Shape scission:
causal segmentation of shape

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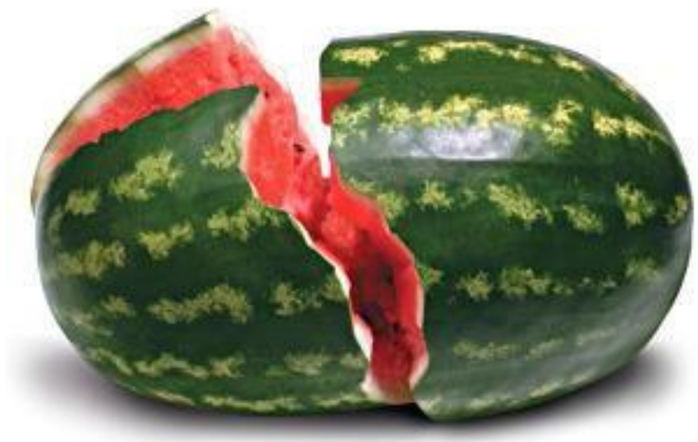
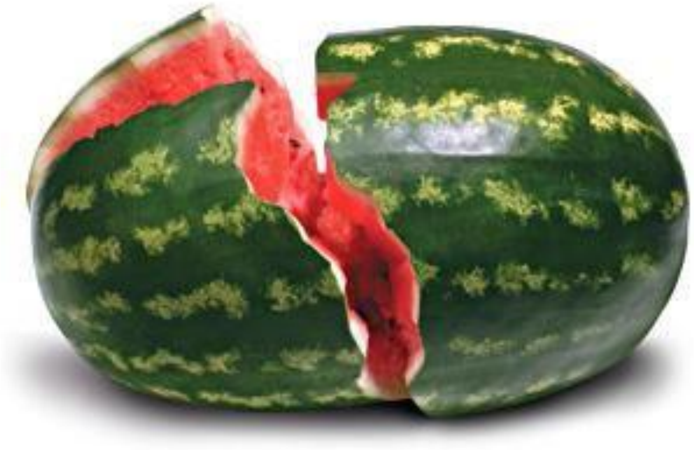
Cardinal Mechanisms of Perception

Shape scission


Shape scission

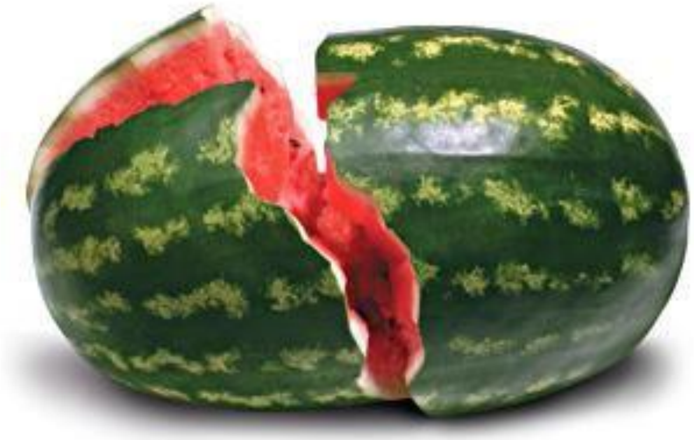
Crumpled!



Shape scission

Crumpled!

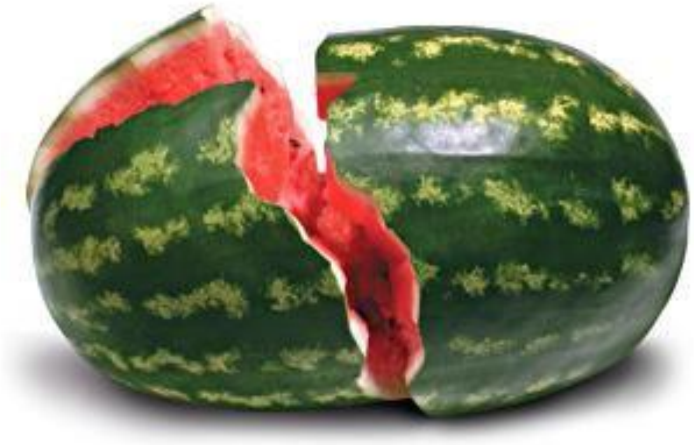
Crushed!



Shape scission

Crumpled!

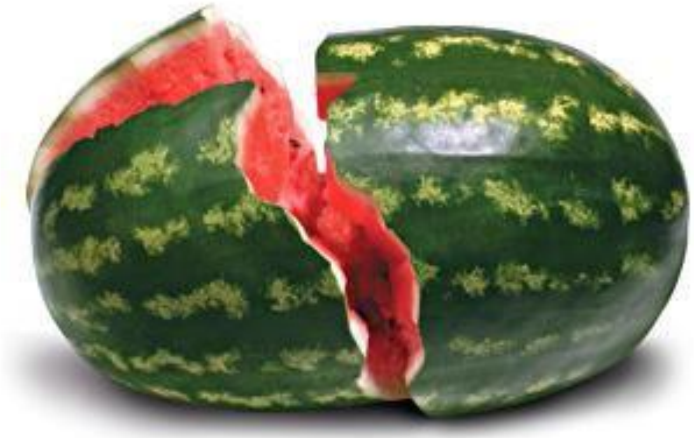
Crushed!



Squeezed!

Shape scission

Crumpled! Crushed! Squeezed!

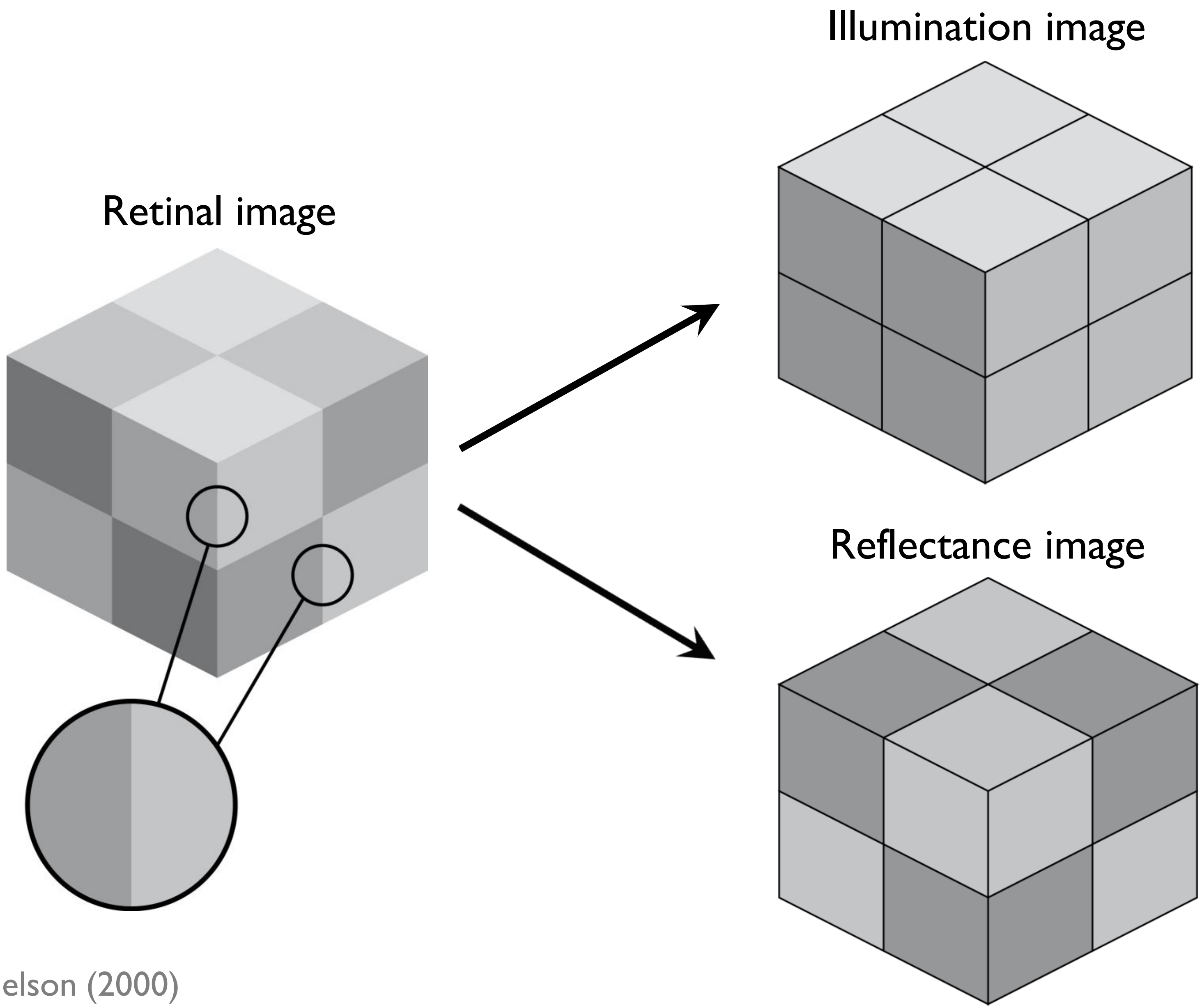




- Evidence that observers can infer the causal history of objects (Chen & Scholl, 2016; Leyton, 1989; Op de Beeck, Torfs, & Wagemans, 2008; Pinna, 2010; Pittenger & Todd, 1983; Spröte & Fleming, 2013, 2016; Spröte, Schmidt, & Fleming, 2016)

Shape scission

- We suggest that we do this by separating shape into causal layers (*shape scission*)

Shape scission



Inspired by Adelson (2000)

Shape scission

Original shape

Observed shape

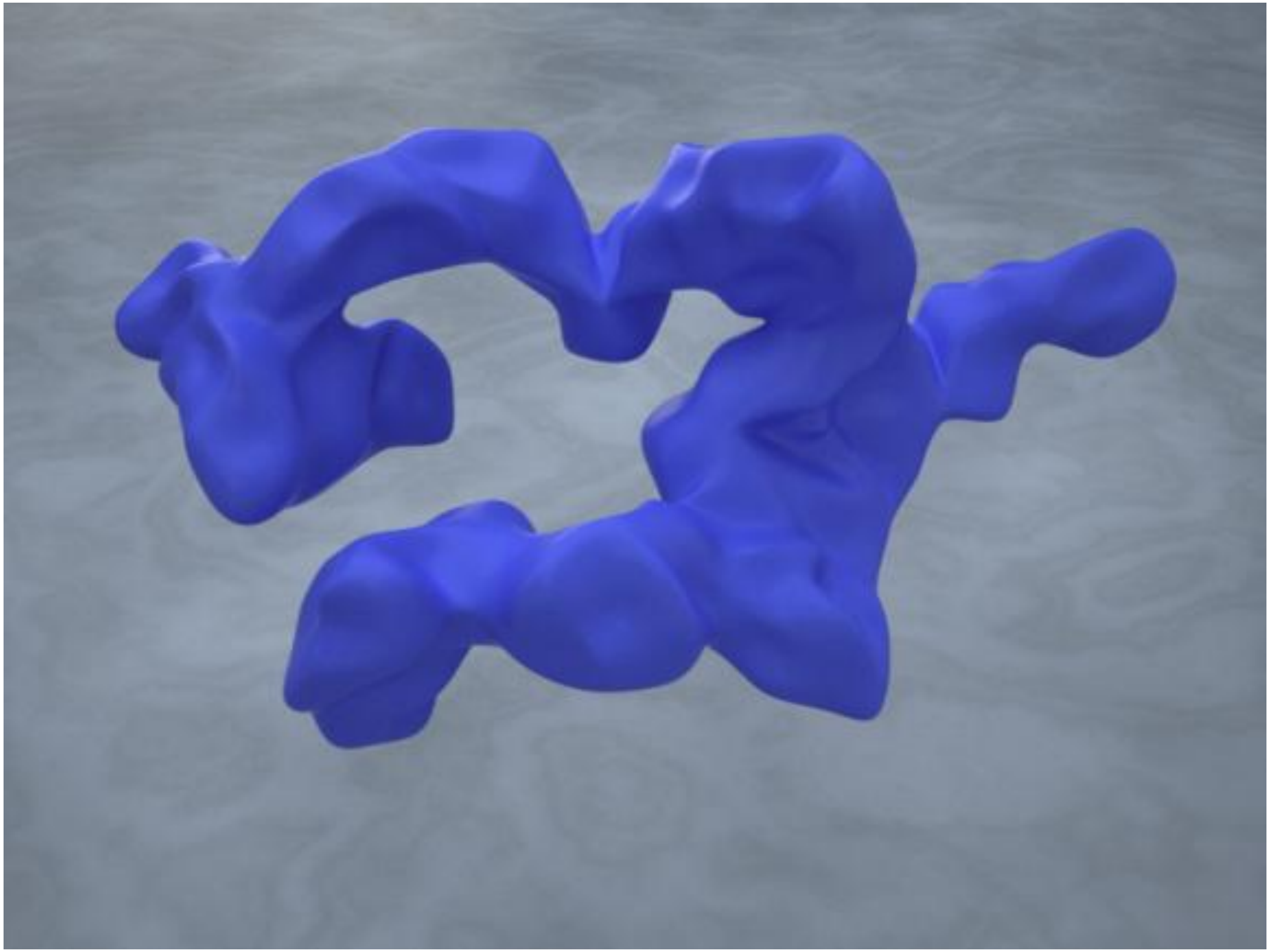
Transformation

Stimuli

To what extent can we
separate shape into causal layers?

