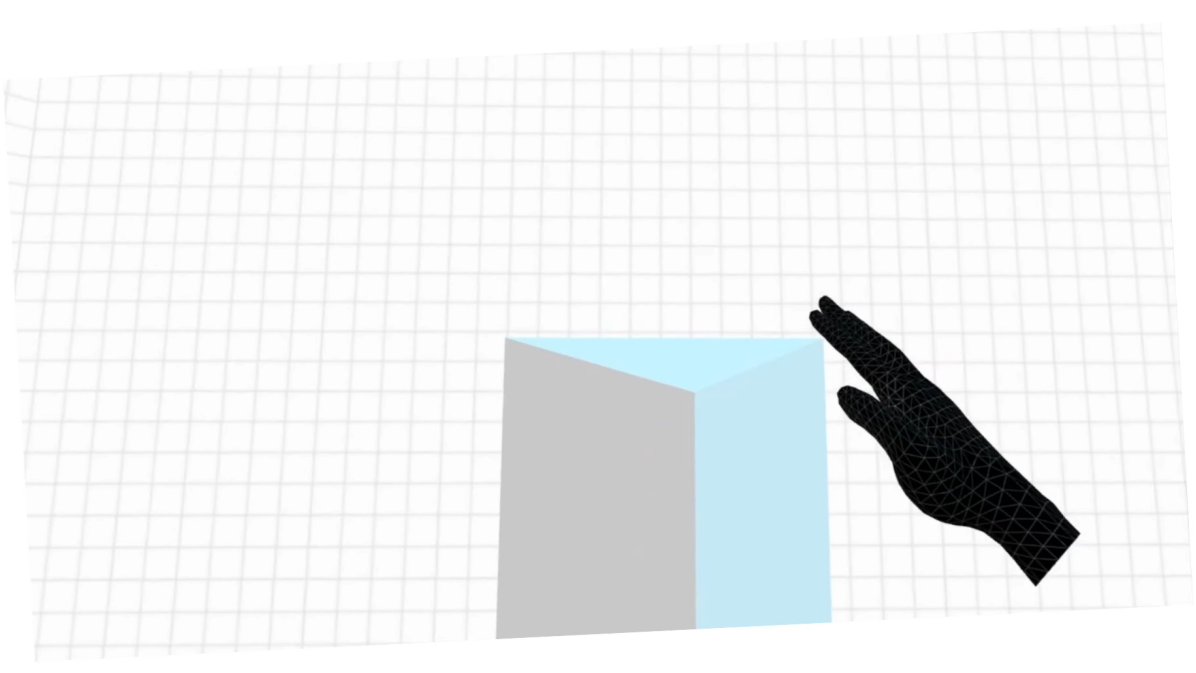


Edge Sound (right)

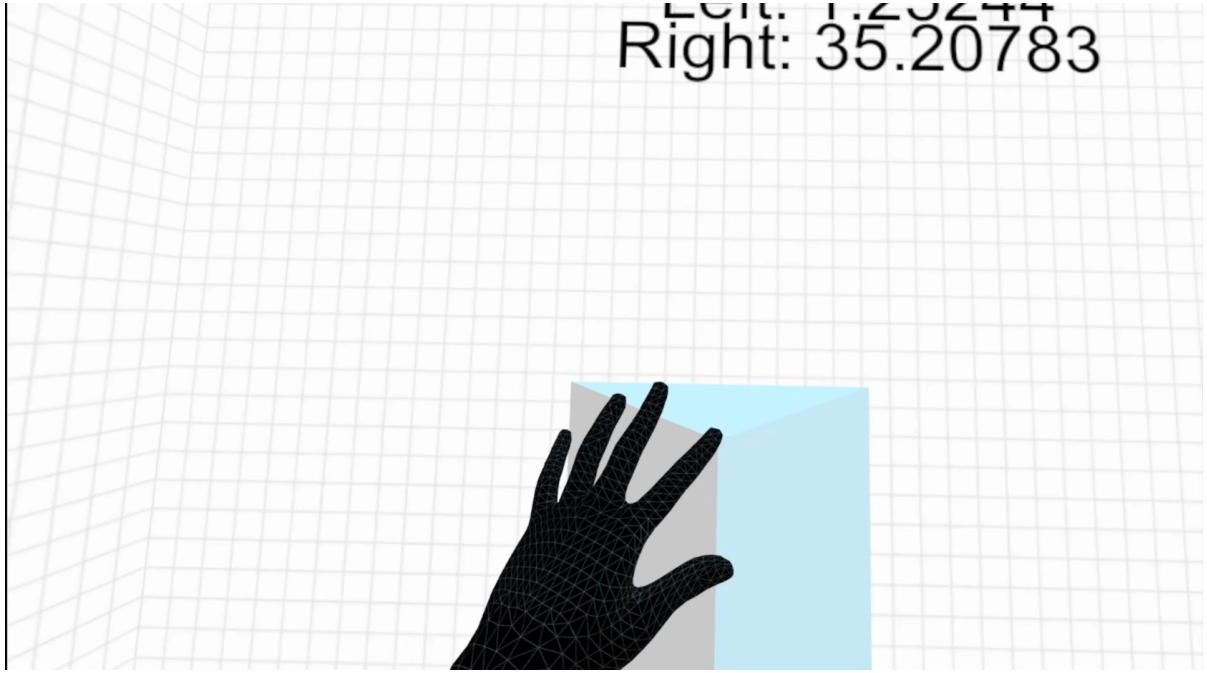


Corner Sound (left)

Edges and corners trigger earcons



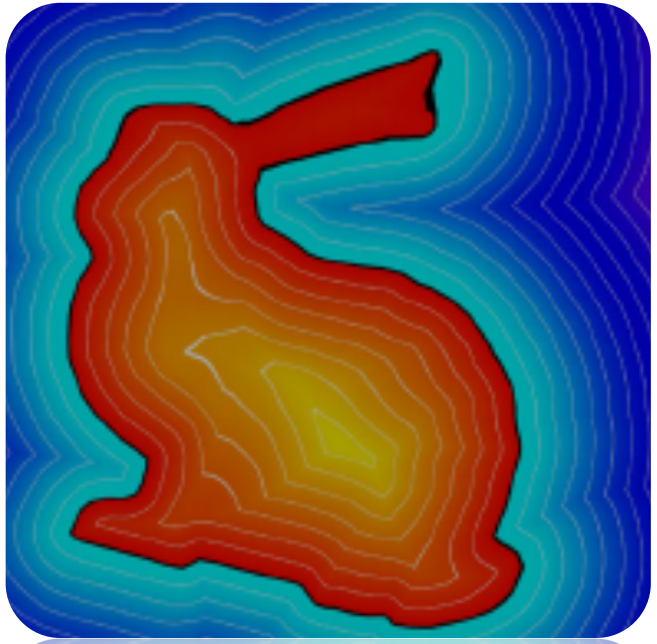
Edge Sound (right)



Corner Sound (left)

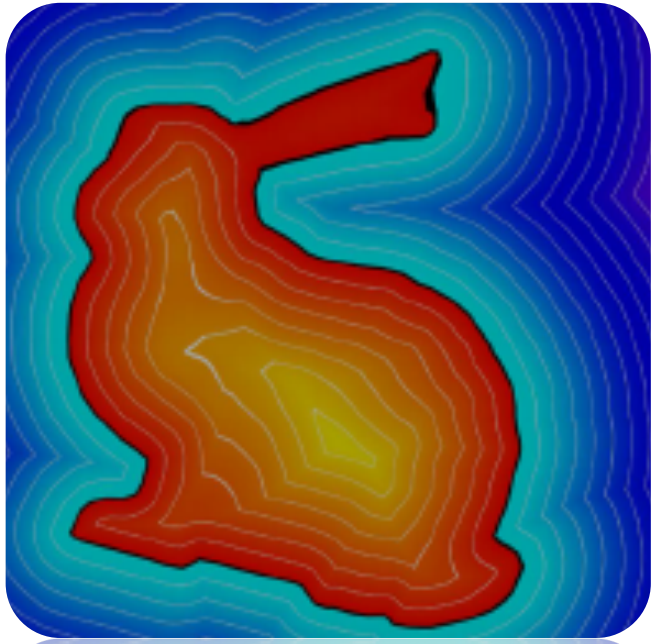
Implementation

- Meta/Oculus Quest
- Signed distance field



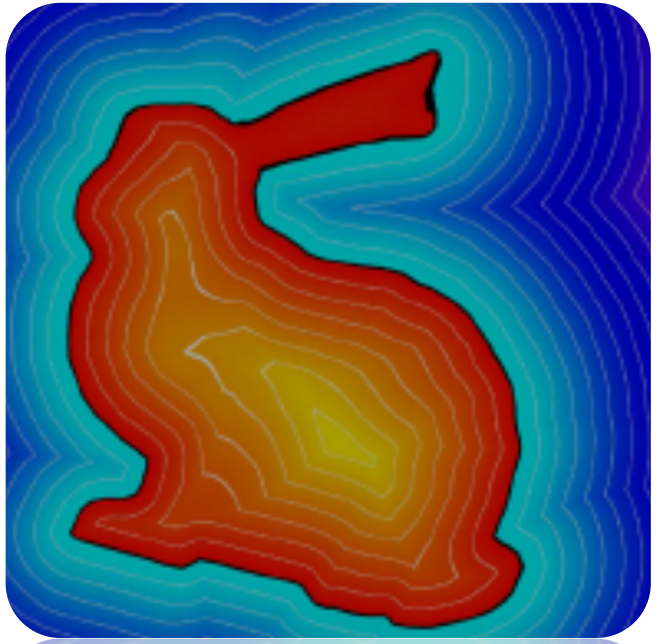
Implementation

- Meta/Oculus Quest
- Signed distance field

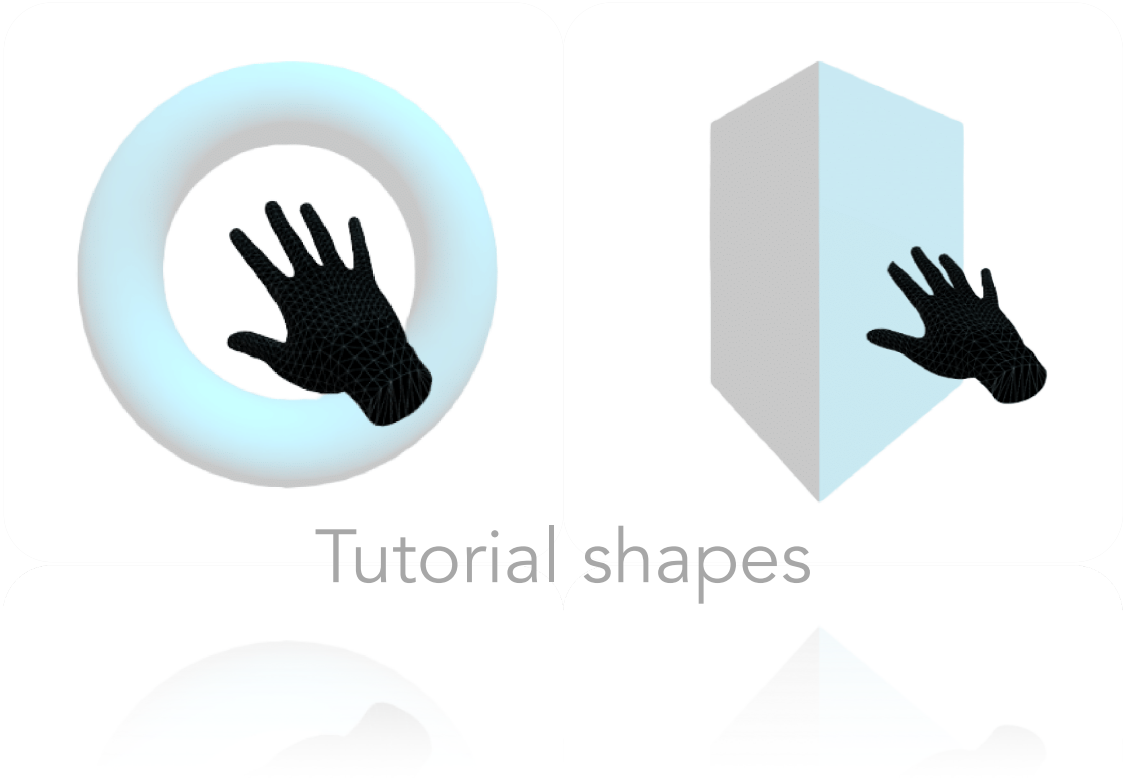


Implementation