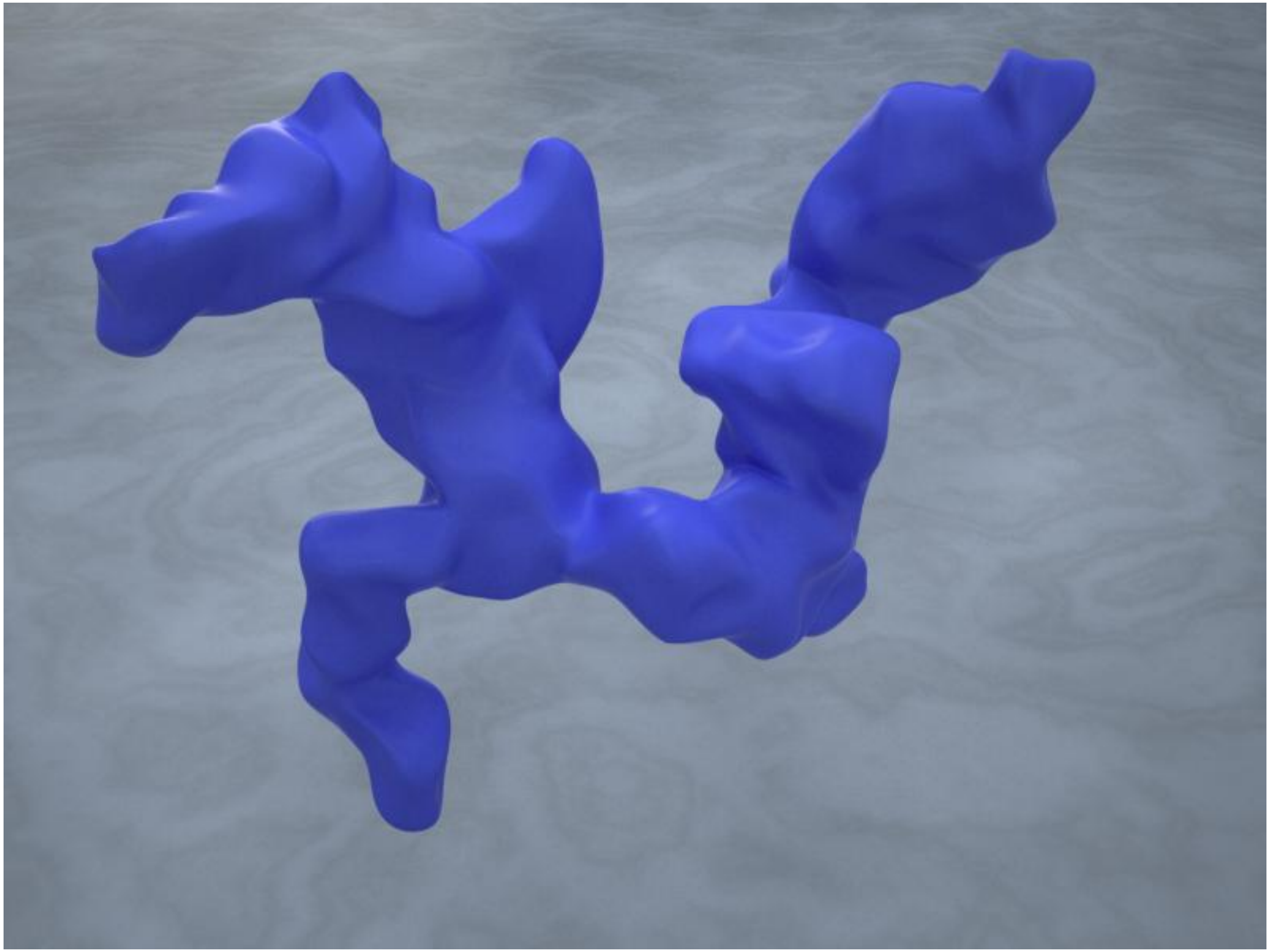
64 Stimuli

- 8 base shapes



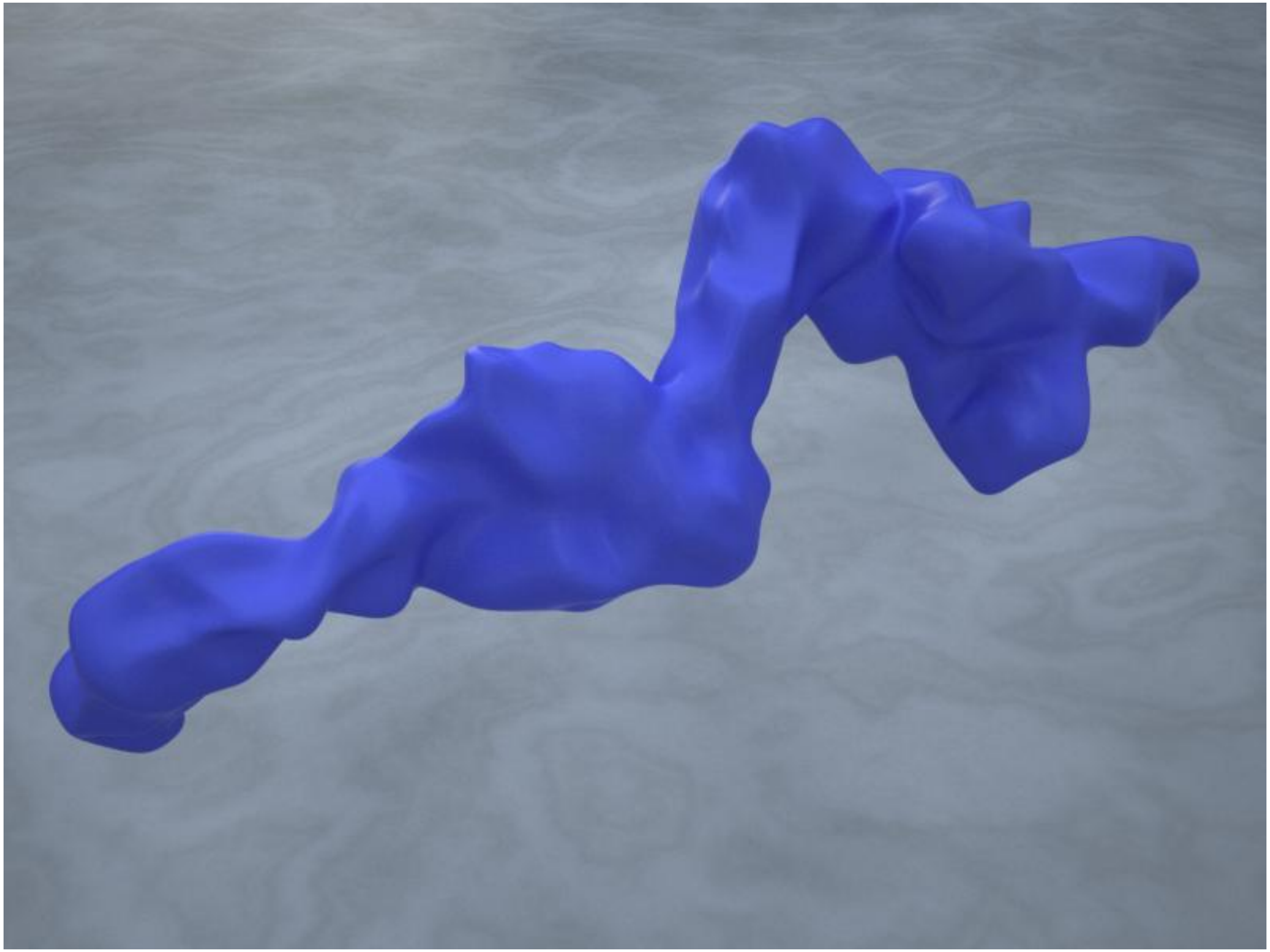
64 Stimuli

- 8 base shapes



64 Stimuli

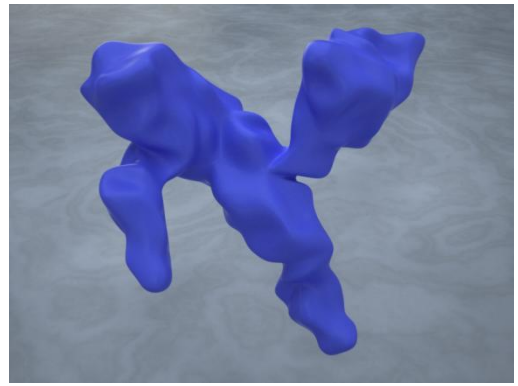
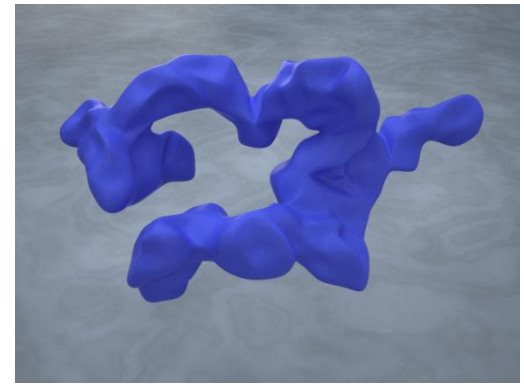
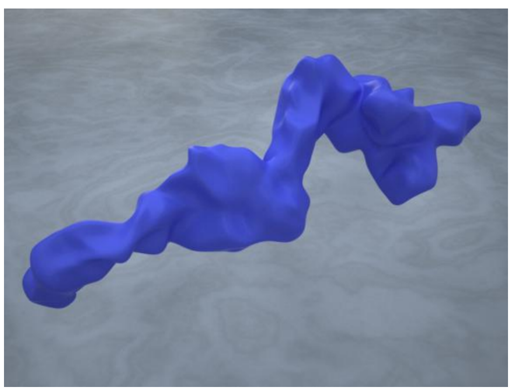
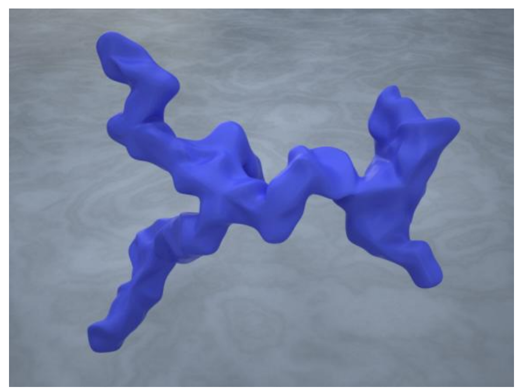
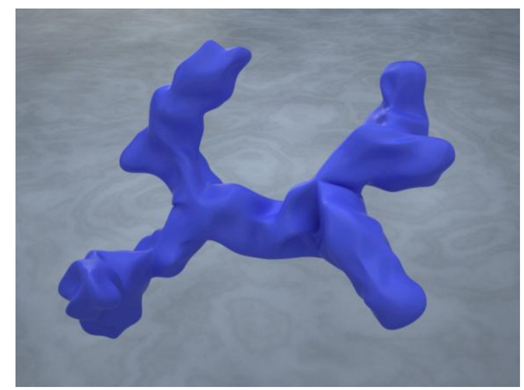
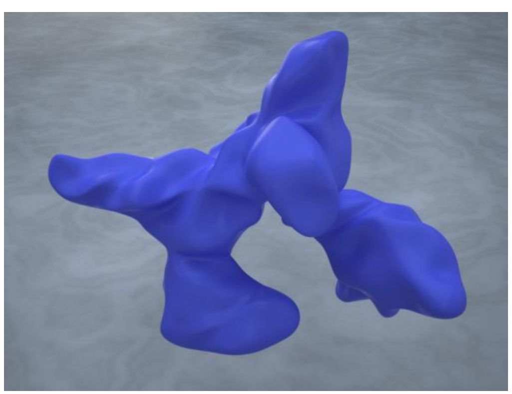
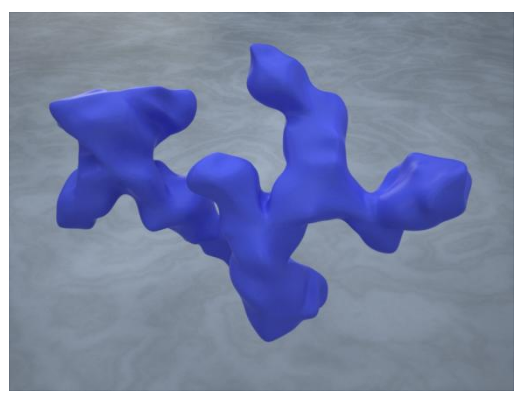
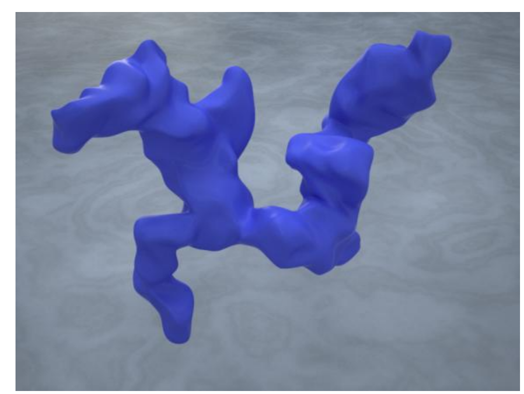
- 8 base shapes



64 Stimuli

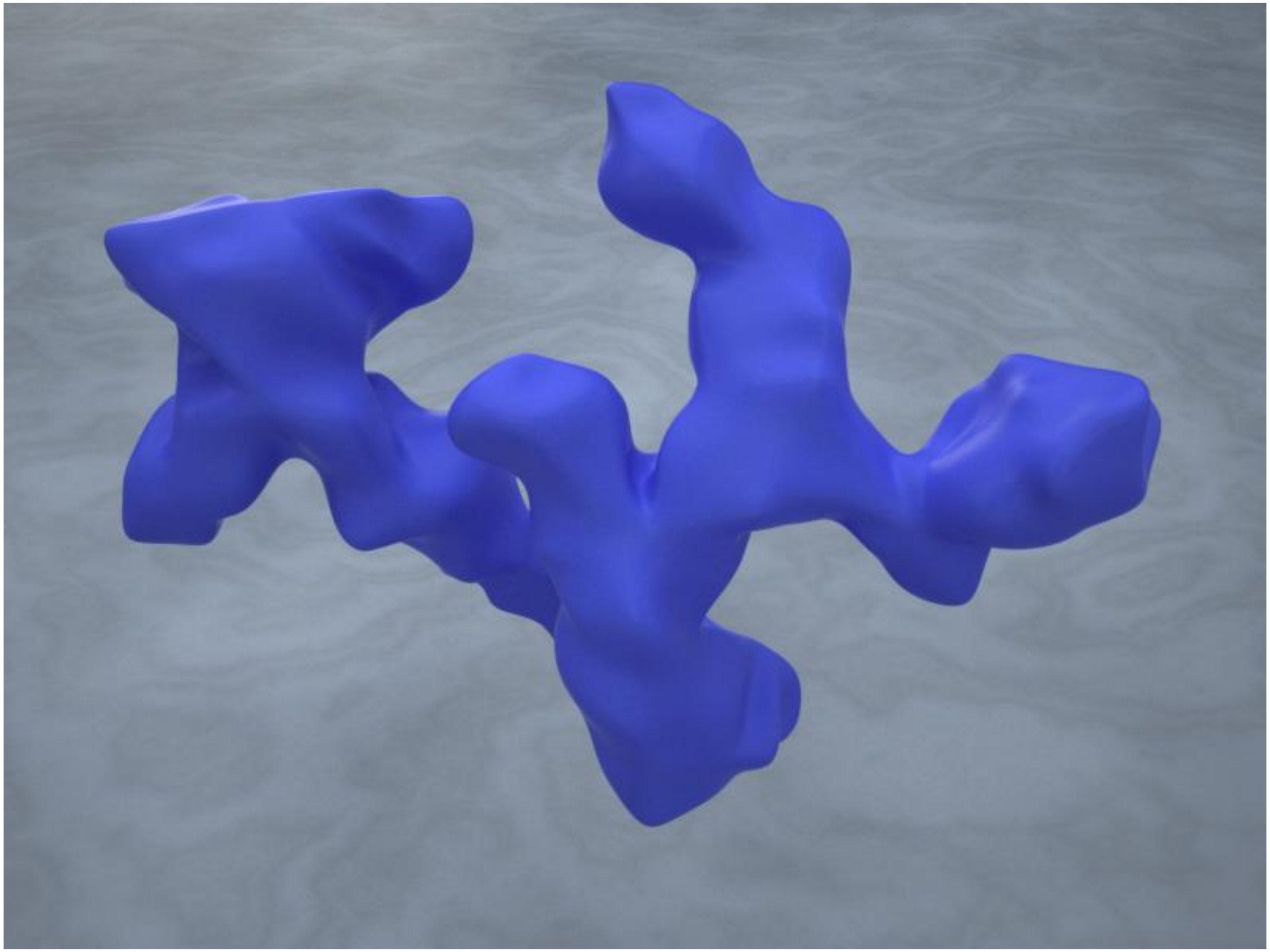
- 8 base shapes

blender

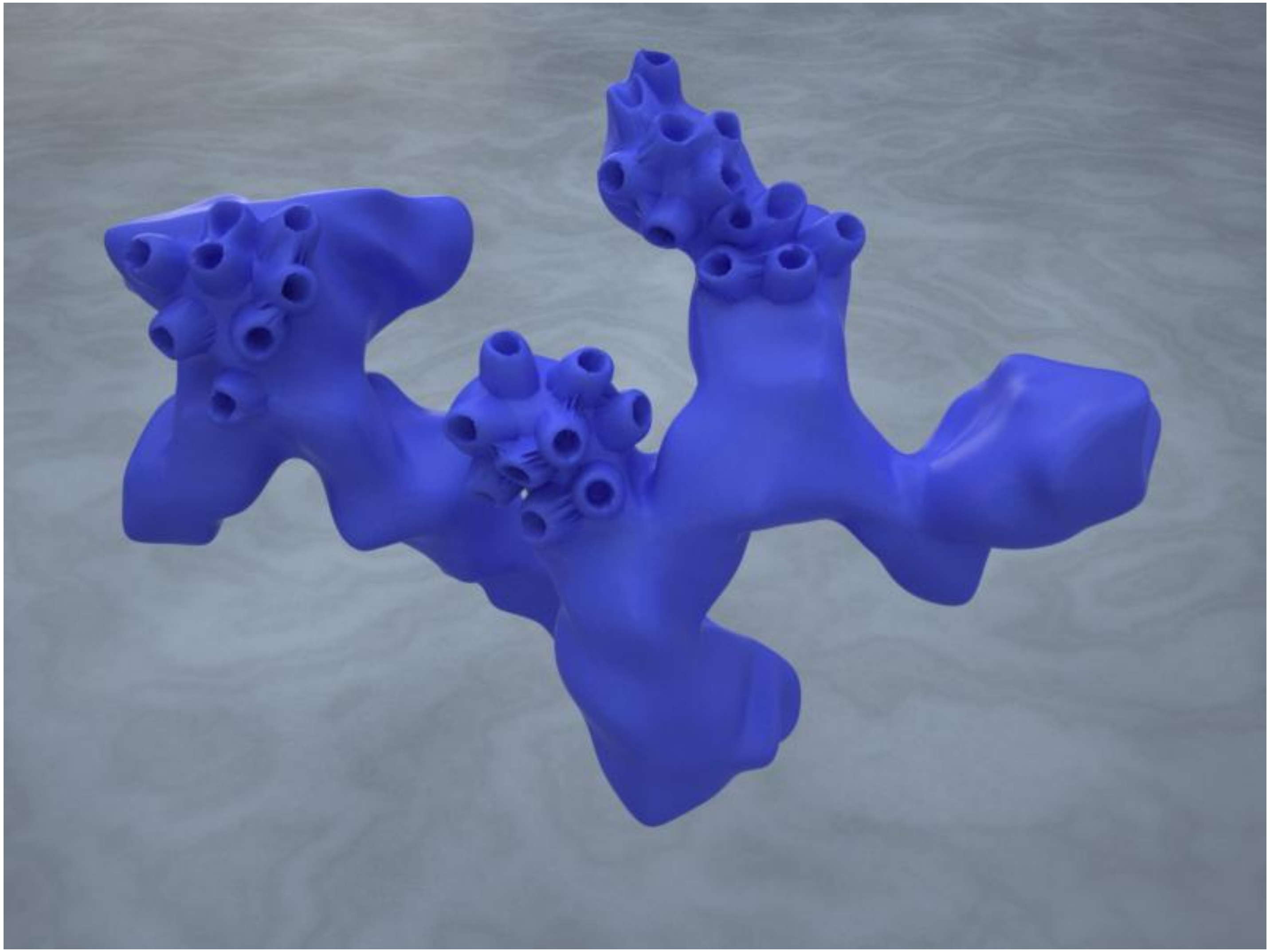
64 Stimuli

- 8 transformations



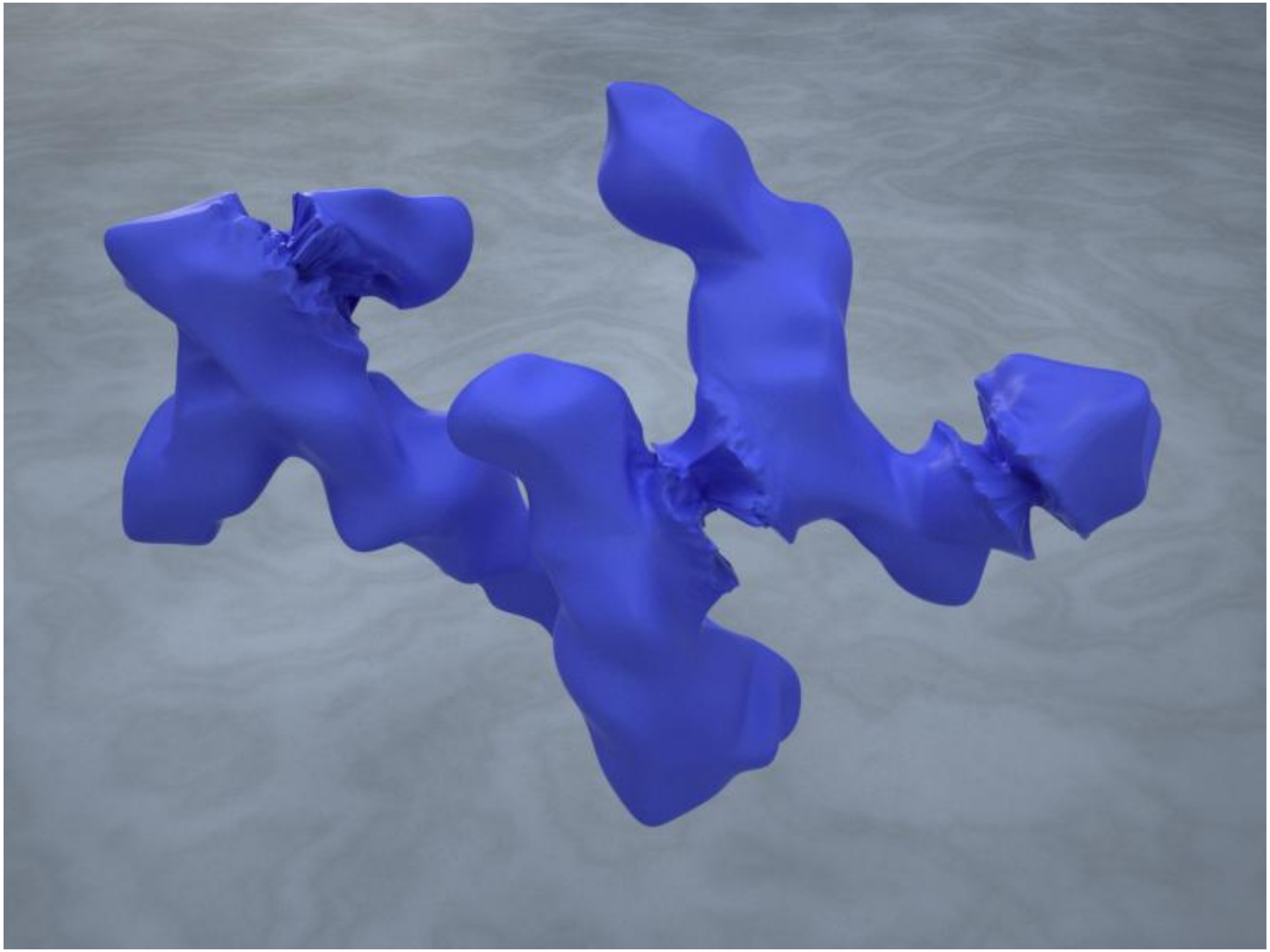
64 Stimuli

- 8 transformations



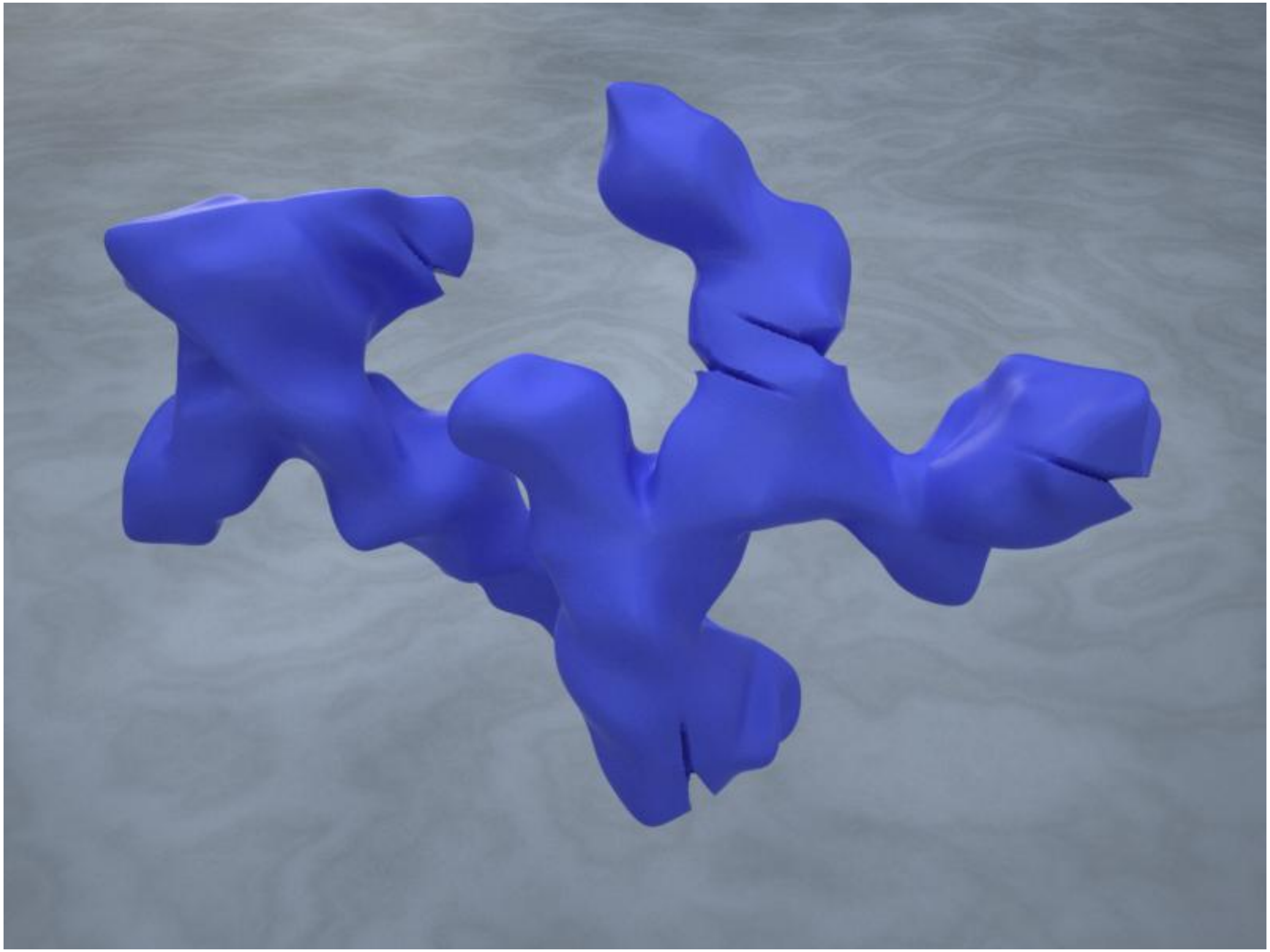
64 Stimuli

- 8 transformations



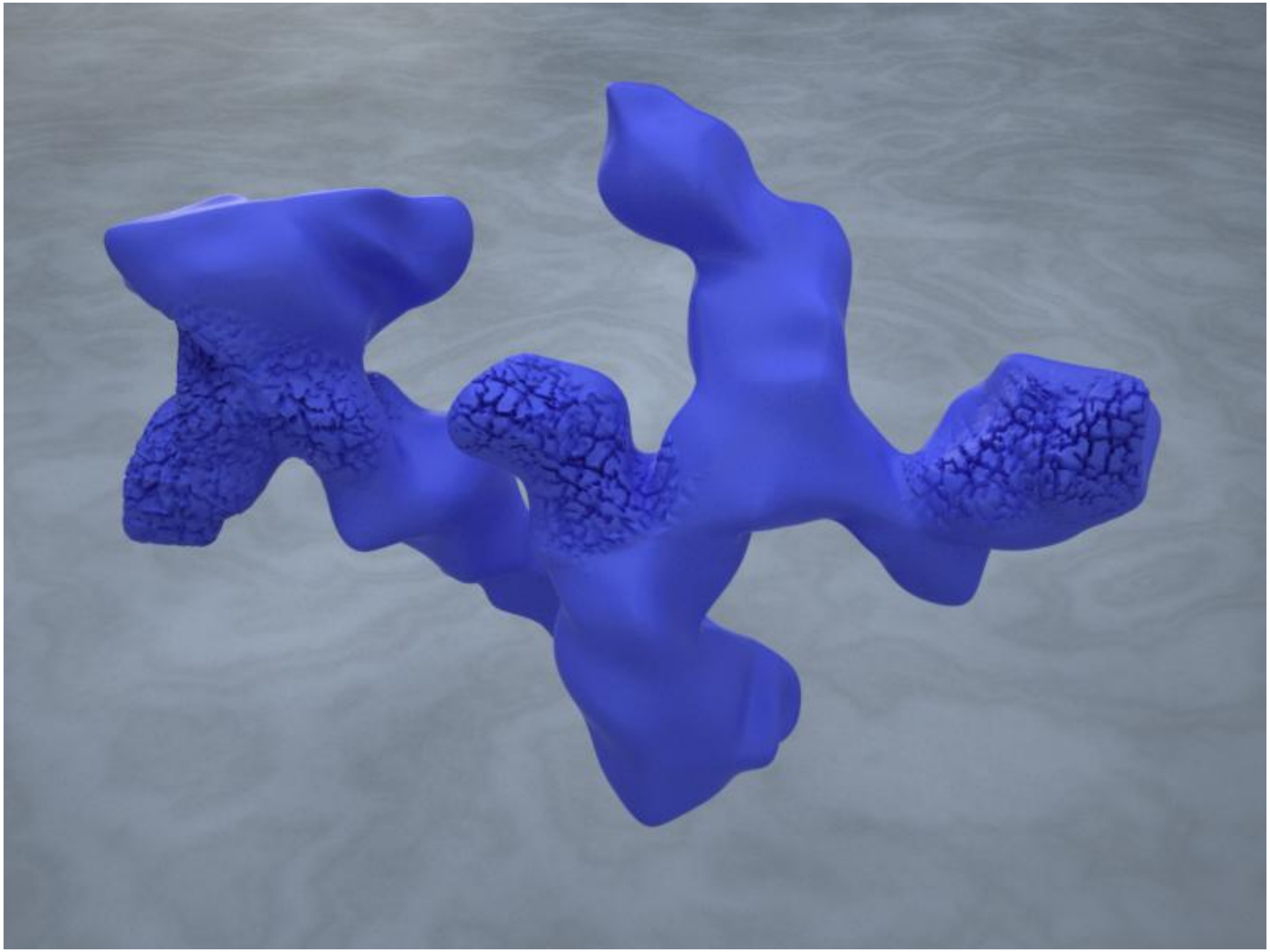
64 Stimuli

- 8 transformations



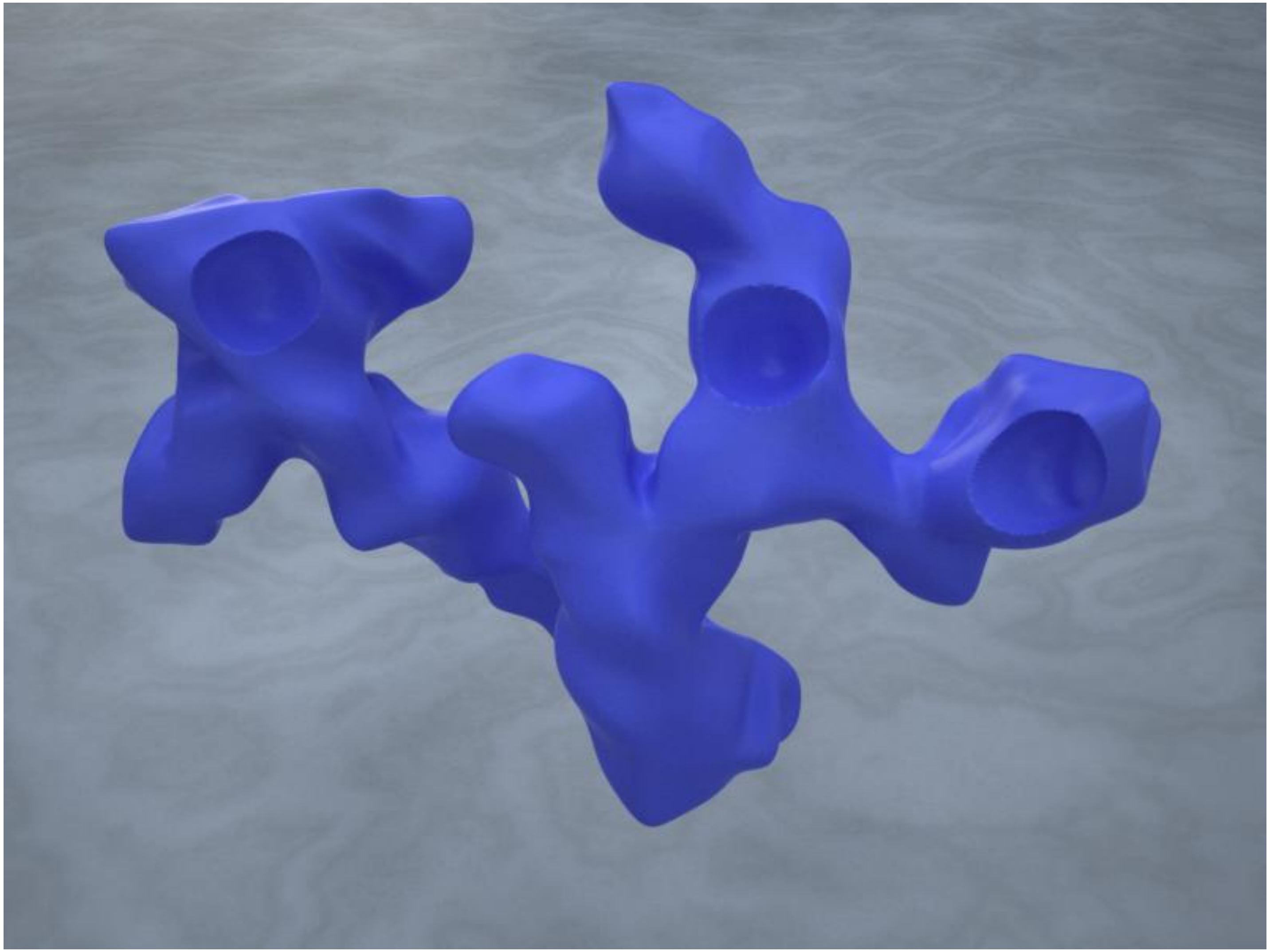
64 Stimuli

- 8 transformations



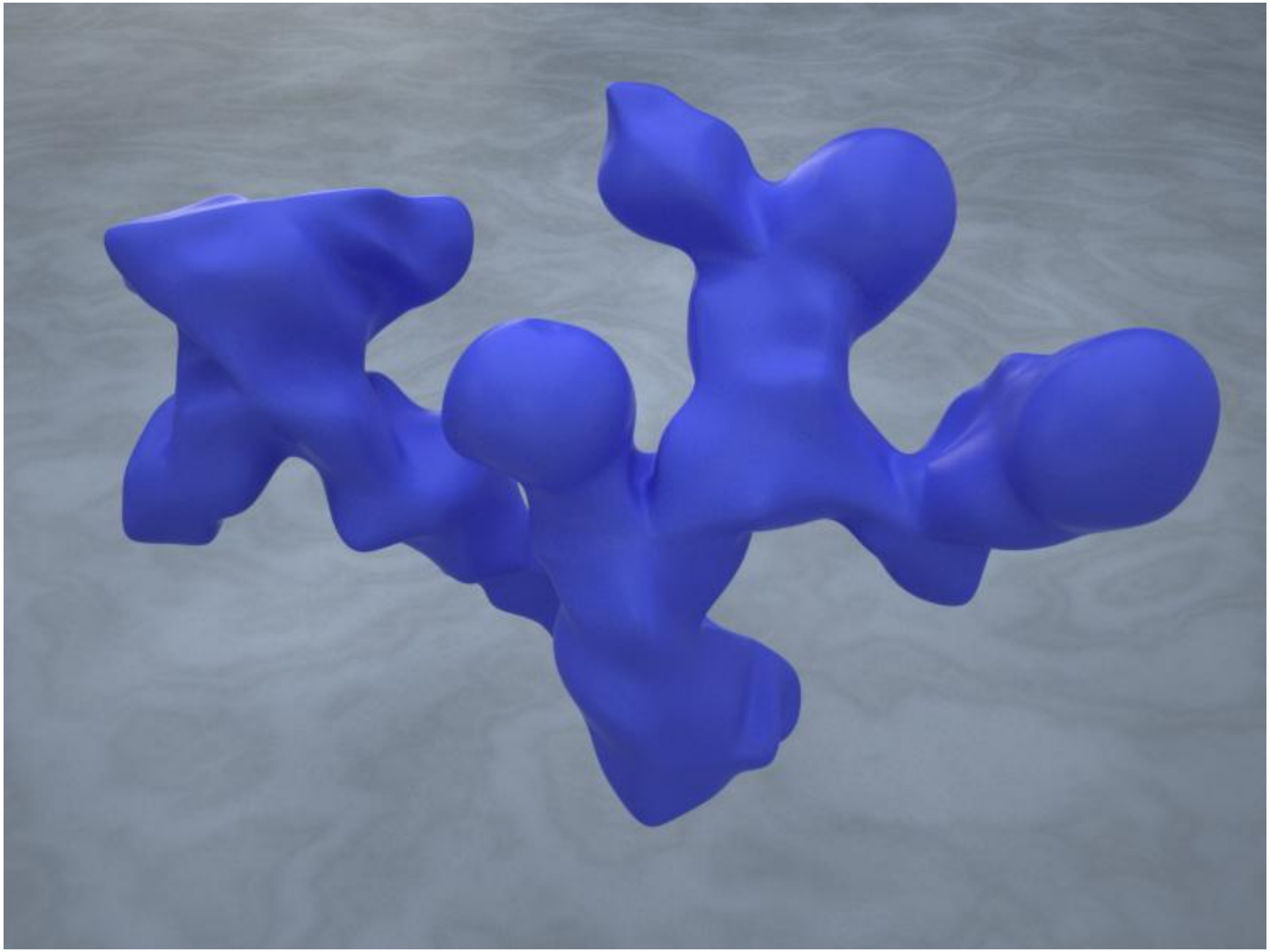
64 Stimuli

- 8 transformations



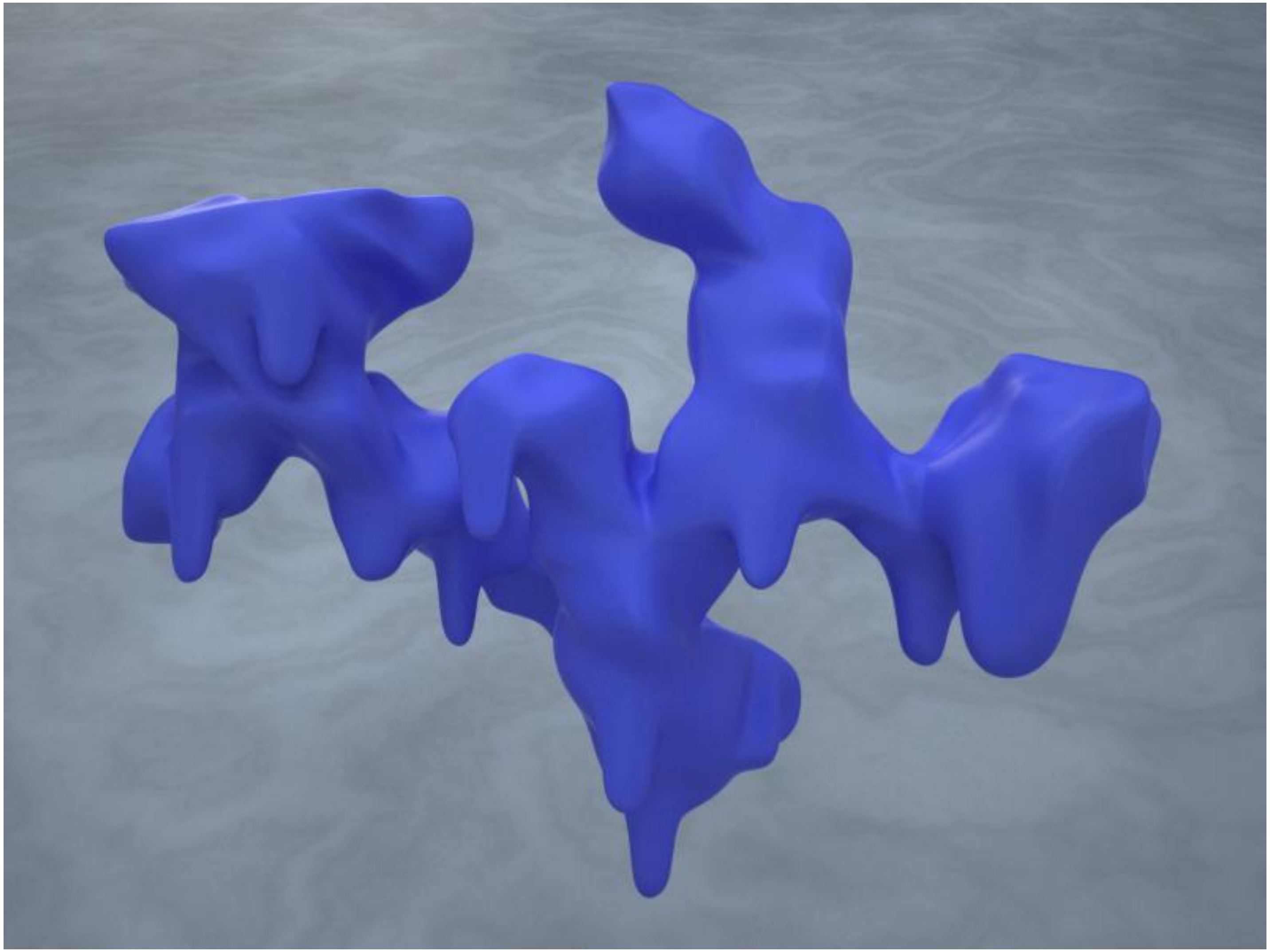
64 Stimuli

- 8 transformations



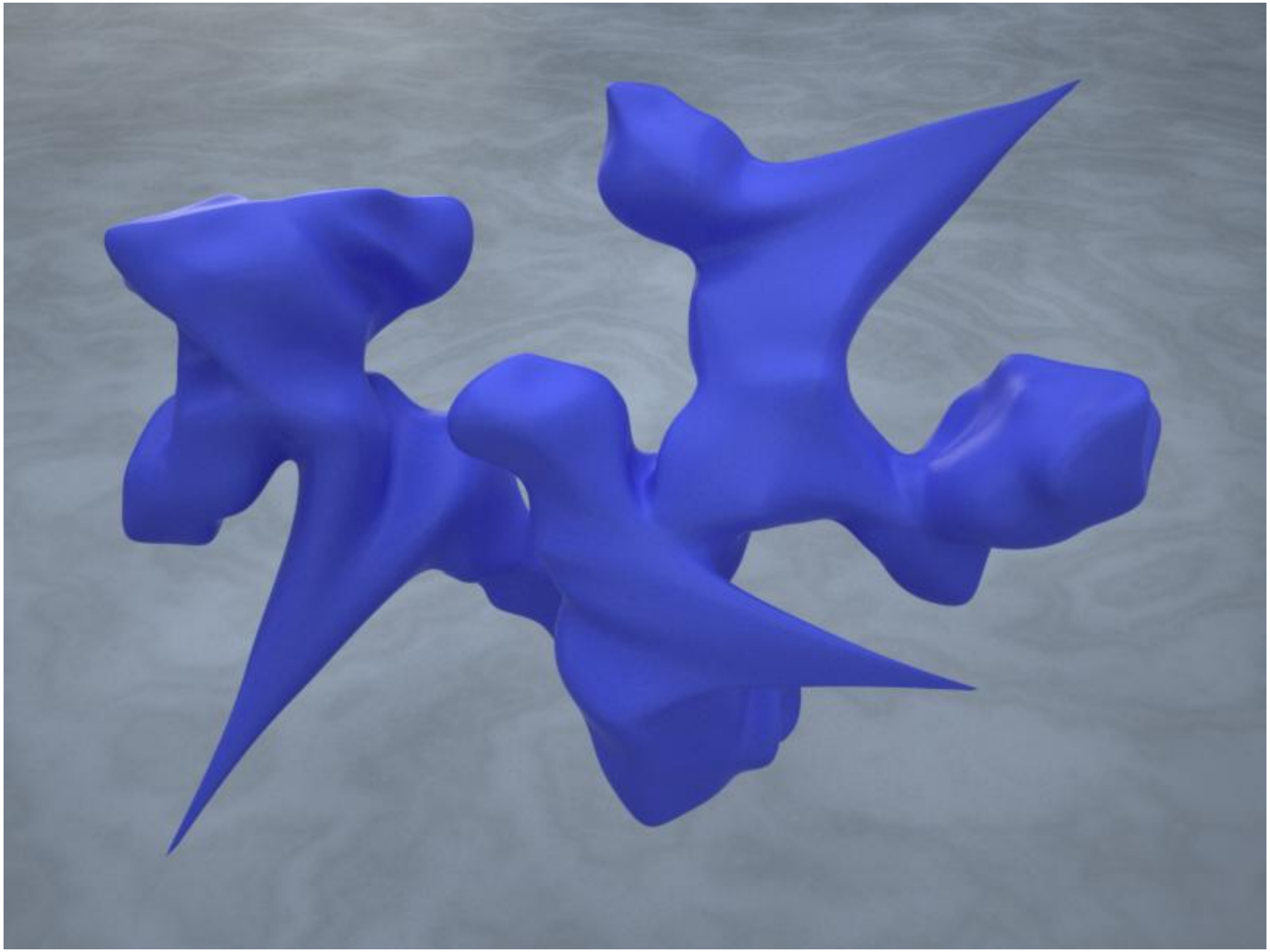
64 Stimuli

- 8 transformations



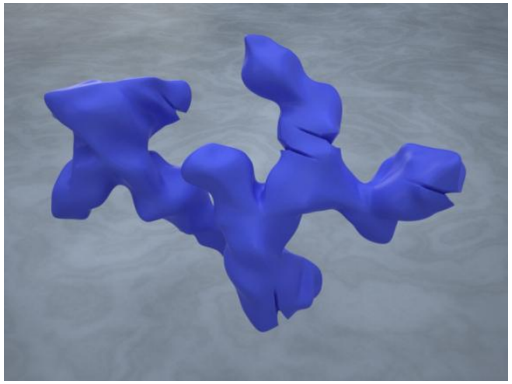
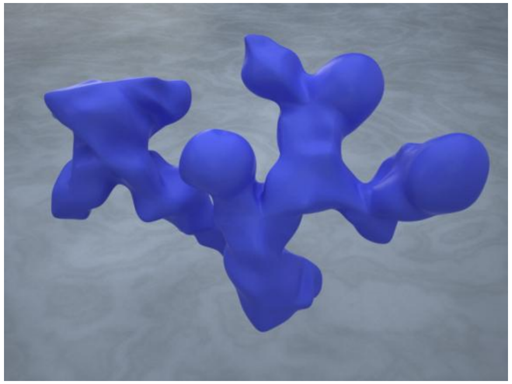
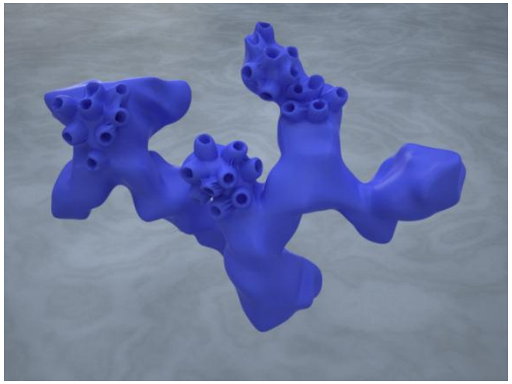
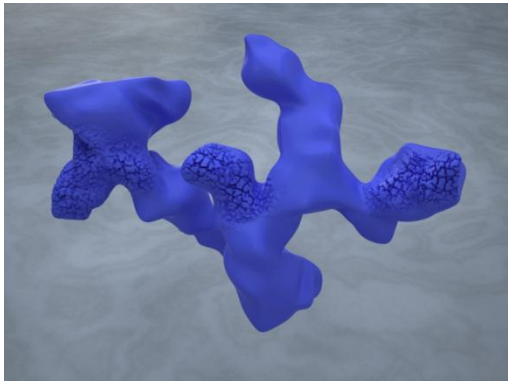
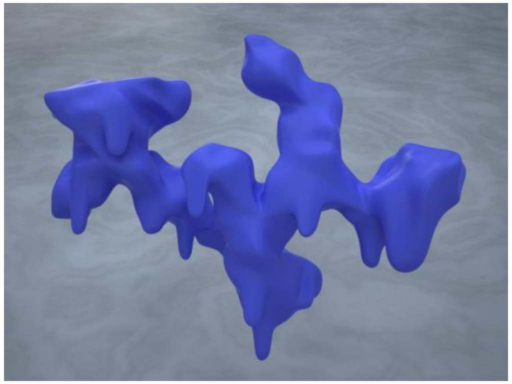
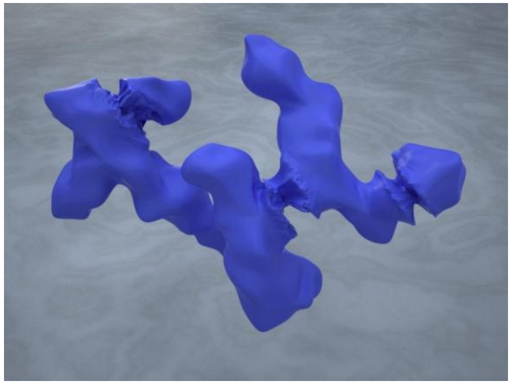
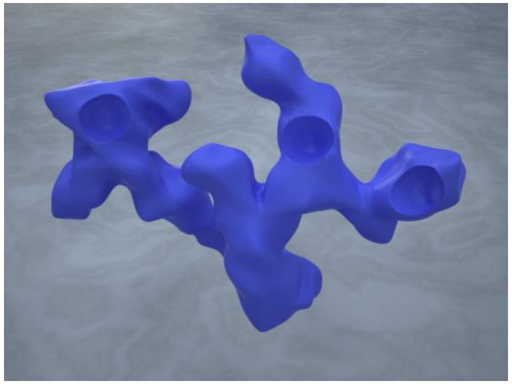
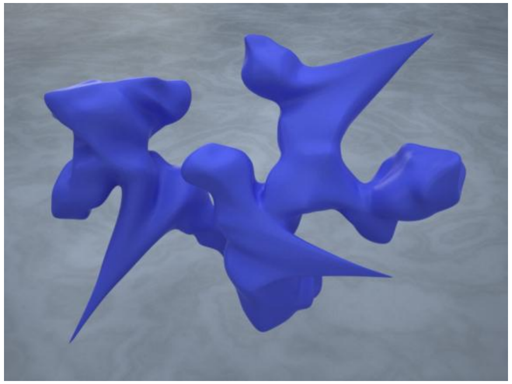
64 Stimuli