- Meta/Oculus Quest
- Signed distance field



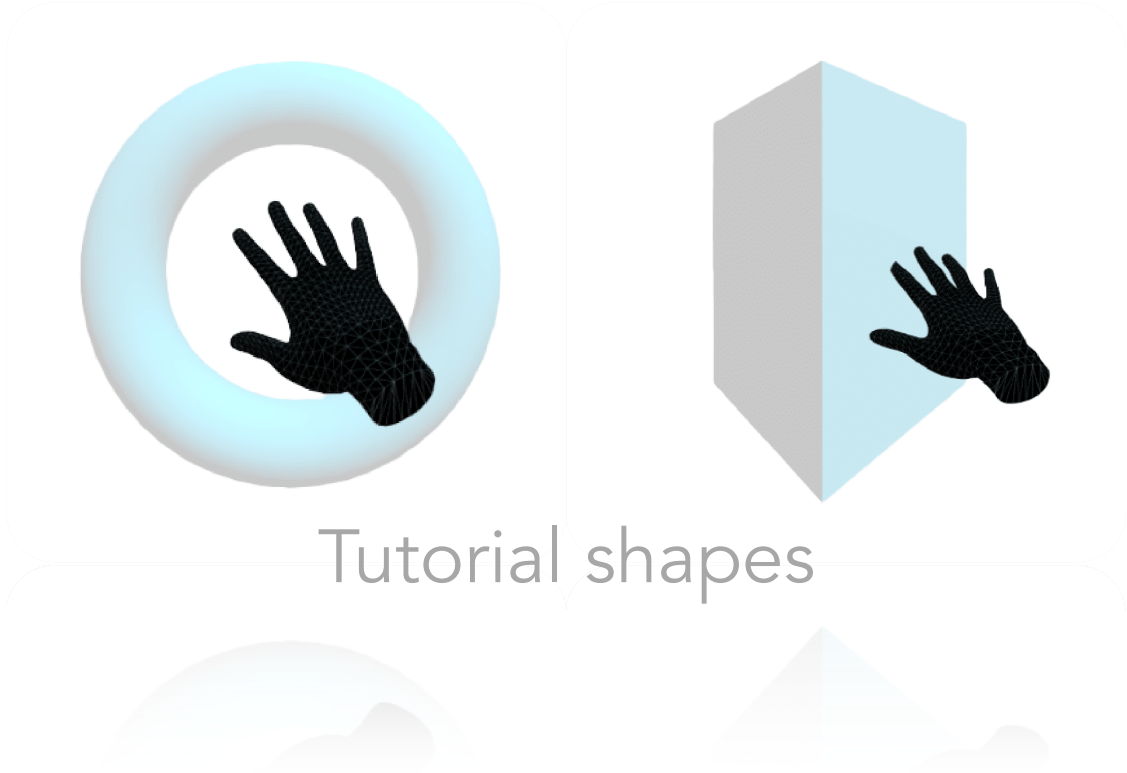
Experiment Setup



Tutorial shapes

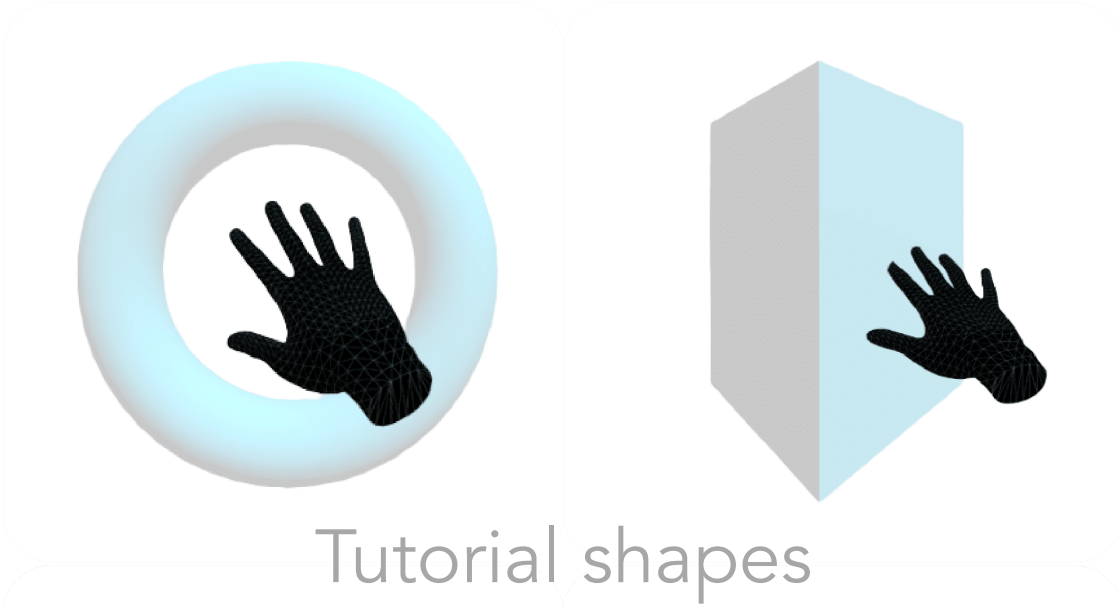
Experiment Setup

- 15 sighted and 6 BVI testers



Experiment Setup

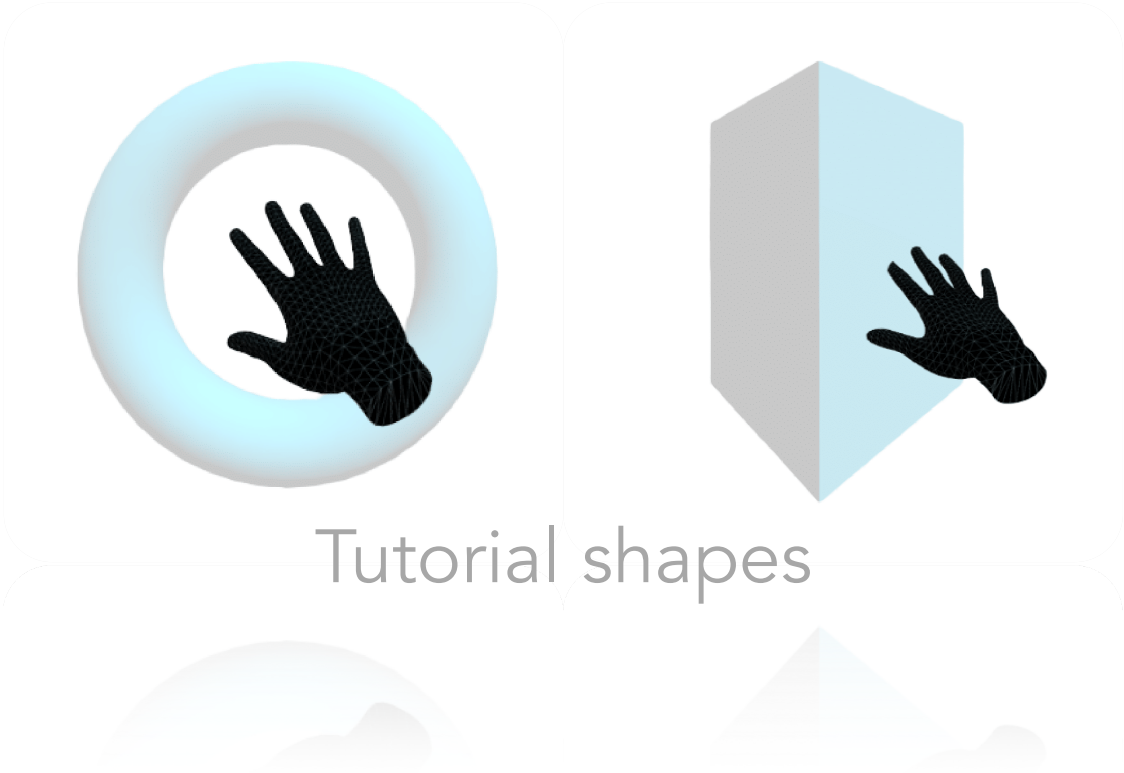
- 15 sighted and 6 BVI testers