- 8 transformations

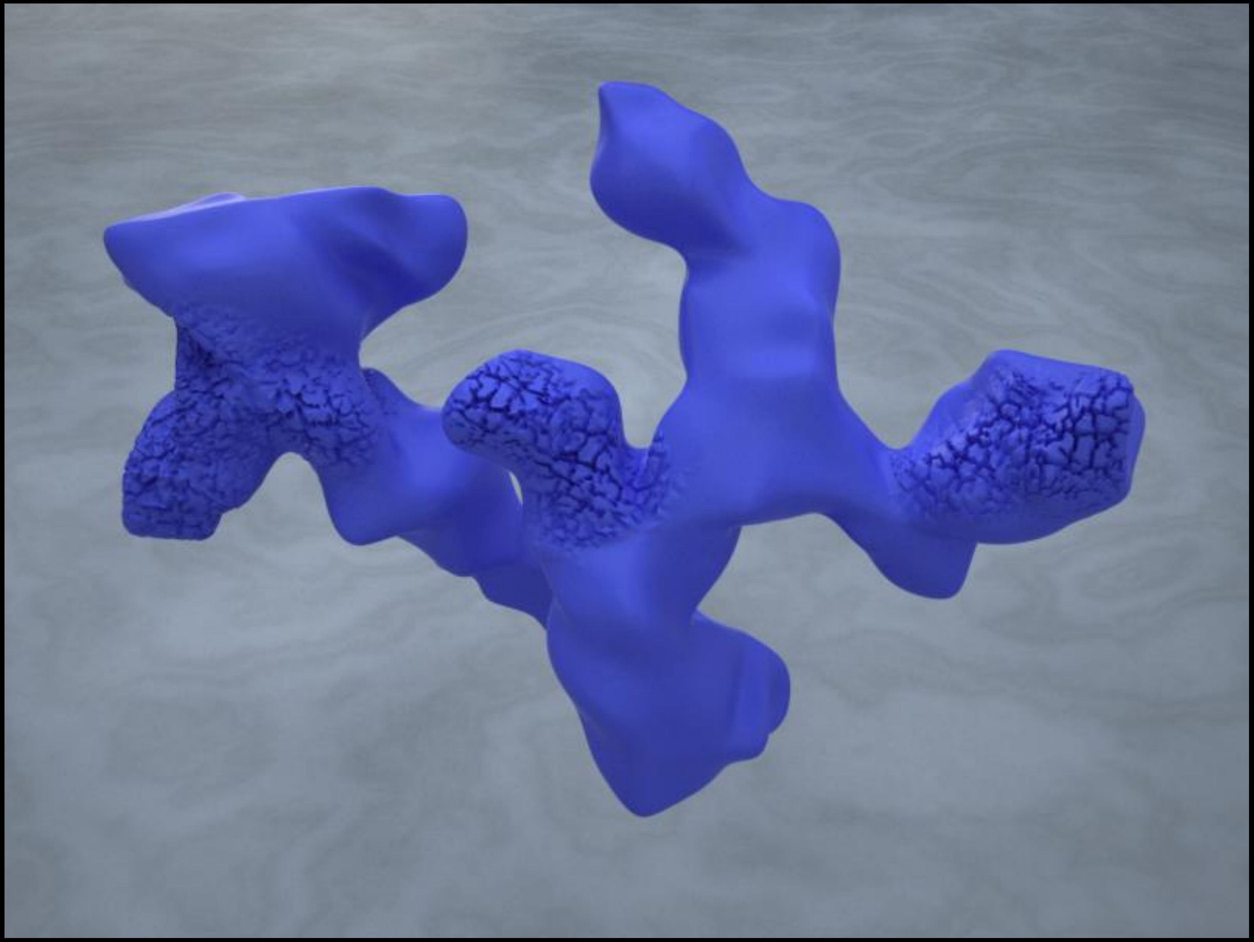


64 Stimuli

- 8 transformations

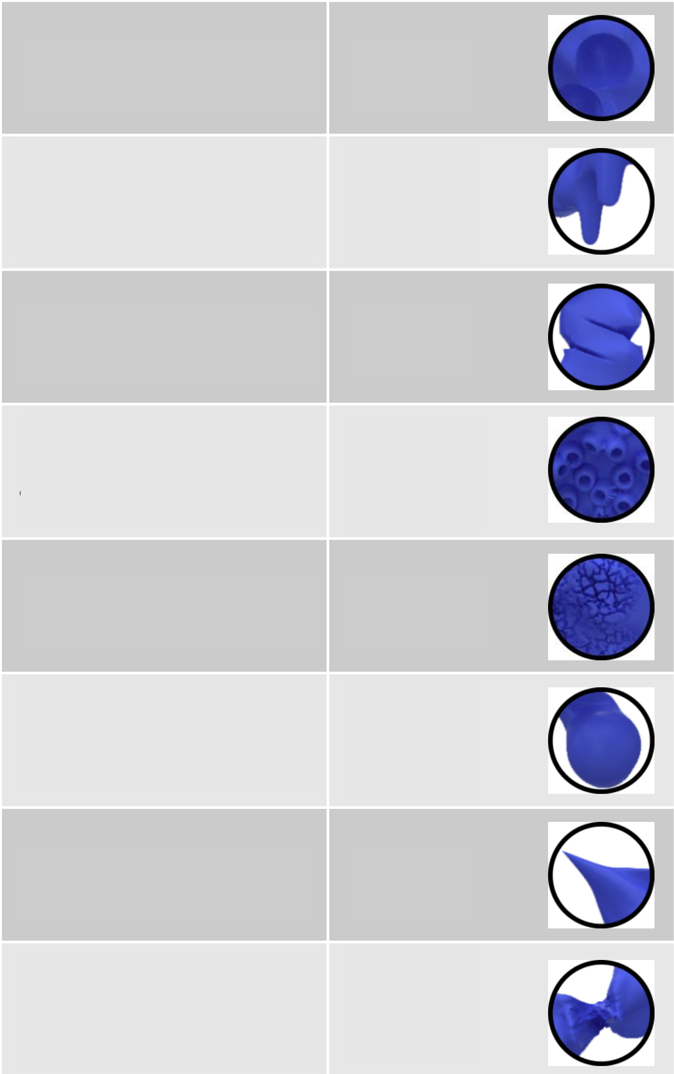
Stimulus validation

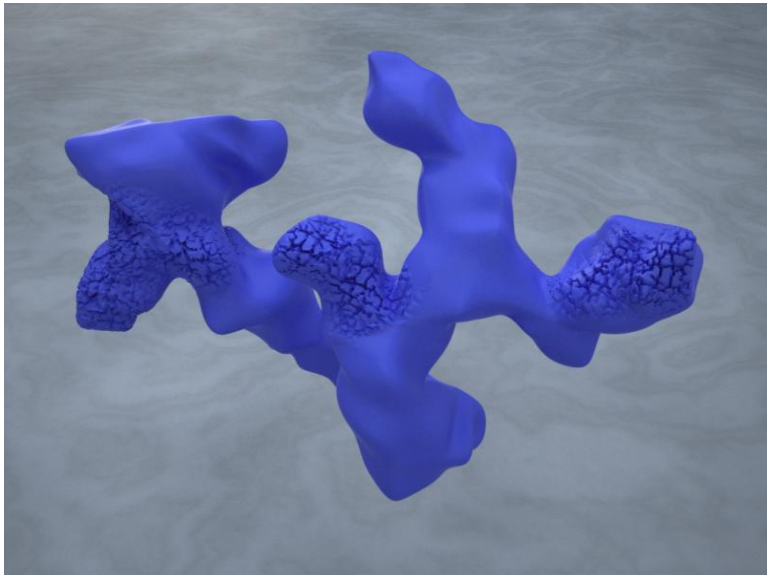


"Name or describe the change or process that happened to the object."

Stimulus validation

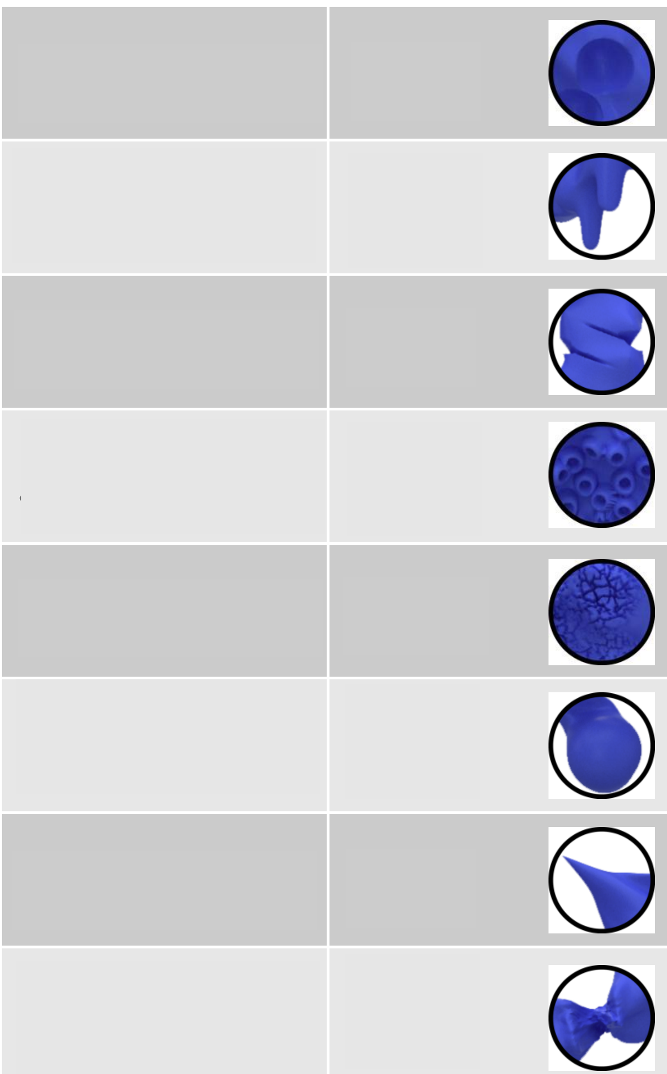
- Responses (n = 16)

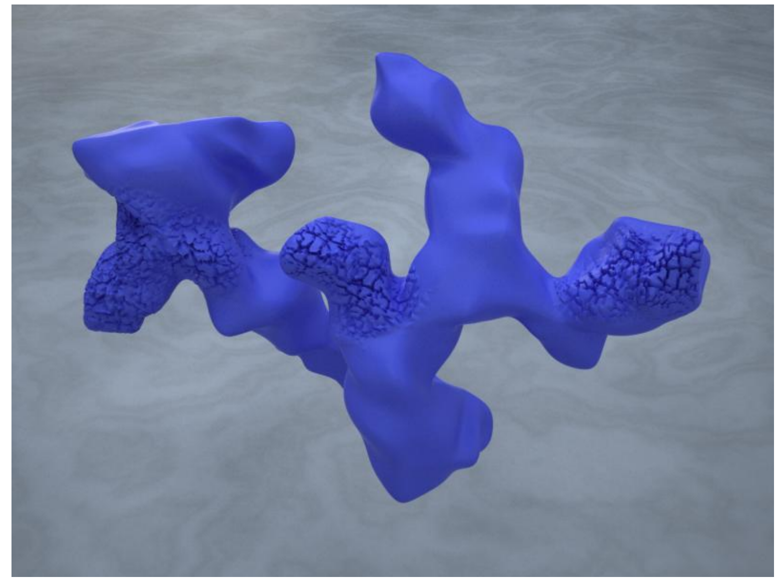


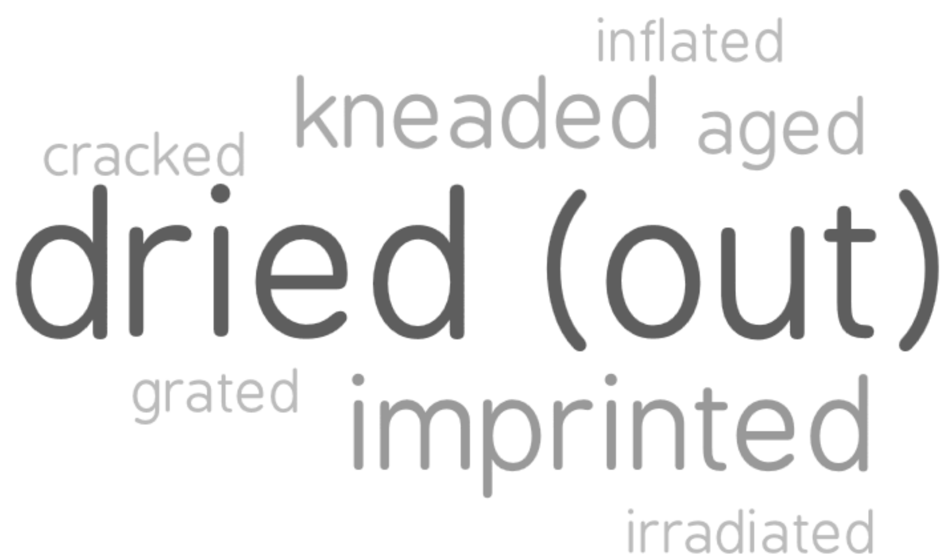


Stimulus validation

- Responses (n = 16)

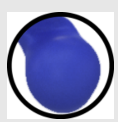


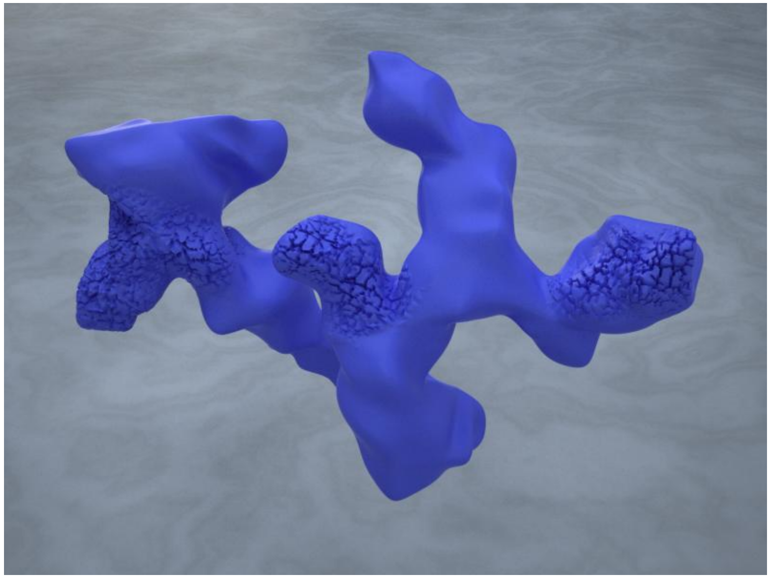




Stimulus validation

- Responses (n = 16)

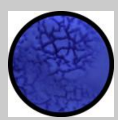
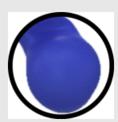
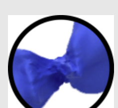
		
		
		
		
dried	81%	
		
		
		

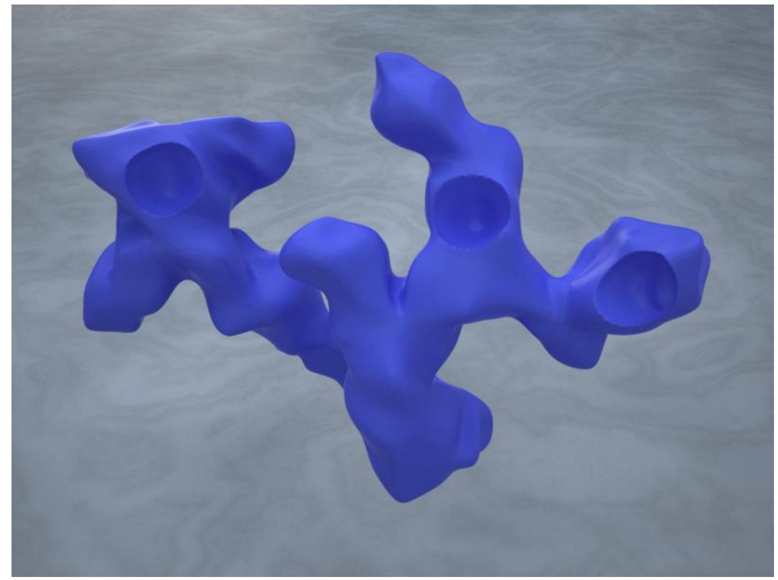


inflated
kneaded aged
cracked
dried (out)
grated imprinted
irradiated

Stimulus validation

- Responses (n = 16)

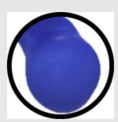
indented	100%	
		
		
		
dried	81%	
		
		
		

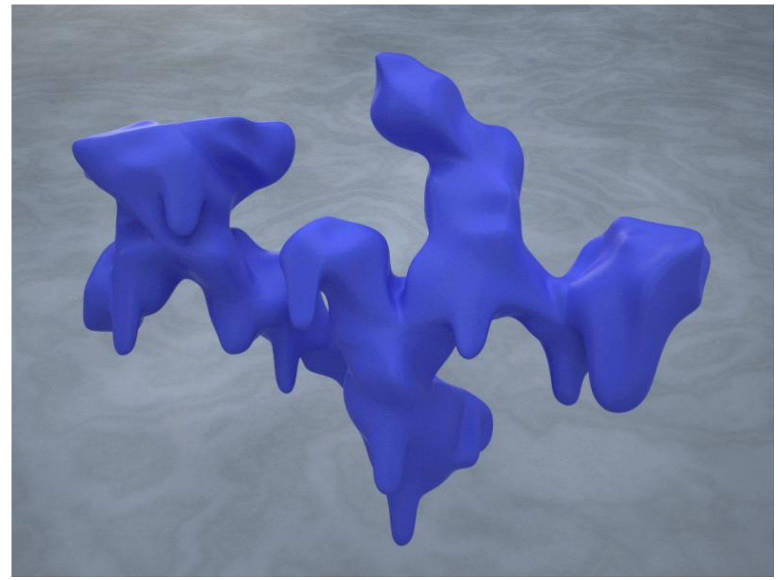


indented / pushed in

Stimulus validation

- Responses (n = 16)

indented	100%	
melted	100%	
		
		
dried	81%	
		
		
		

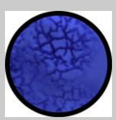
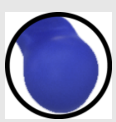


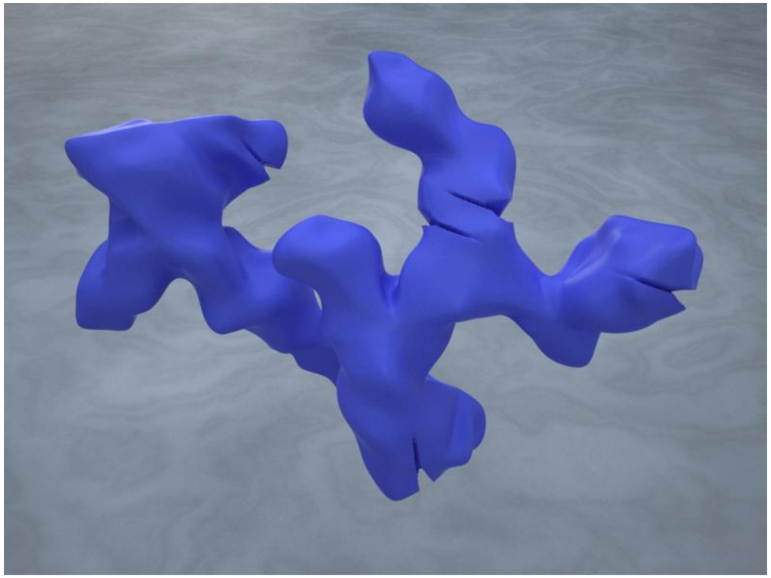
showered

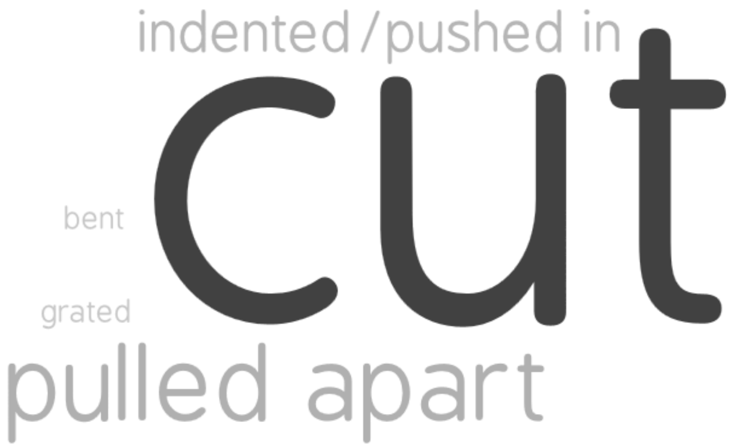
melted / runny

Stimulus validation

- Responses (n = 16)

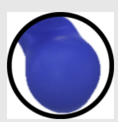
indented	100%	
melted	100%	
cut	94%	
		
dried	81%	
		
		
		

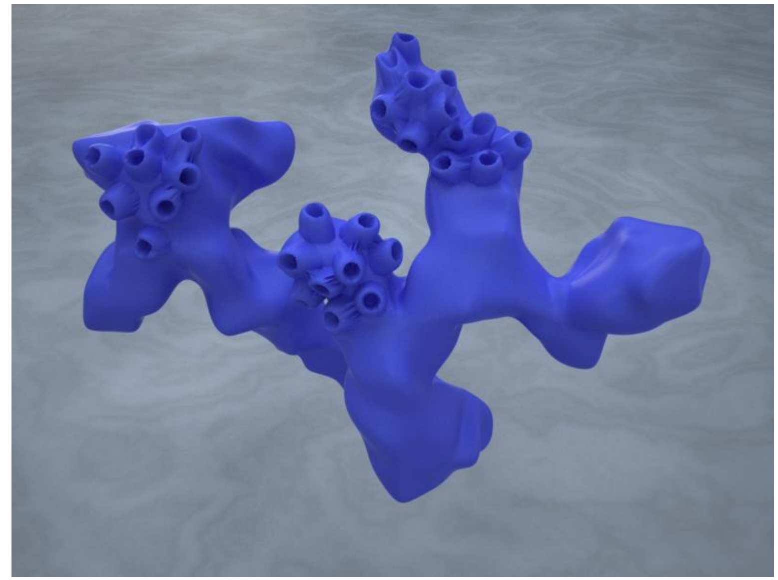




Stimulus validation

- Responses (n = 16)

indented	100%	
melted	100%	
cut	94%	
grown	88%	
dried	81%	
		
		
		



pulled out

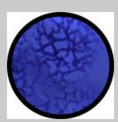
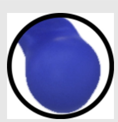
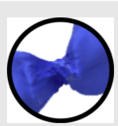
grown / bulged out

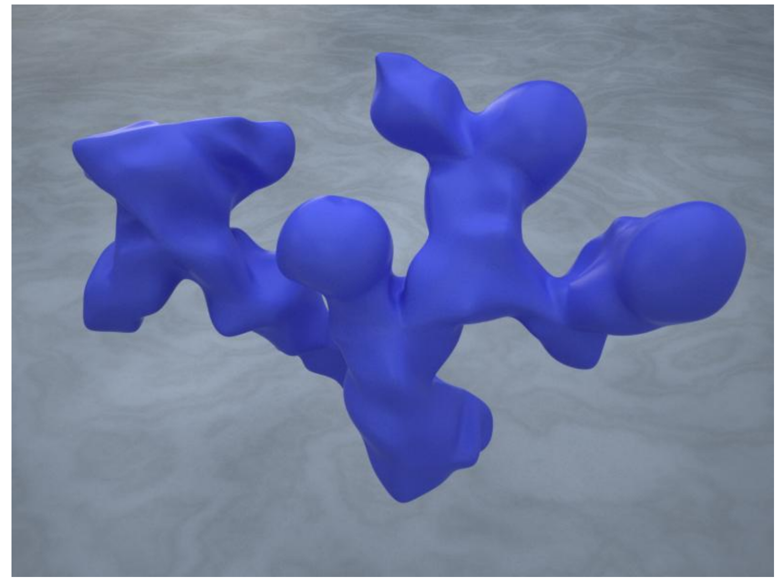
pierced / pressed in with rod

grown over / colonized

Stimulus validation

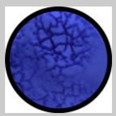
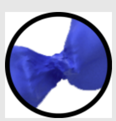
- Responses (n = 16)

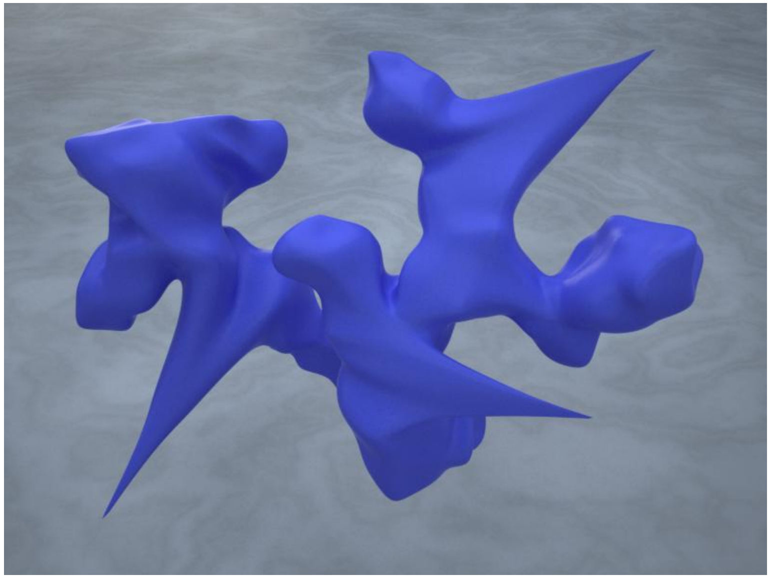
indented	100%	
melted	100%	
cut	94%	
grown	88%	
dried	81%	
inflated	69%	
		
		



Stimulus validation

- Responses (n = 16)

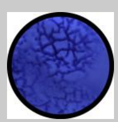
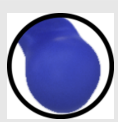
indented	100%	
melted	100%	
cut	94%	
grown	88%	
dried	81%	
inflated	69%	
stretched	57%	
		

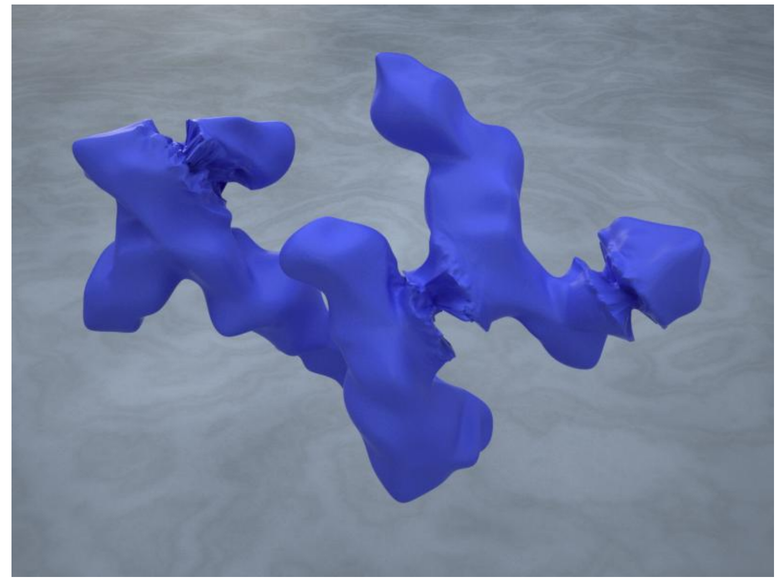


cooled down
filed off / carved
pierced from inside
stretched
spikes kneaded

Stimulus validation

- Responses (n = 16)

indented	100%	
melted	100%	
cut	94%	
grown	88%	
dried	81%	
inflated	69%	
stretched	57%	
twisted/pulled/ strangulated/	44%	



twisted off
strangulated
fissioned
pulled apart
gnawed

Experiment 1: Shape scission

- Classification experiment (n = 15)

„Group objects according to what happened to them“

Experiment 1: Shape scission

- Classification experiment (n = 15)

  „Group objects according to what happened to them“

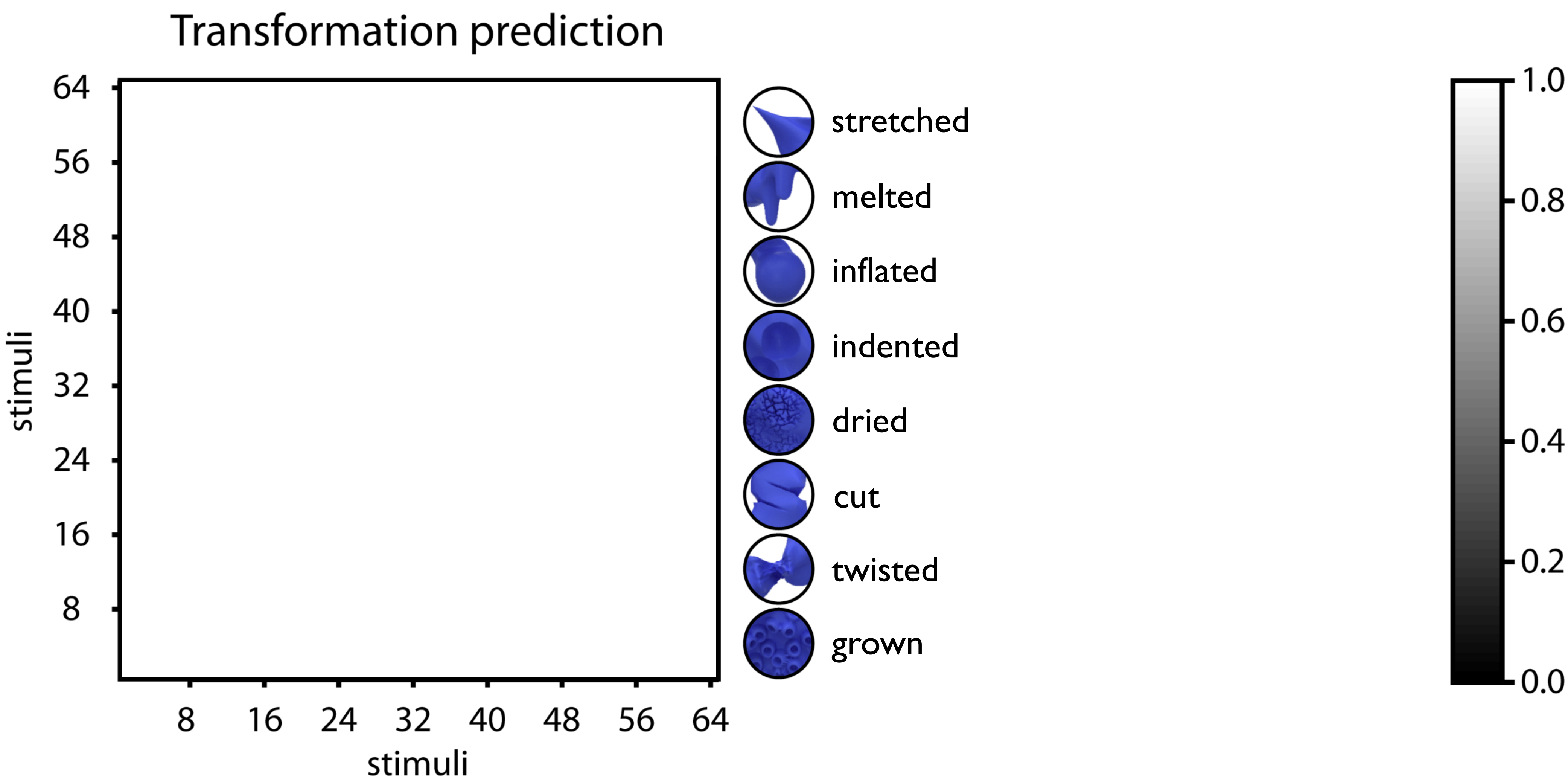
Experiment 1: Shape scission

- Classification experiment (n = 15)

„Group objects according to what happened to them"

„Group objects according to the shape they had before something happened to them"

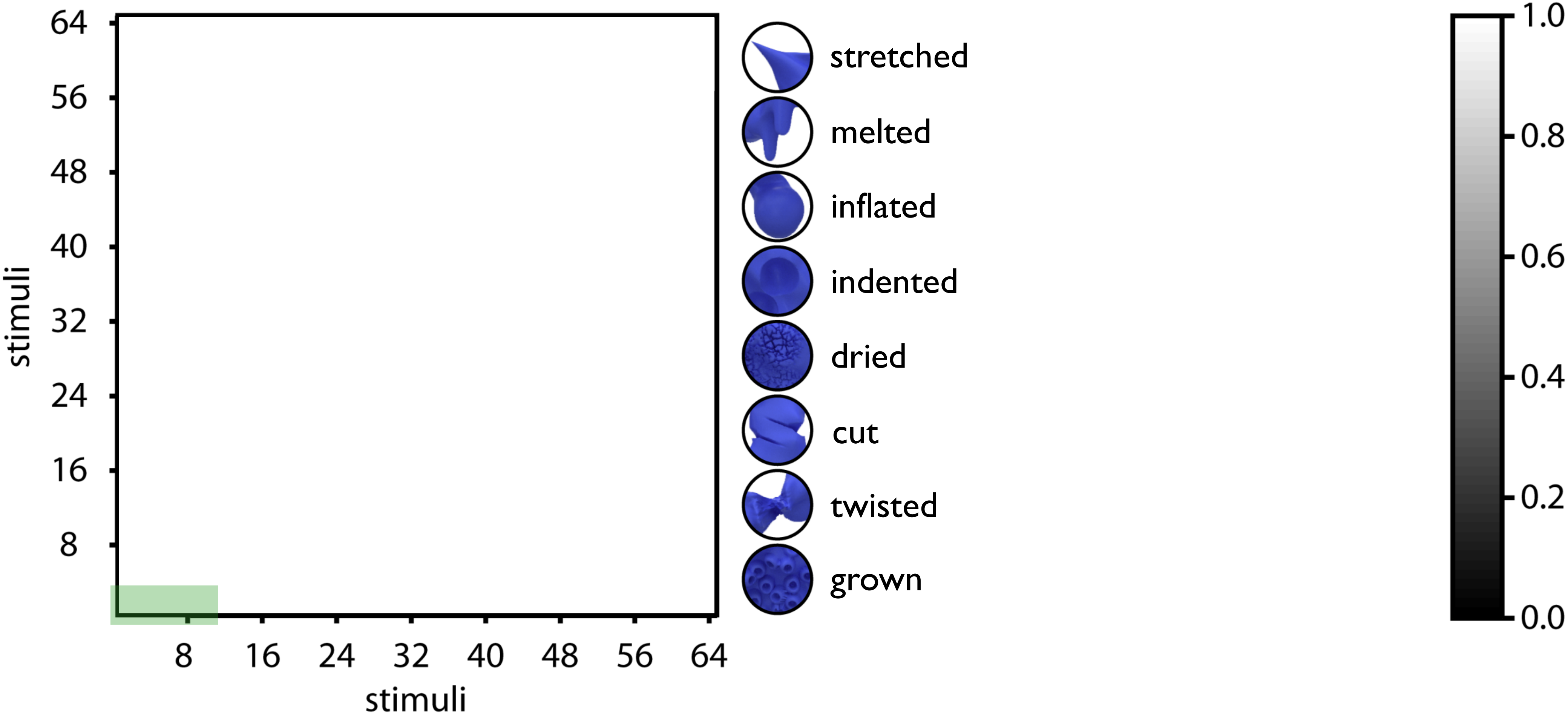
Experiment 1: Shape scission



Perceived as within same group

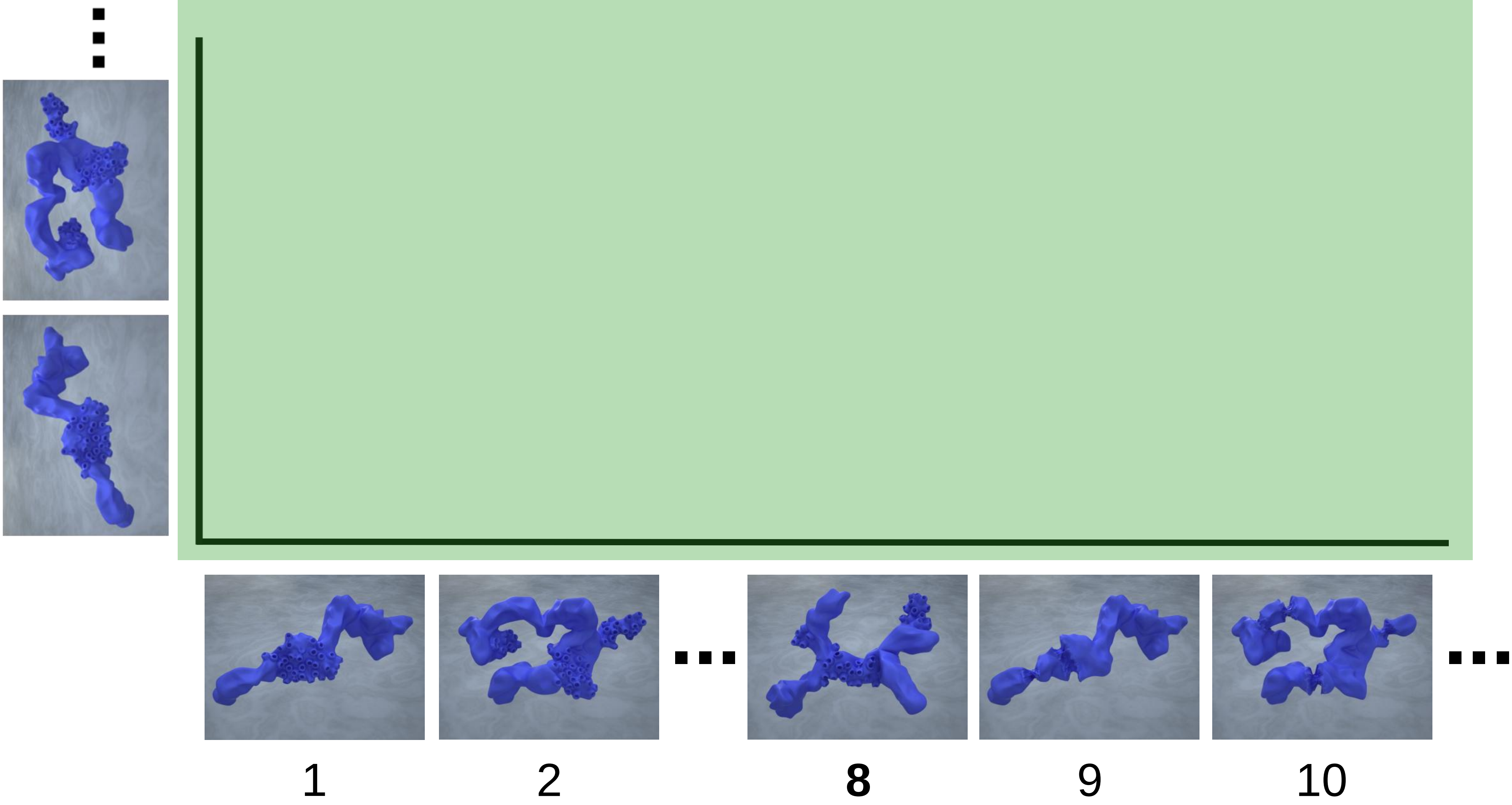
Experiment 1: Shape scission

Transformation prediction

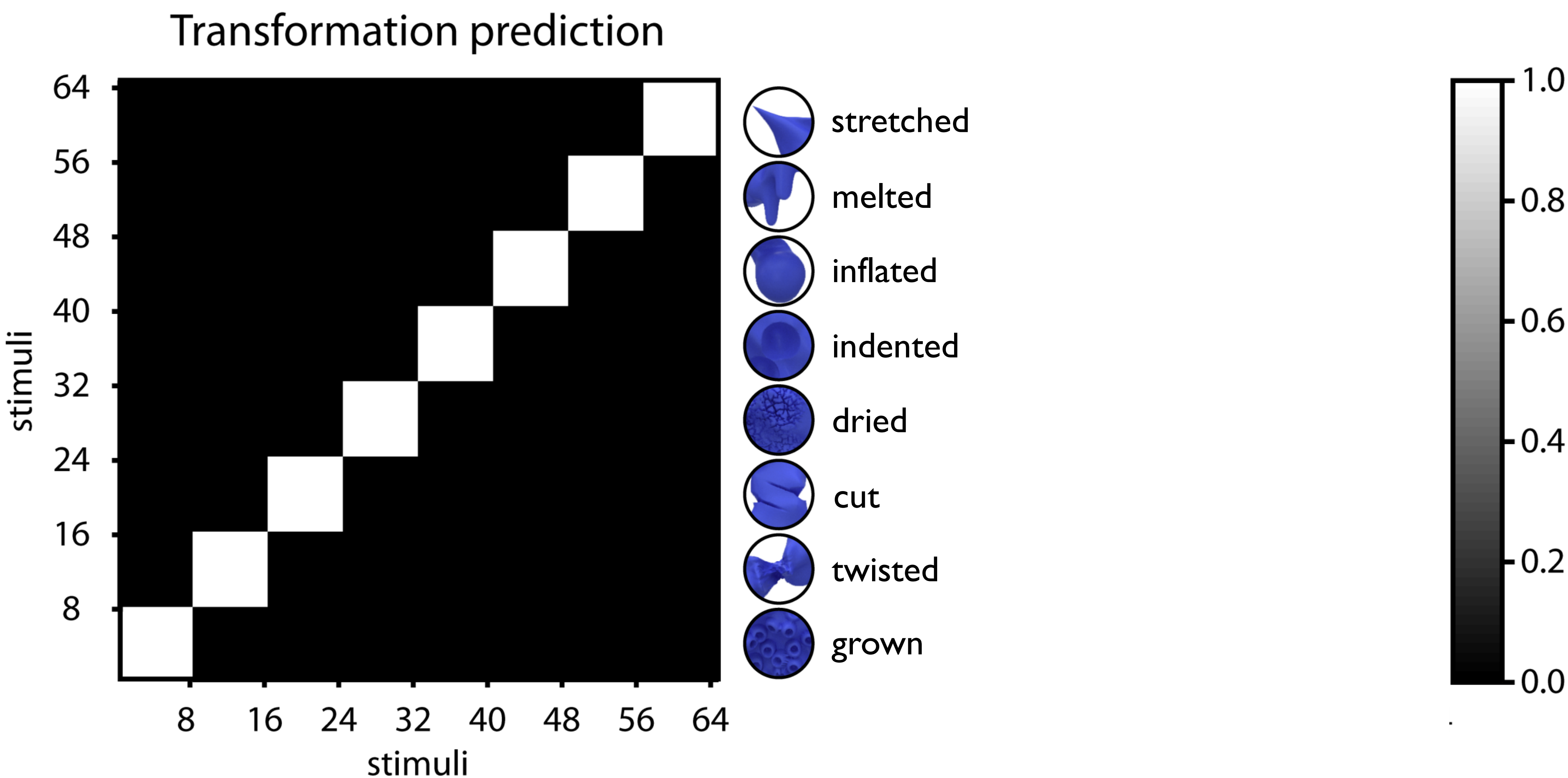


Perceived as within same group

Experiment 1: Shape scission



Experiment 1: Shape scission



Perceived as within same group

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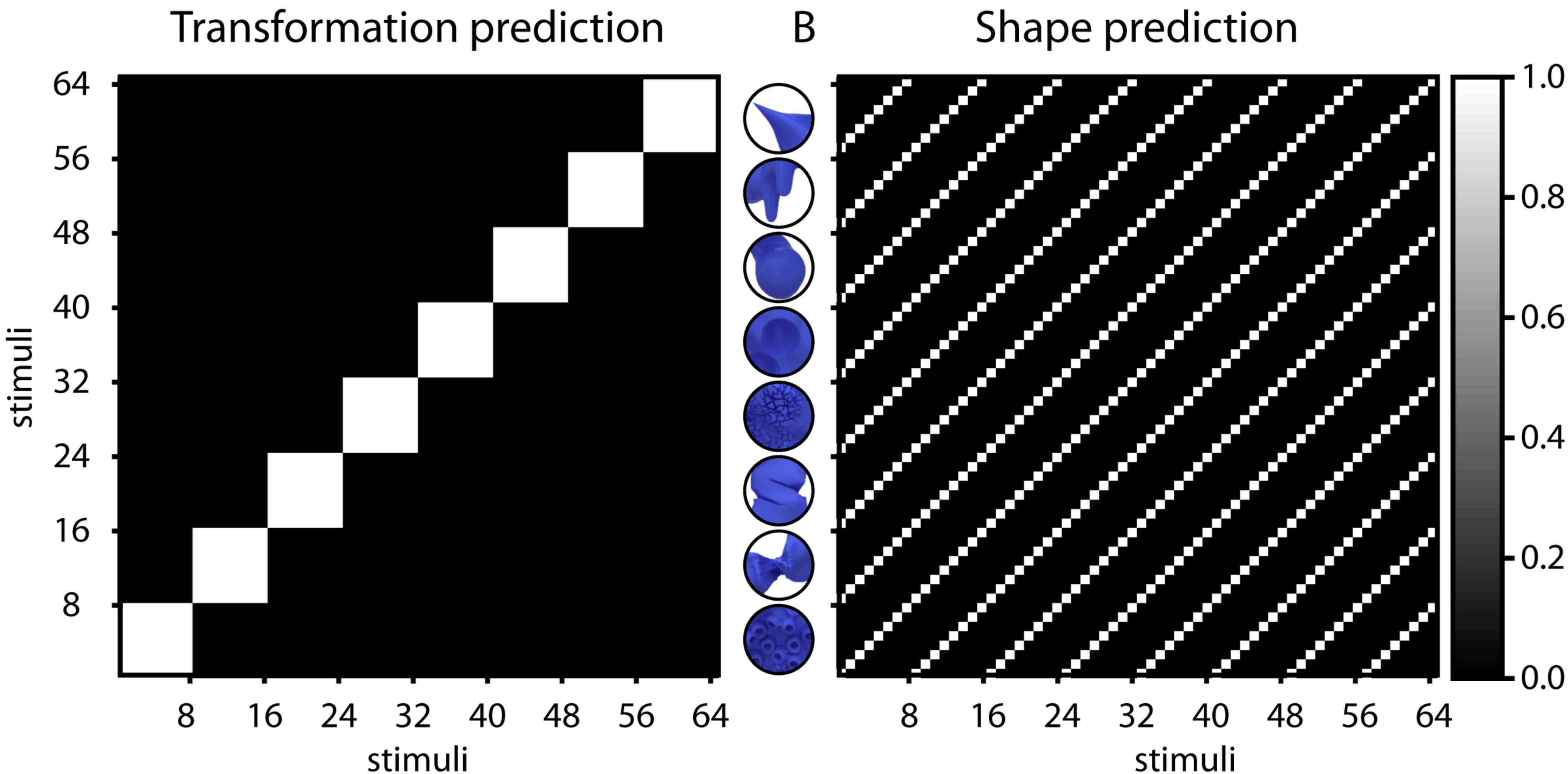