- Two rounds:
  - Pilot Study
  - Formal Study



Tutorial shapes

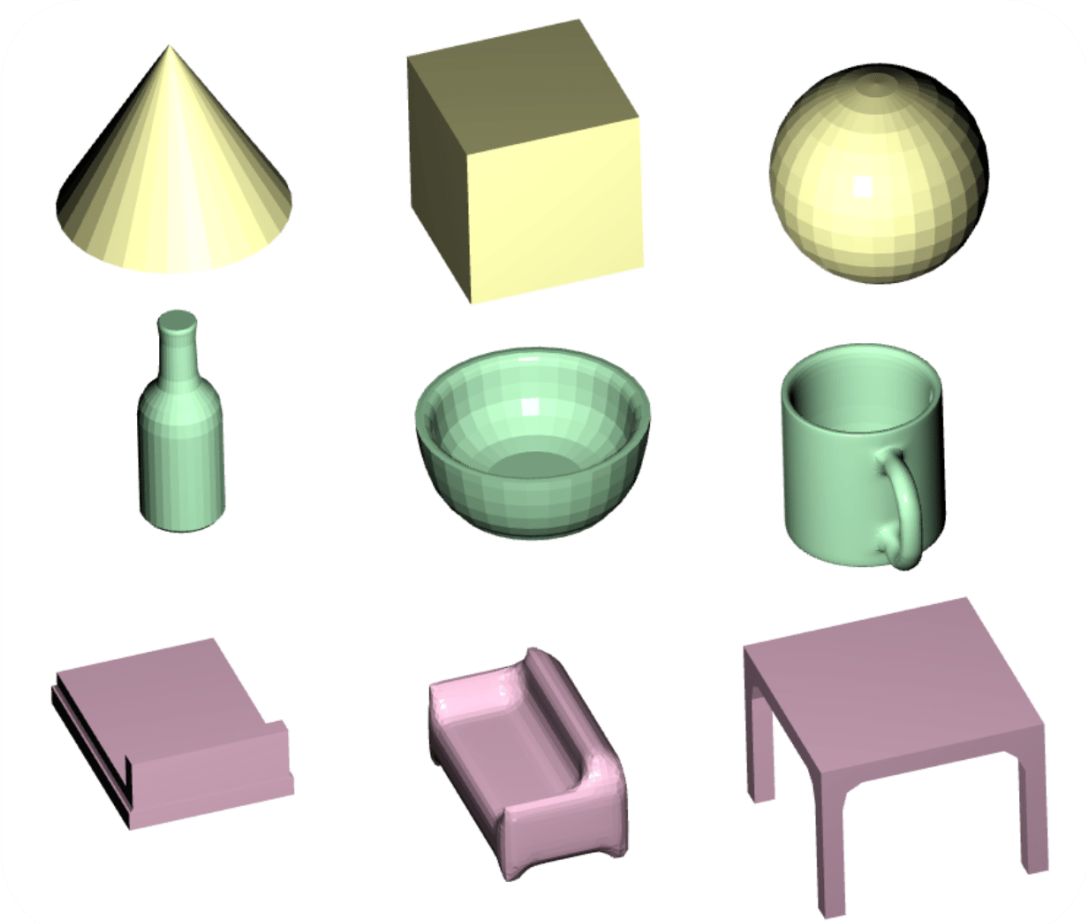
Experiment Setup

- 15 sighted and 6 BVI testers
- Two rounds:
  - Pilot Study
  - Formal Study
- Two shape perception tasks
  - Shape Recognition
  - Landmark localization