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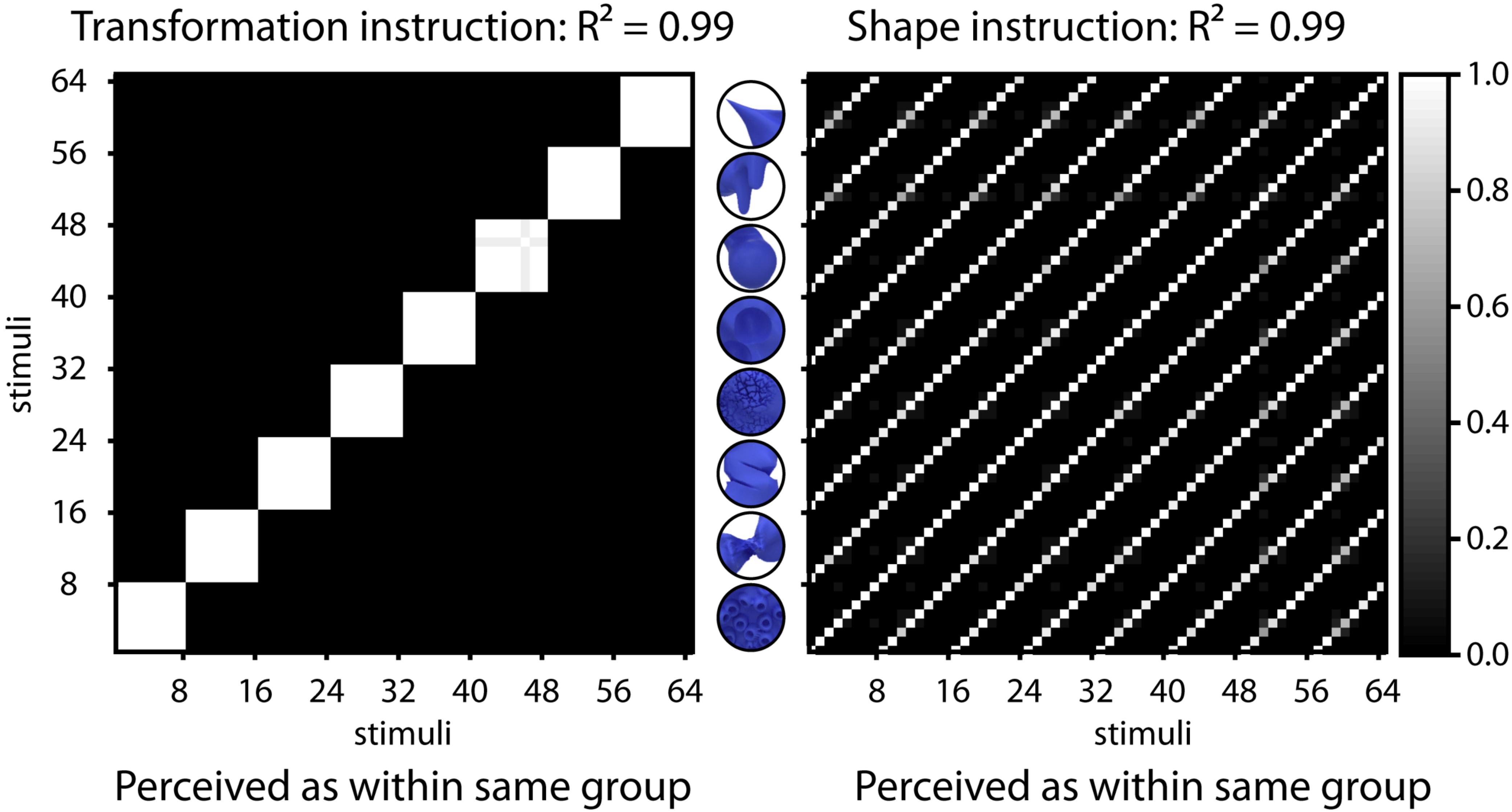


Experiment 1: Shape scission

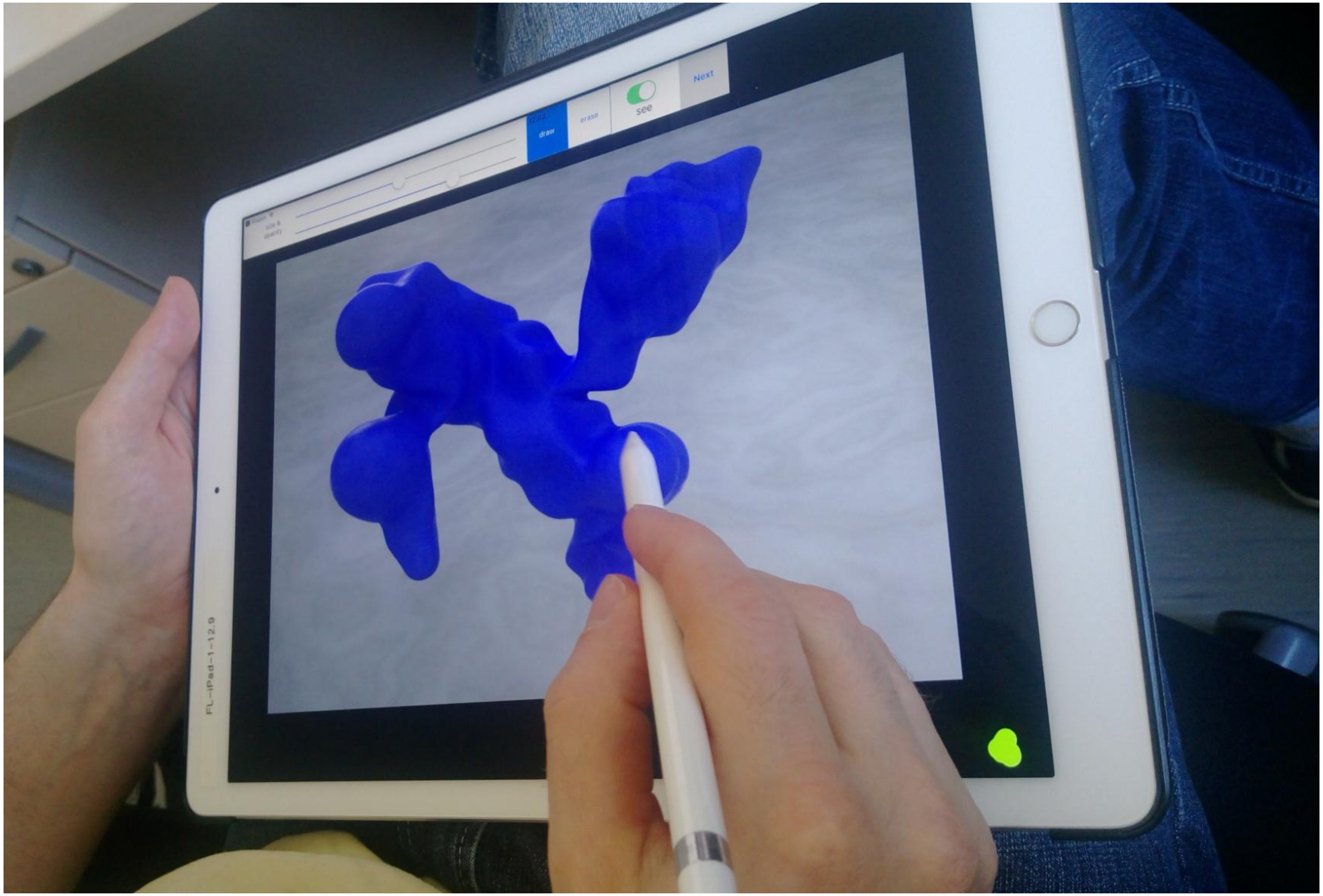
- Observers can identify “transformations” across objects and “objects” across transformations

Experiment 1: Shape scission

- Observers can identify "transformations" across objects and "objects" across transformations
- Can they infer other characteristics of transformations on top of this causal separation?

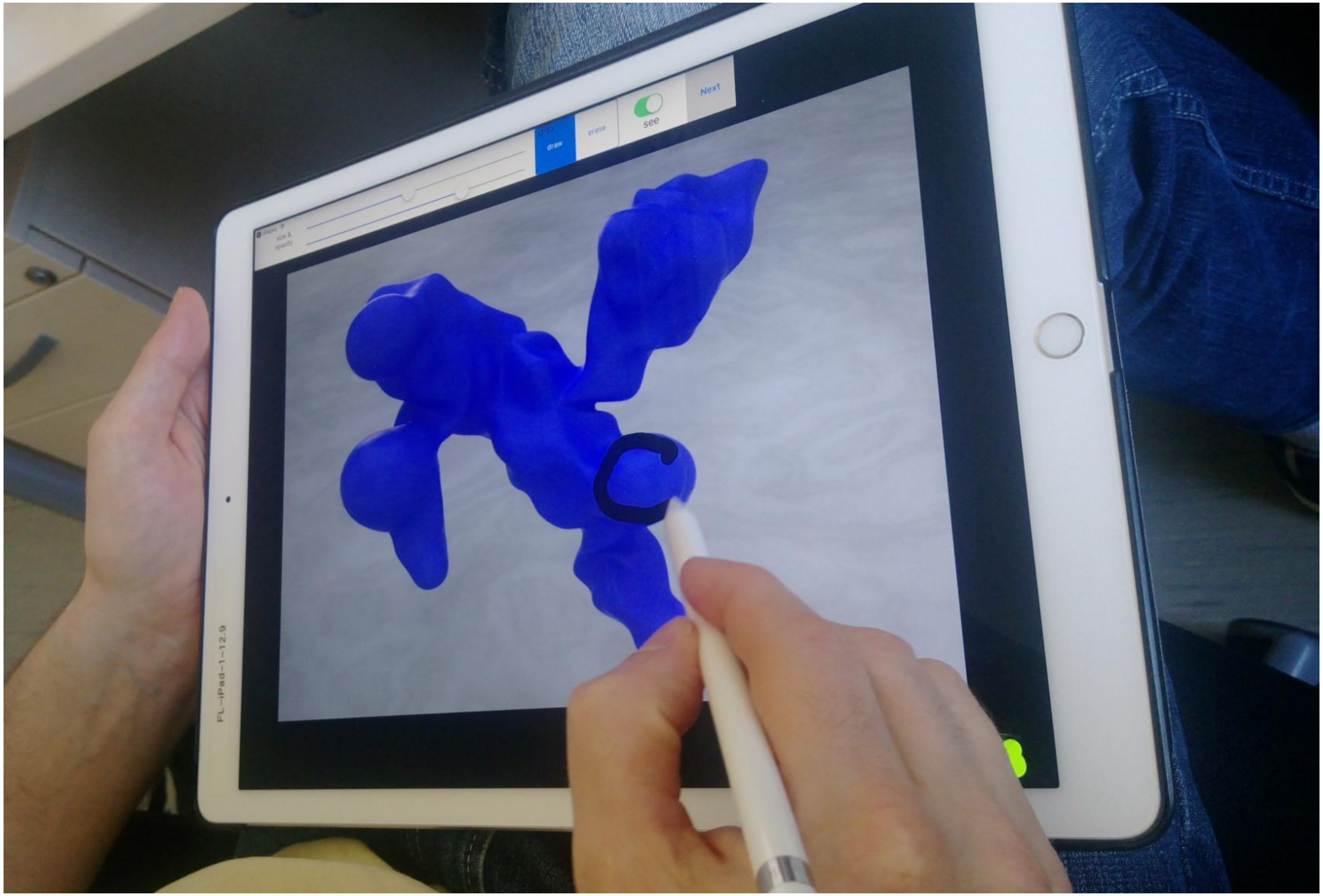
Experiment 2: Location

- Painting experiment



Experiment 2: Location

- Painting experiment



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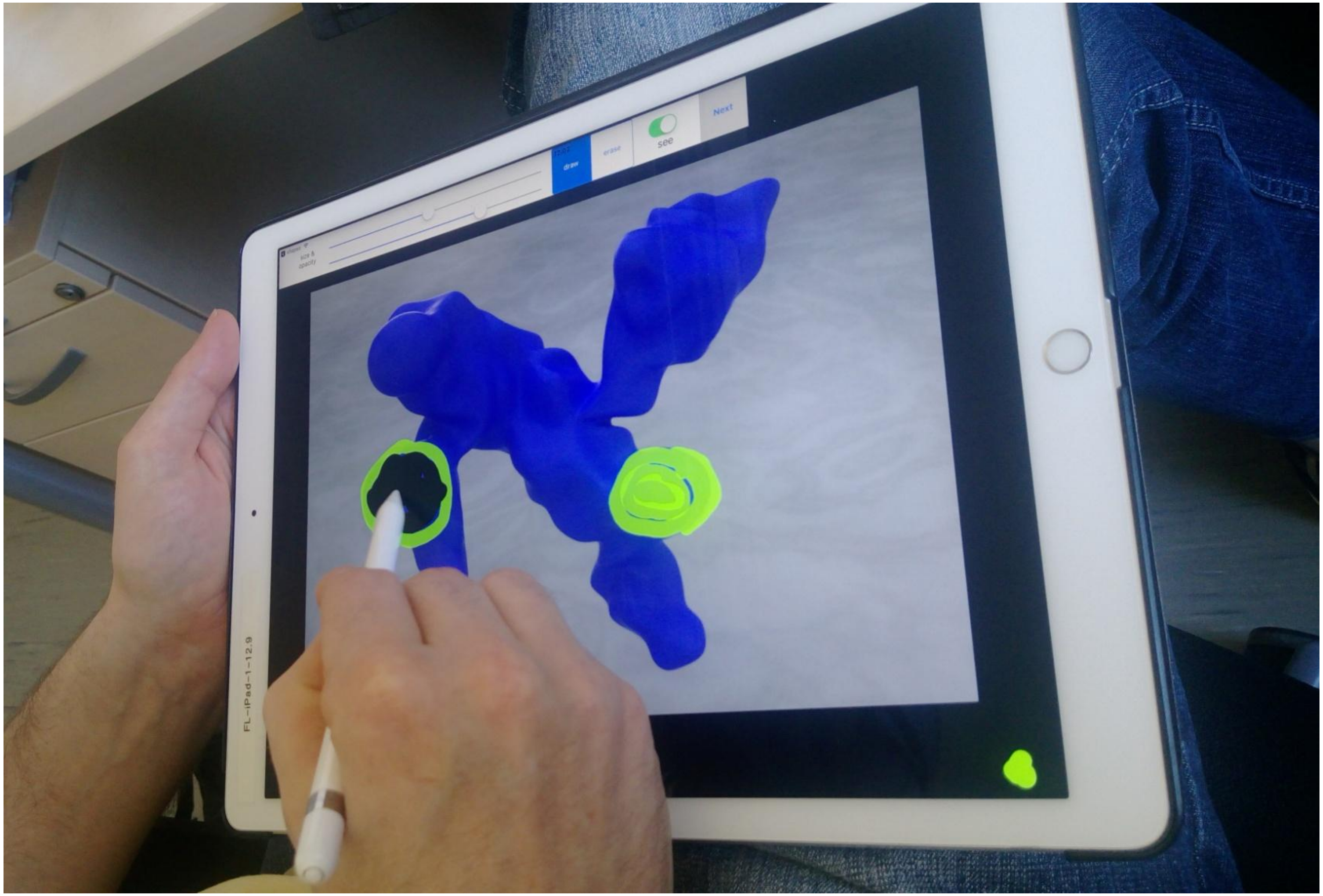

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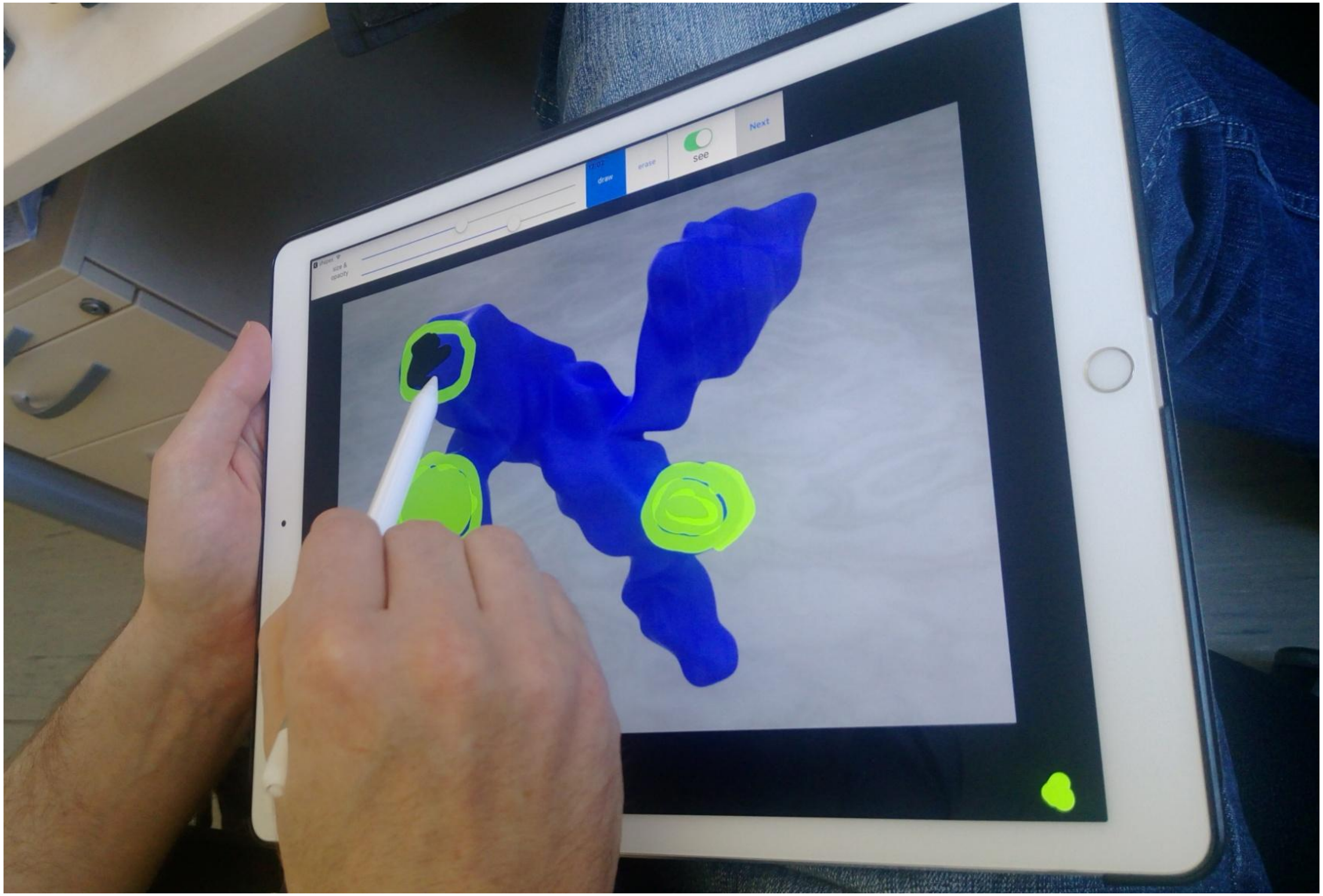

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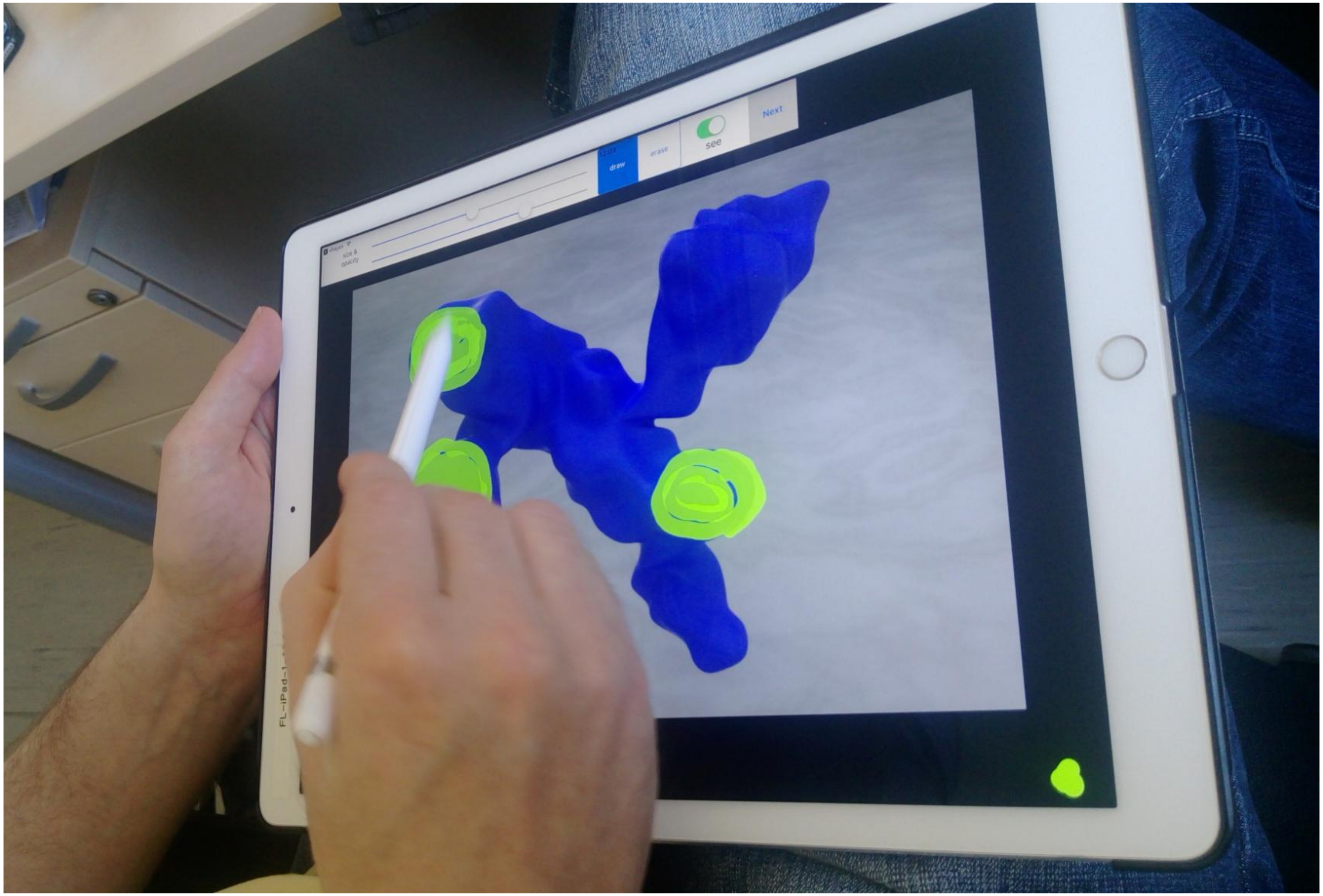

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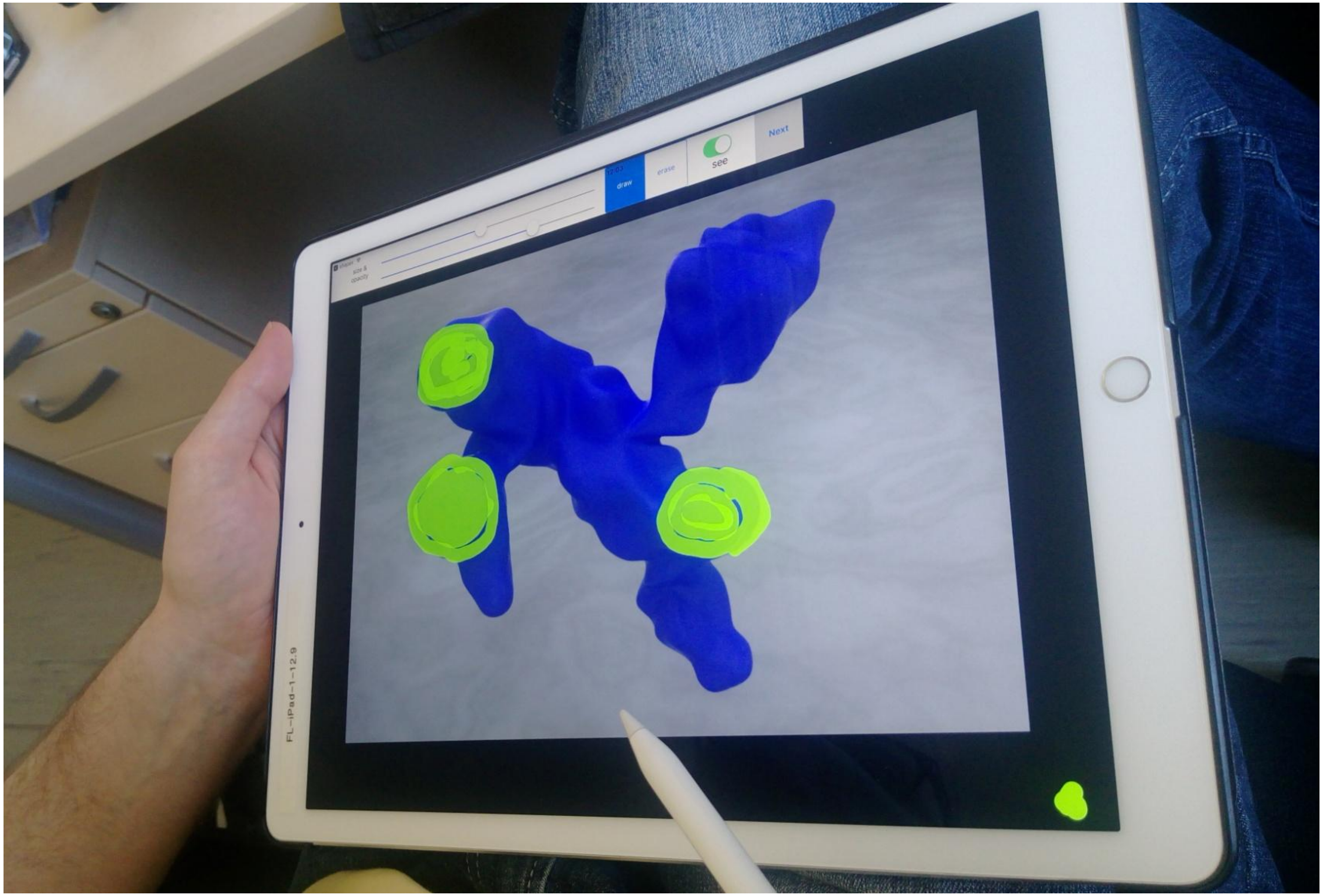
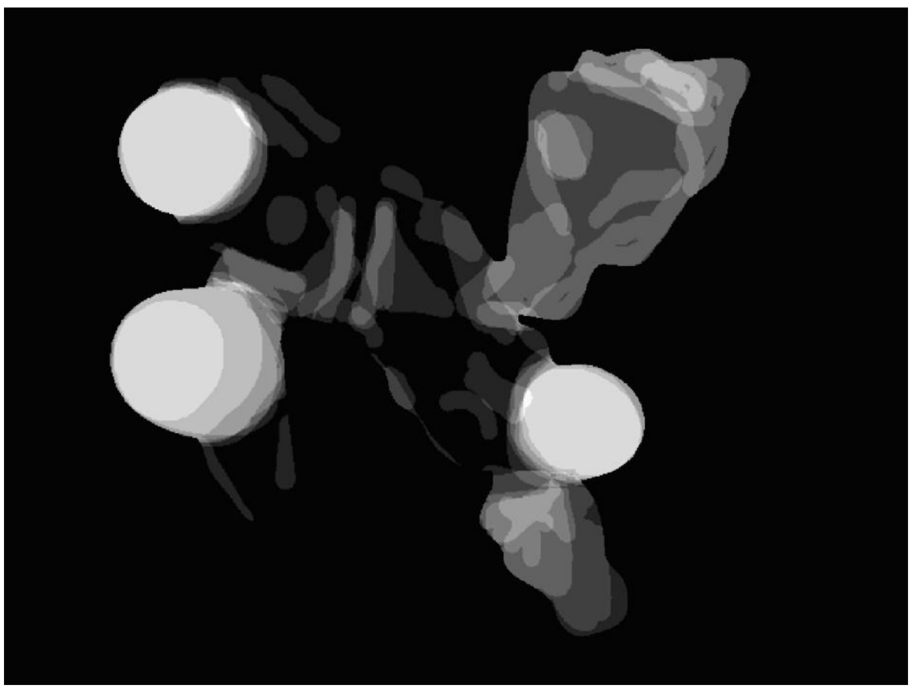


Experiment 2: Location

- Responses

painting (n = 14)



Experiment 2: Location

- Responses

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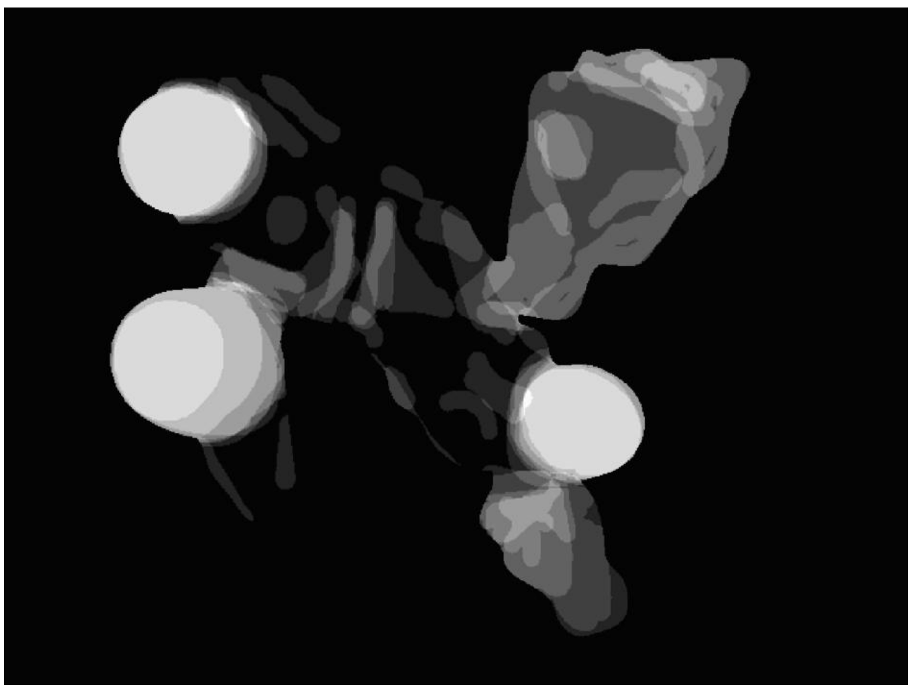
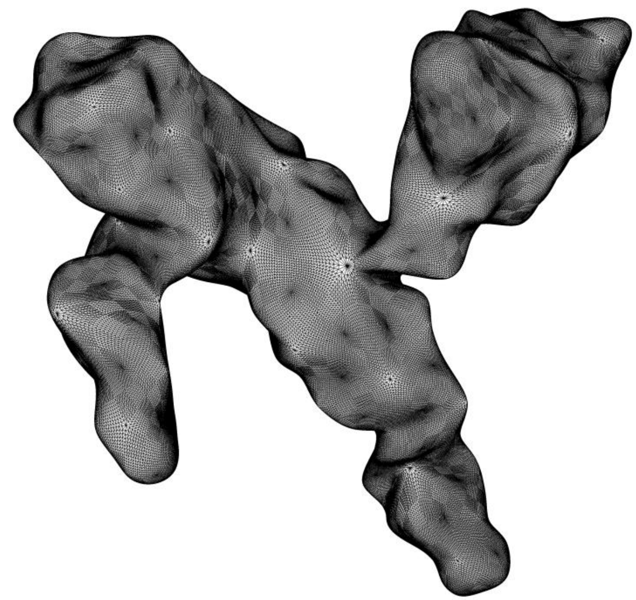


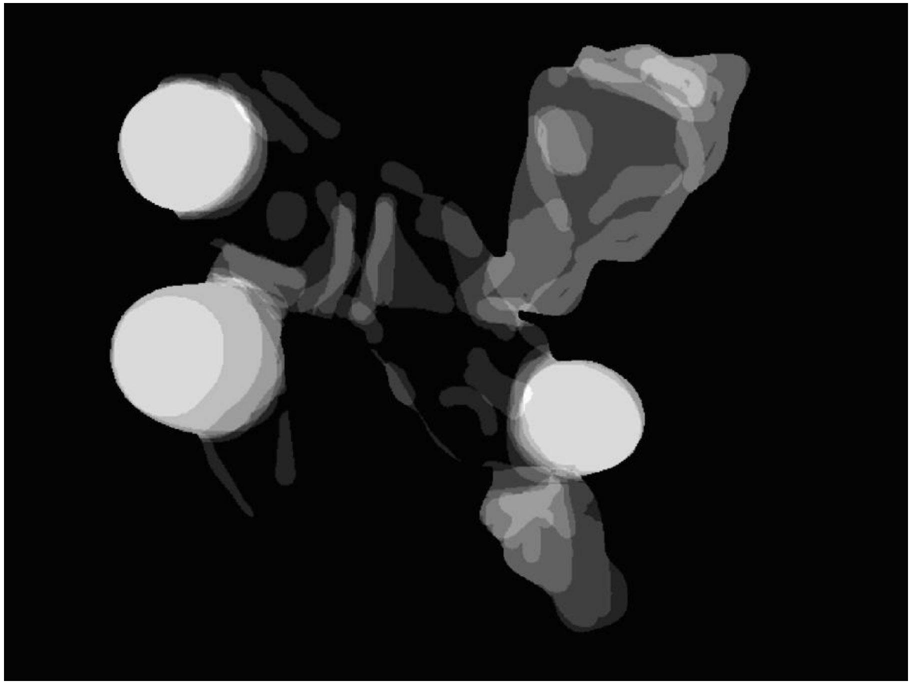
3D mesh base shape



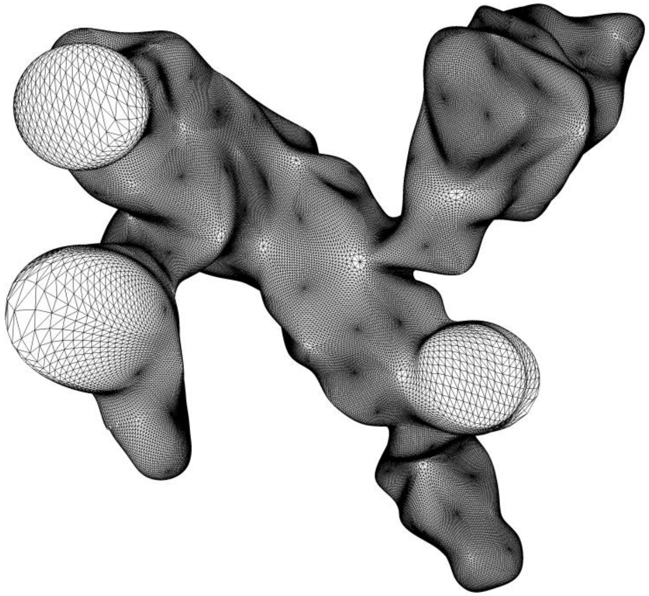
Experiment 2: Location

- Responses

painting (n = 14)



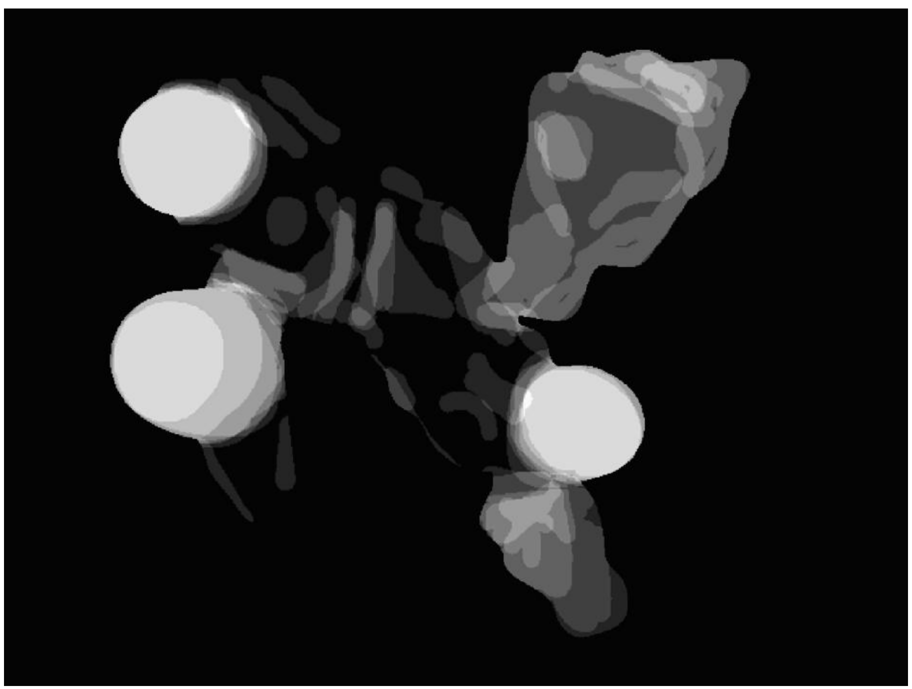
3D mesh transformed shape



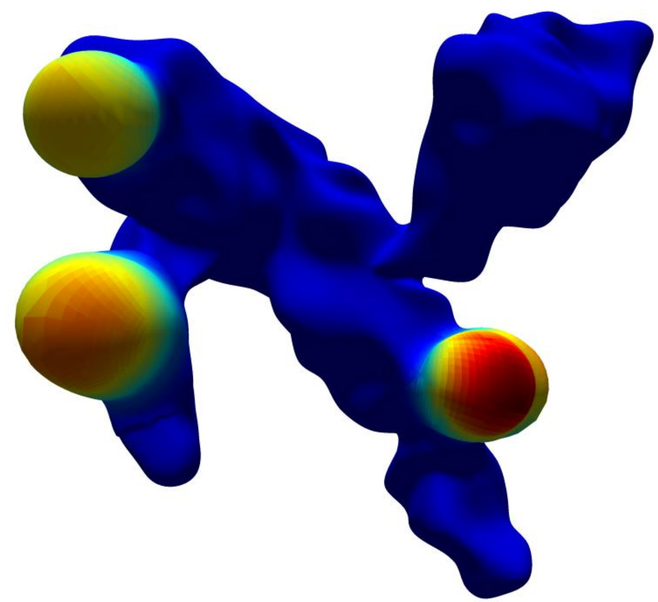
Experiment 2: Location

- Responses

painting (n = 14)



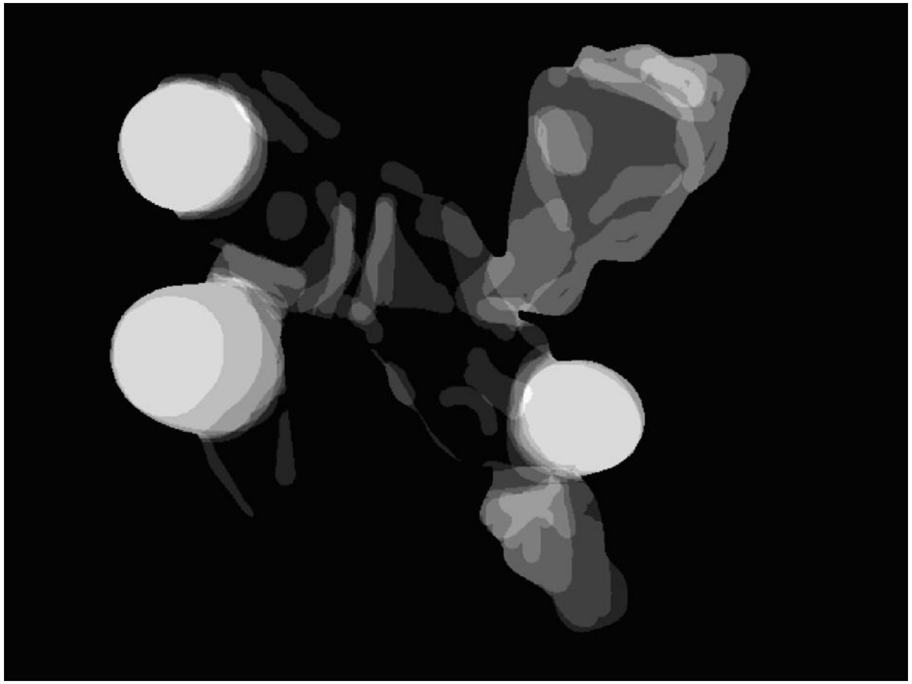
3D mesh difference



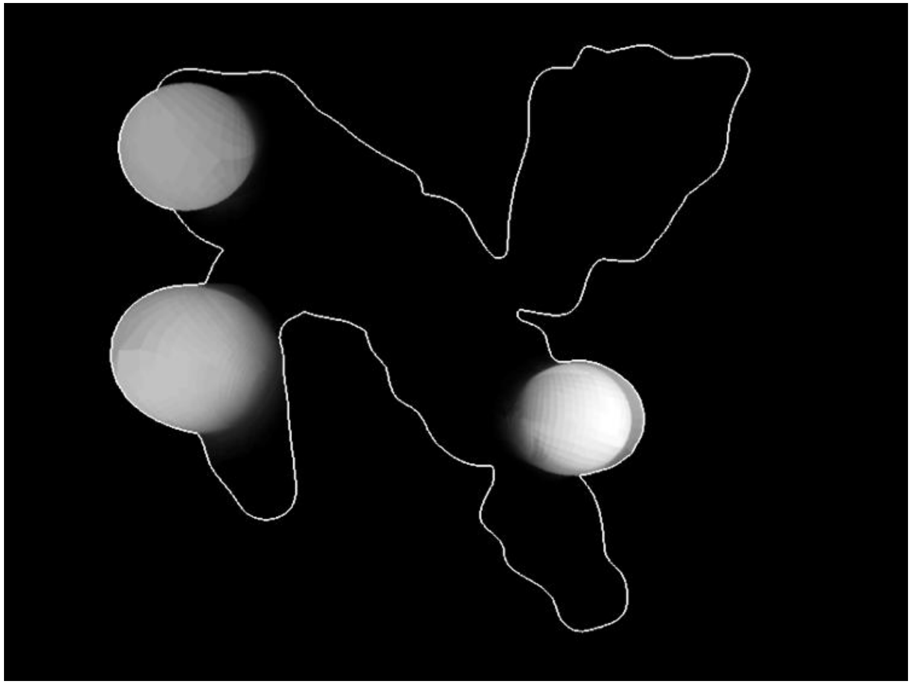
Experiment 2: Location

- Responses

painting (n = 14)



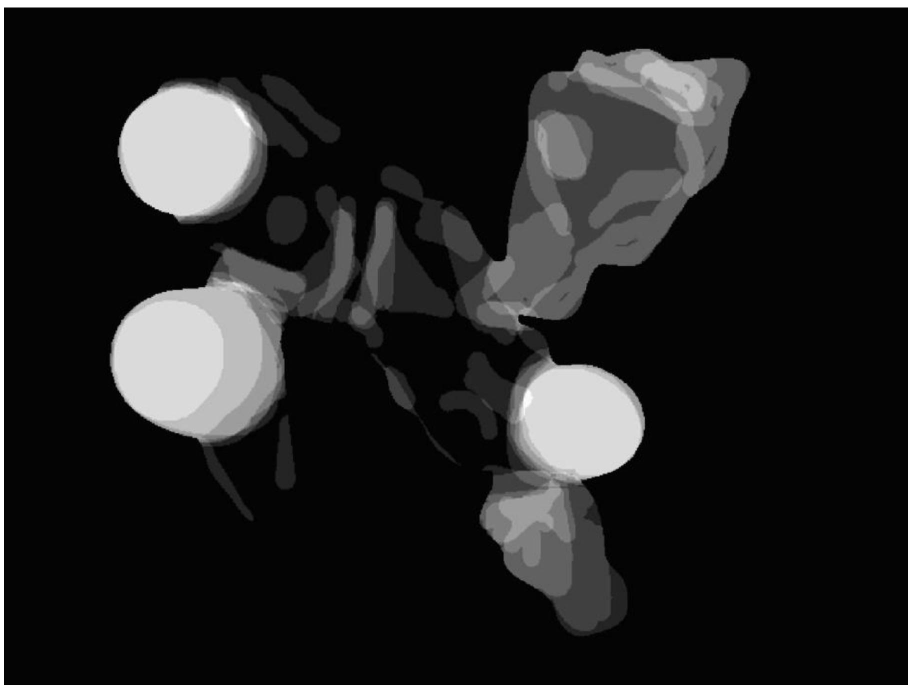
prediction from difference



Experiment 2: Location

- Responses

painting (n = 14)



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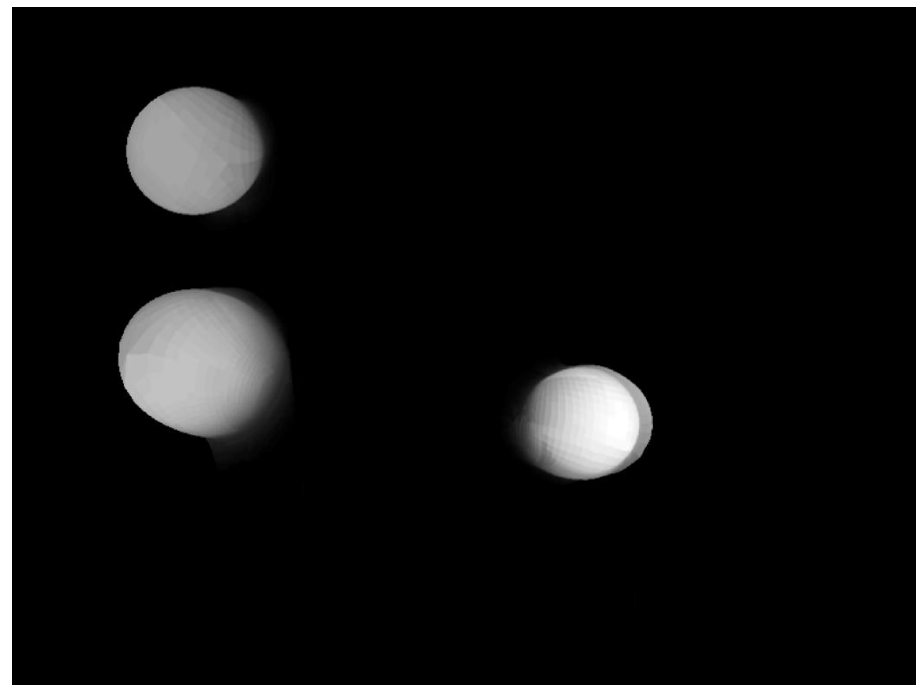