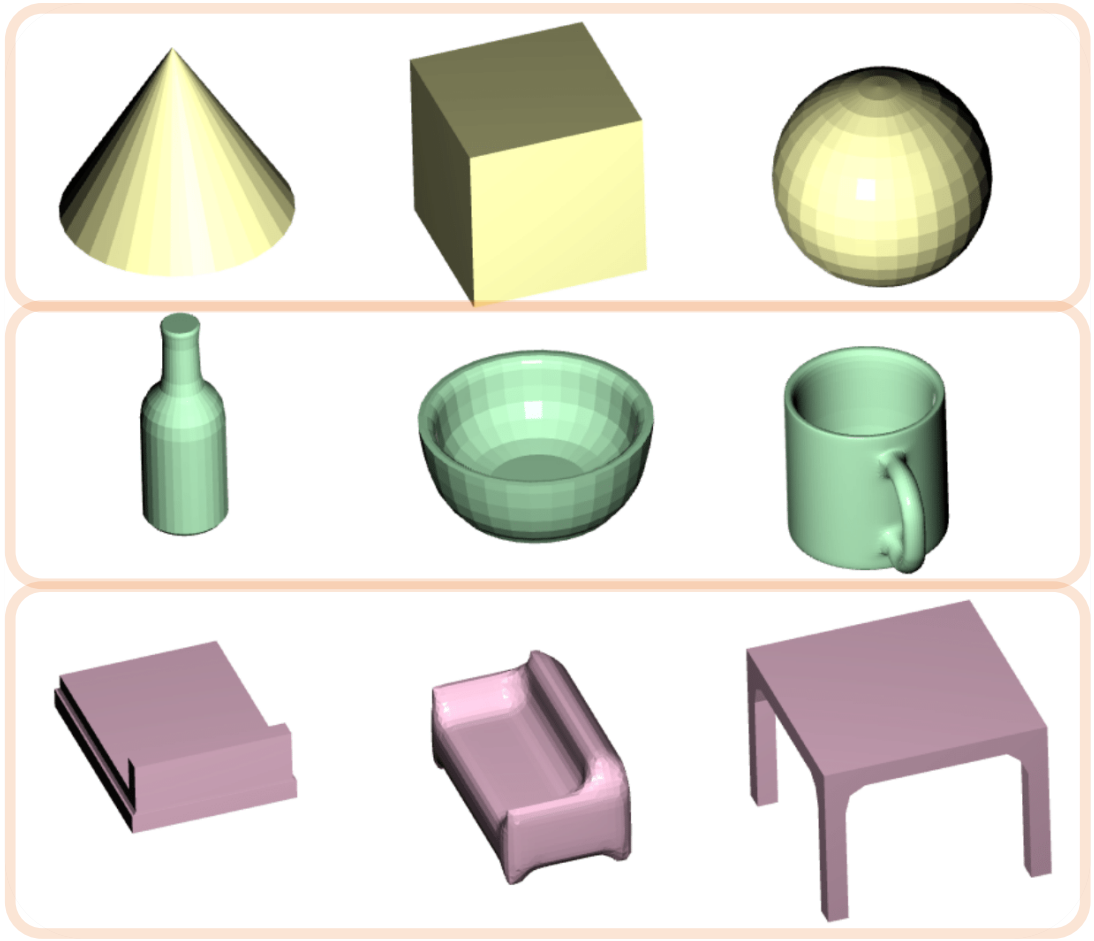
Tutorial shapes

Shape Recognition



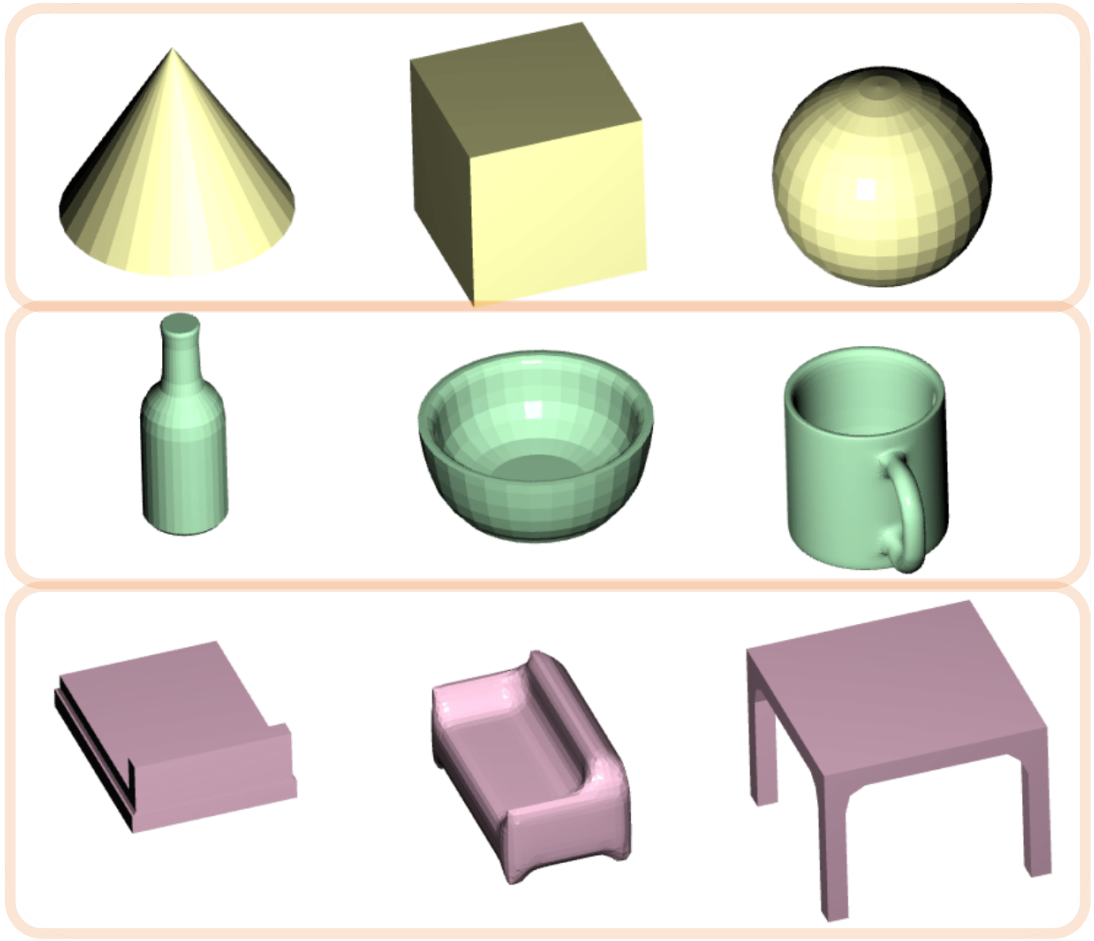
Shape Recognition

- Identify one of three shapes



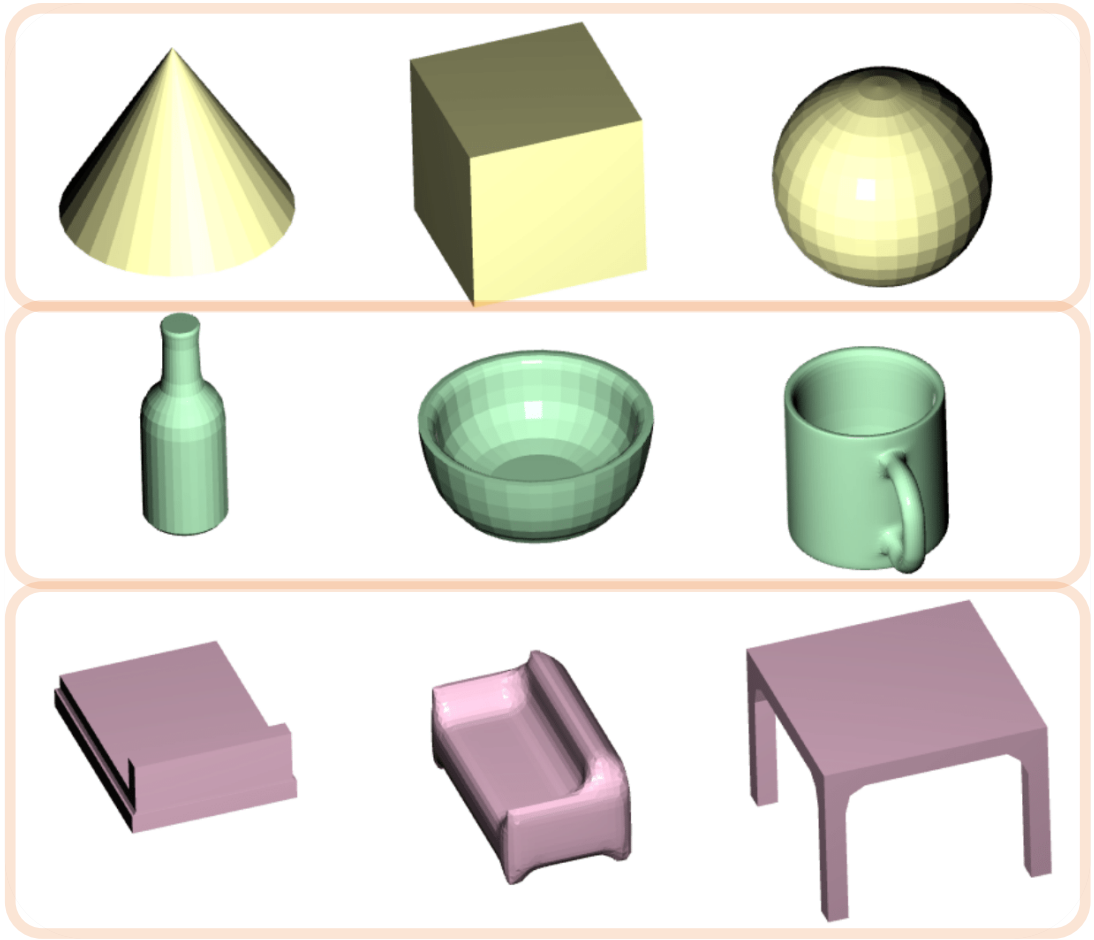
Shape Recognition

- Identify one of three shapes
- ShapeSonic users: 82% success
  (vs. 33% chance)

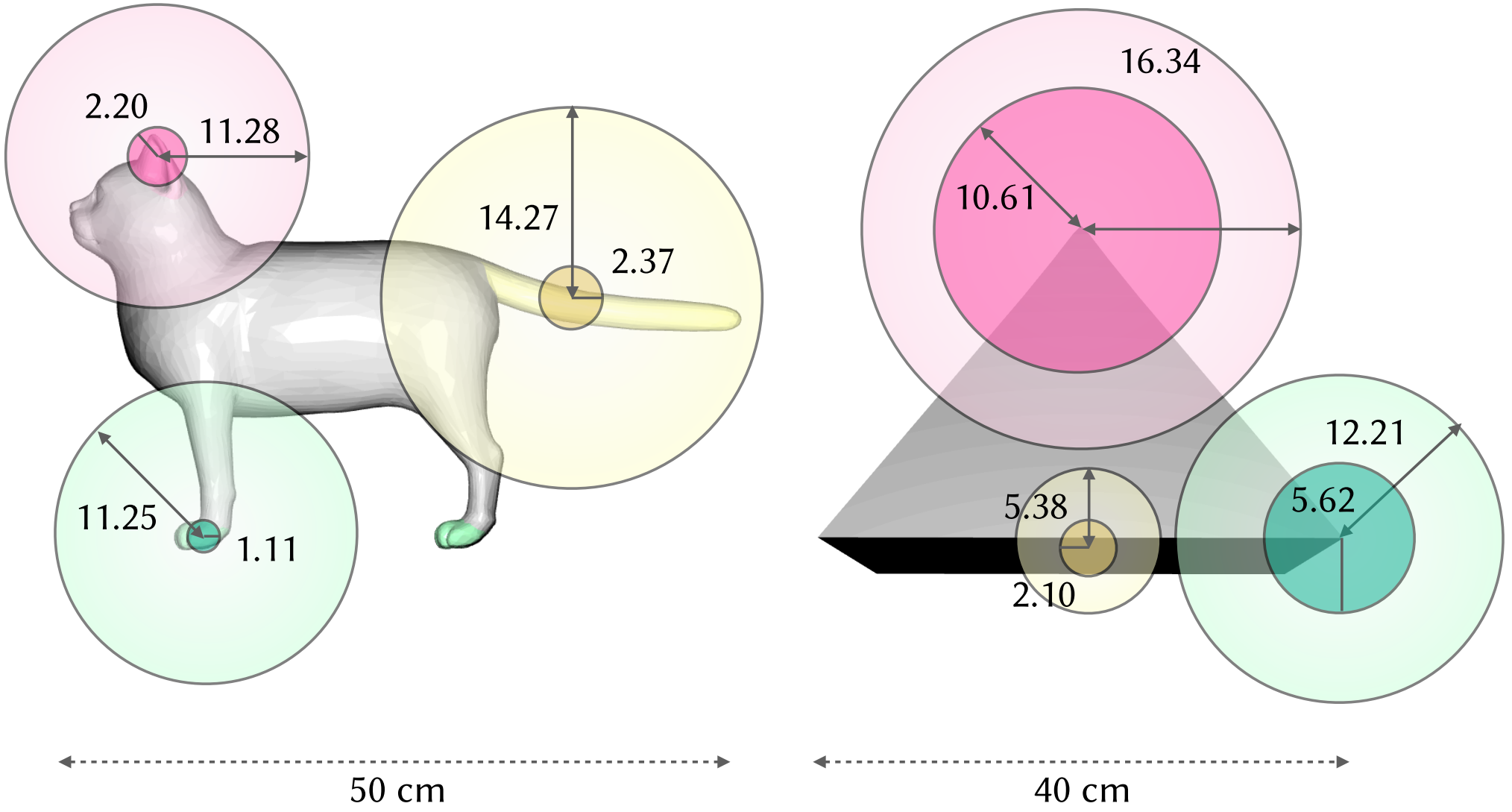


Shape Recognition

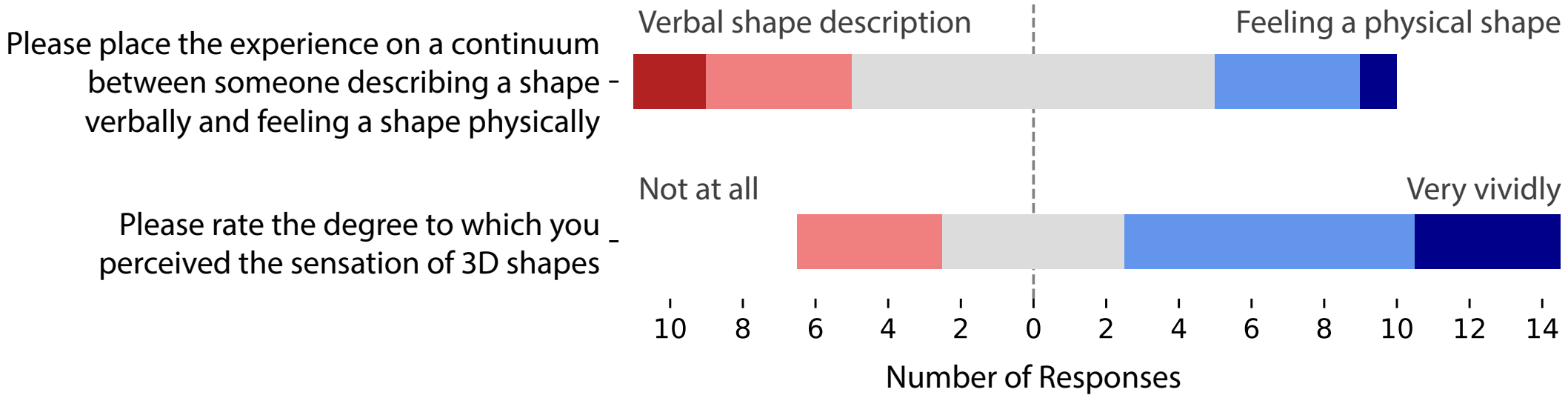
- Identify one of three shapes
- ShapeSonic users: 82% success (vs. 33% chance)
- Sighted and BVI users had similar performance (81% vs. 83%)



Landmark Localization

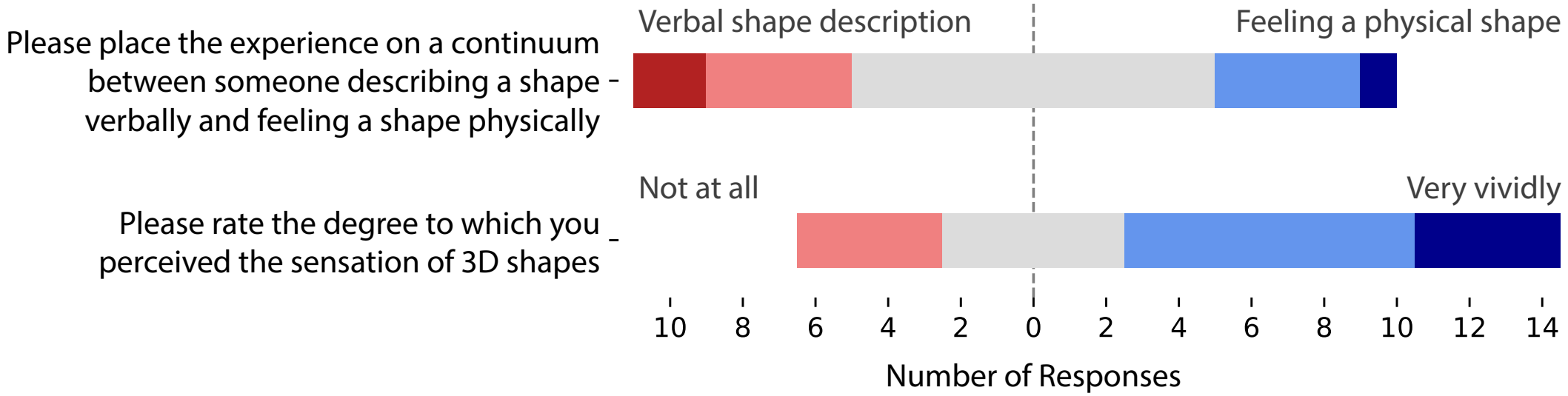


Observations



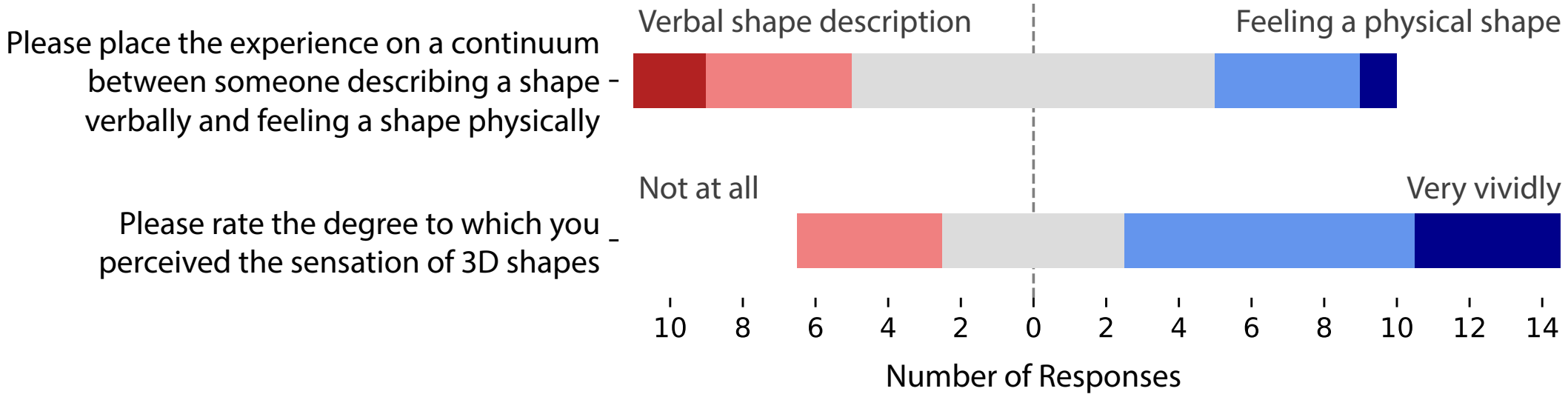
Observations

- Perceived as halfway between verbal description and feeling a physical shape.



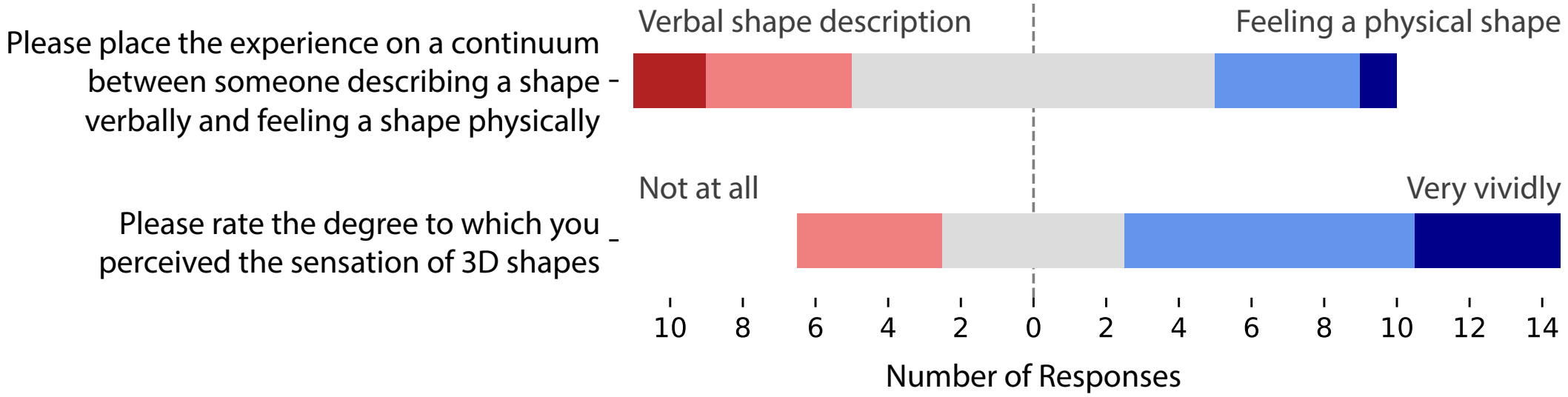
Observations

- Perceived as halfway between verbal description and feeling a physical shape.
- Haven't reached the skill ceiling.



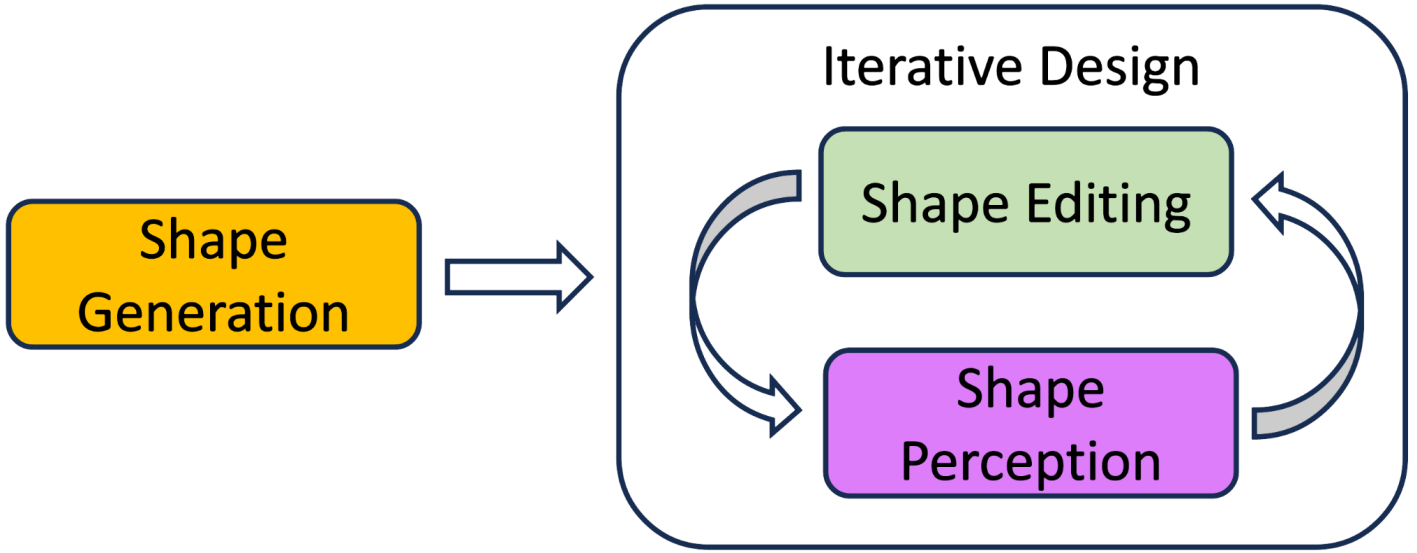
Observations

- Perceived as halfway between verbal description and feeling a physical shape.
- Haven't reached the skill ceiling.
- Hand tracking latency is an impediment.



Future Work

- Sonify physical attributes
- Complex objects and scenarios
- Non-visual 3D shape design



ShapeSonic: Sonifying Fingertip Interactions for Non-Visual Virtual Shape Perception

https://cragl.cs.gmu.edu/shapesonic/

GEORGE MASON UNIVERSITY

CraGL Computational Reality Creativity and Graphics Lab

THE UNIVERSITY OF CHICAGO 1890

Adobe