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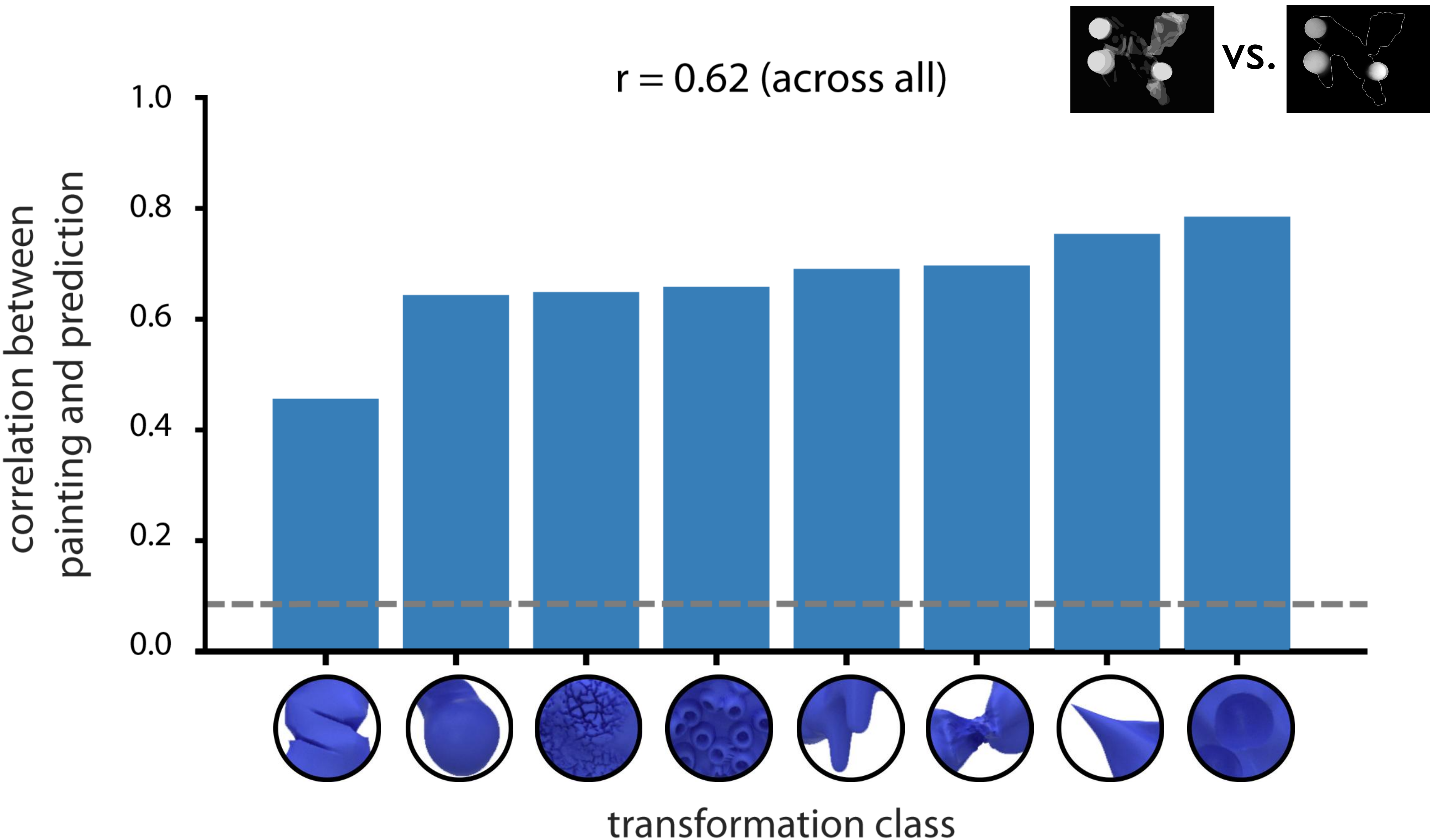
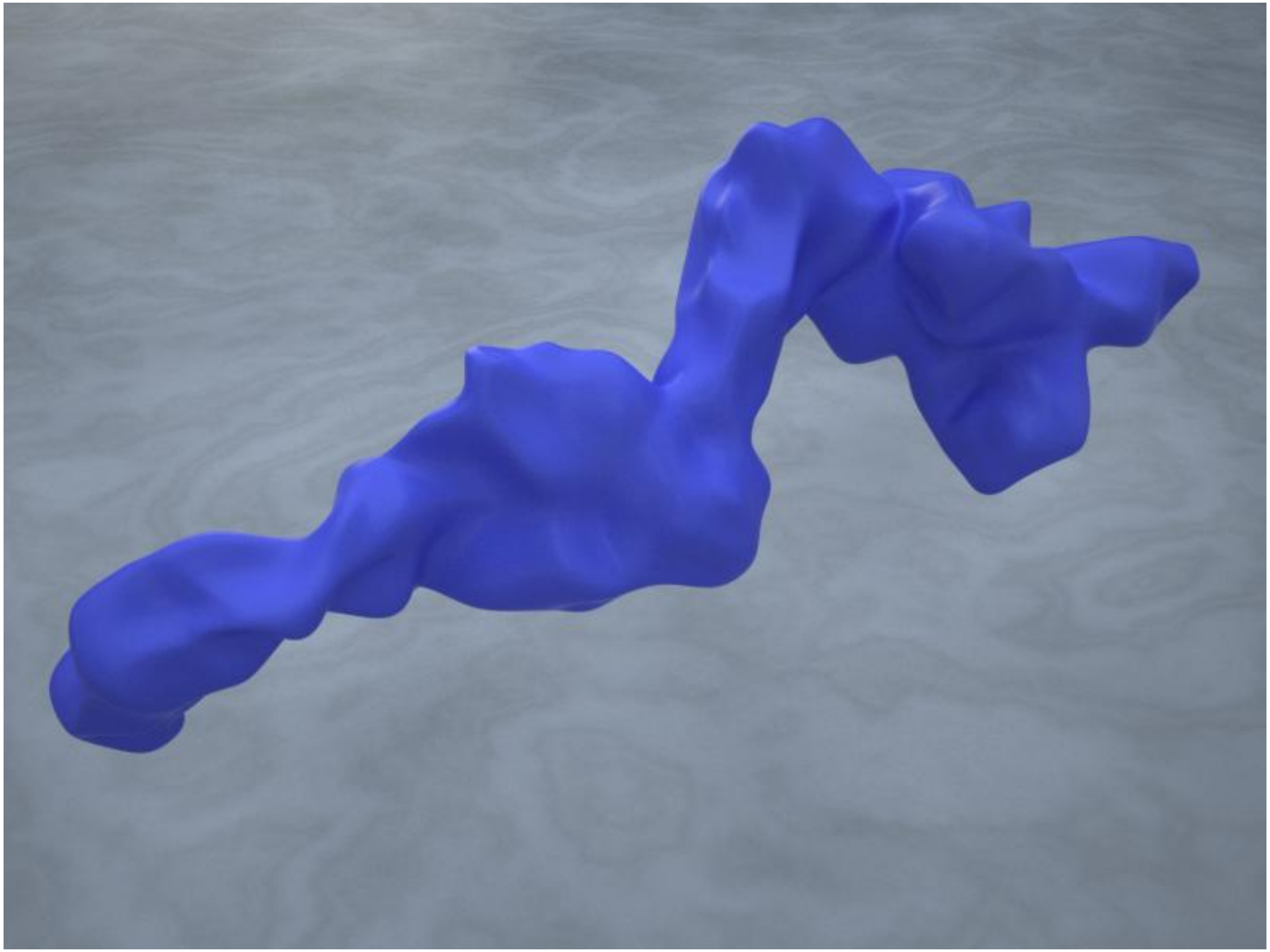


Experiment 3: Magnitude

5 levels of deformation (examples)



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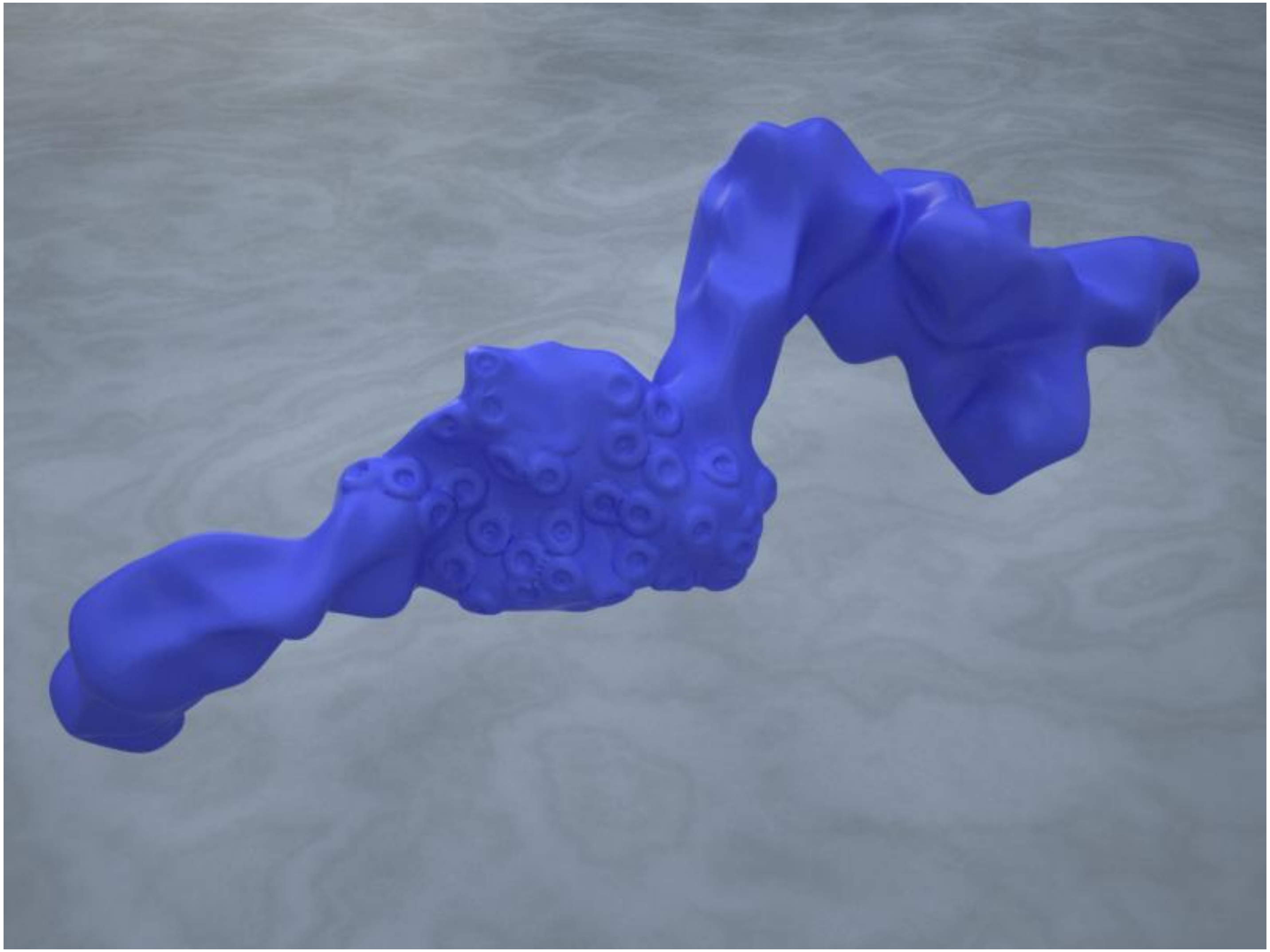

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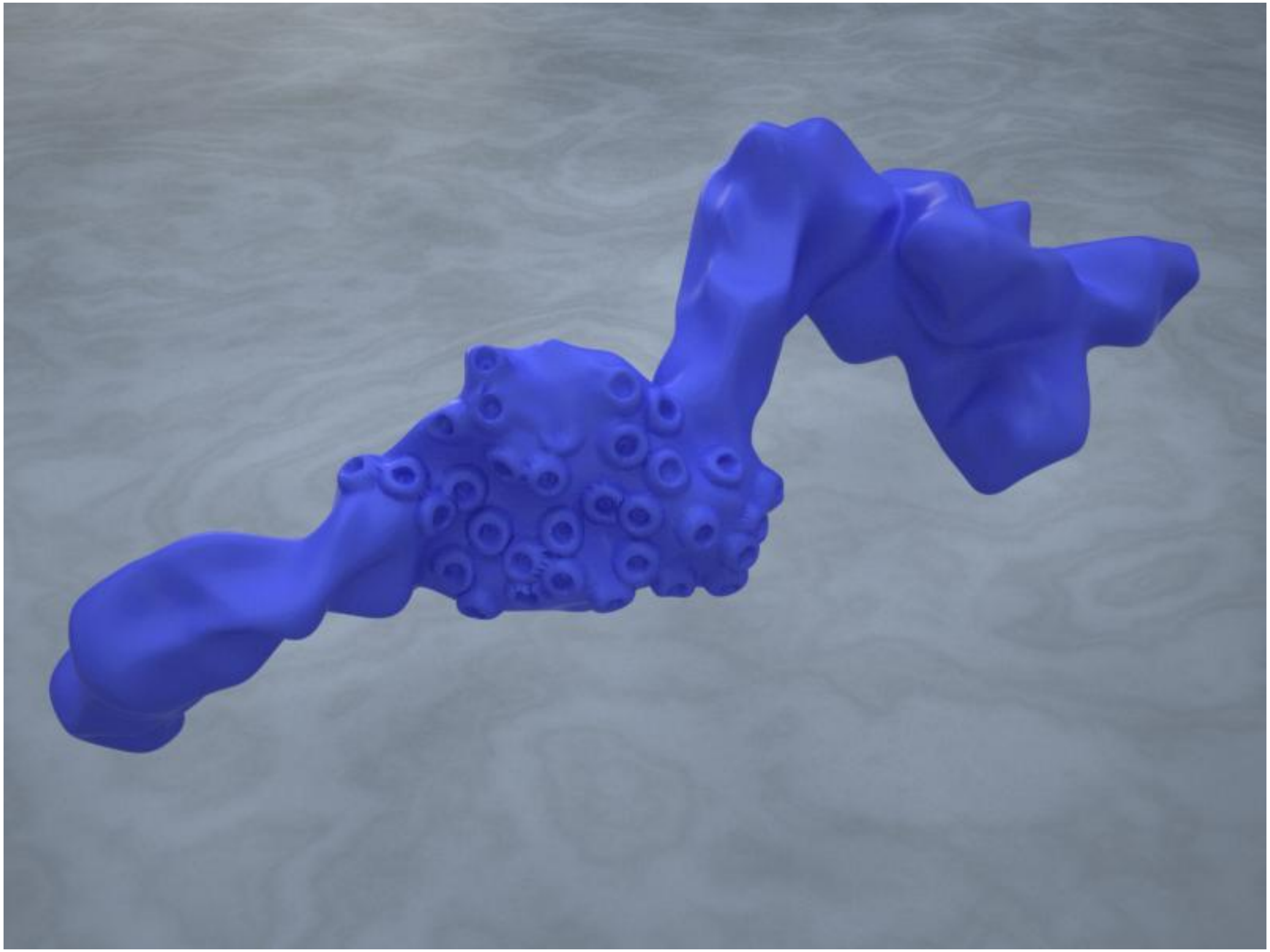

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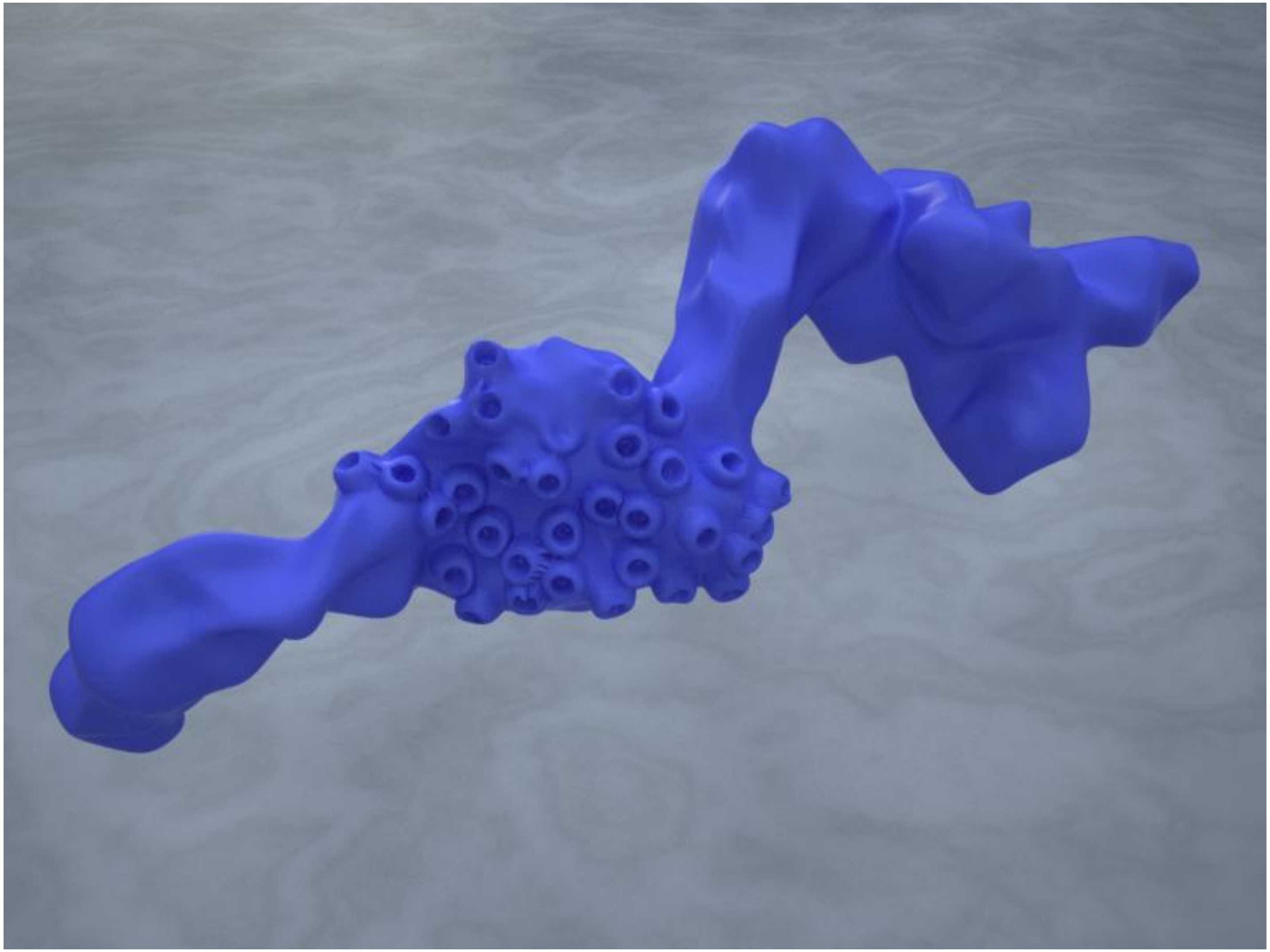

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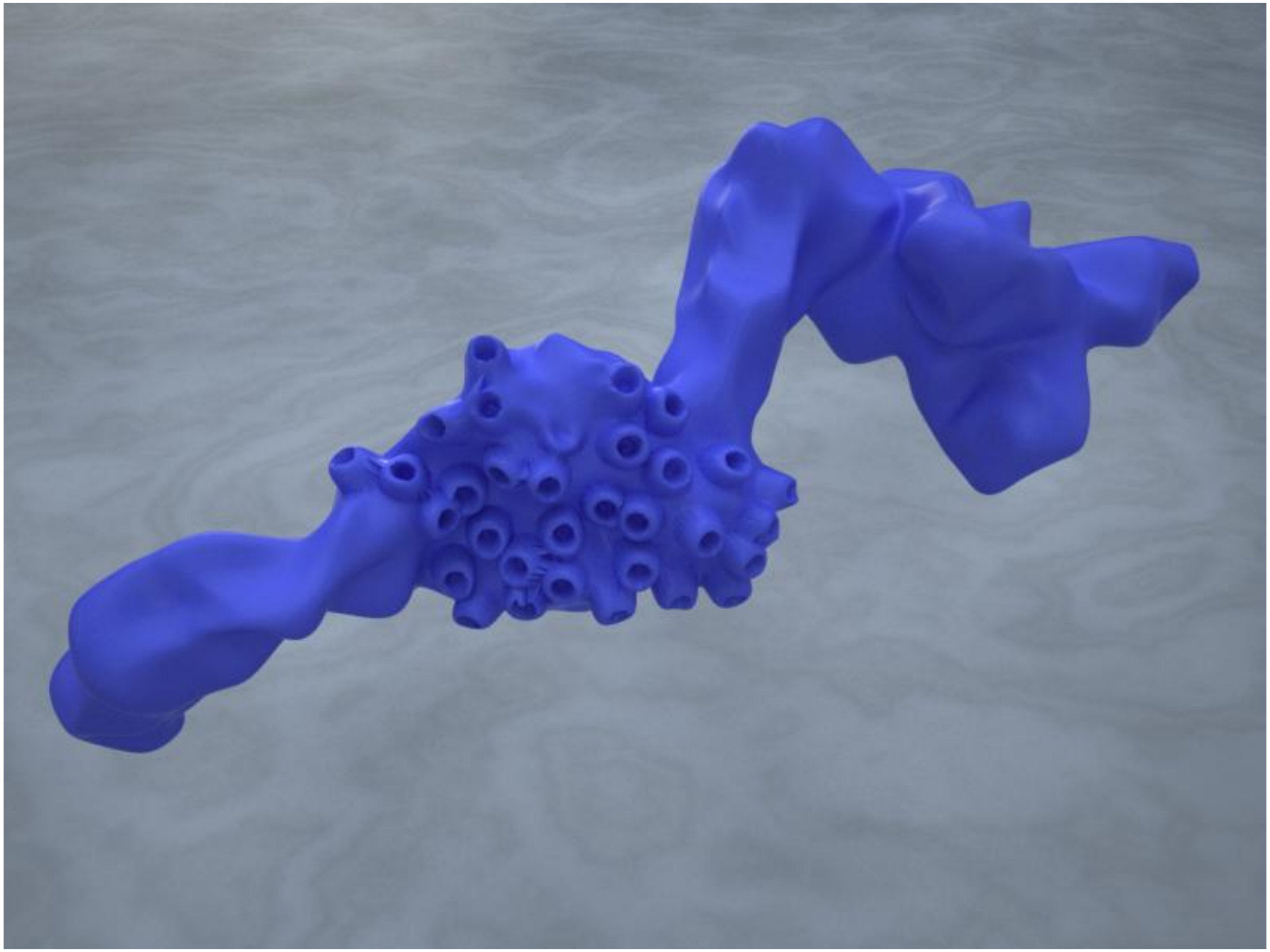

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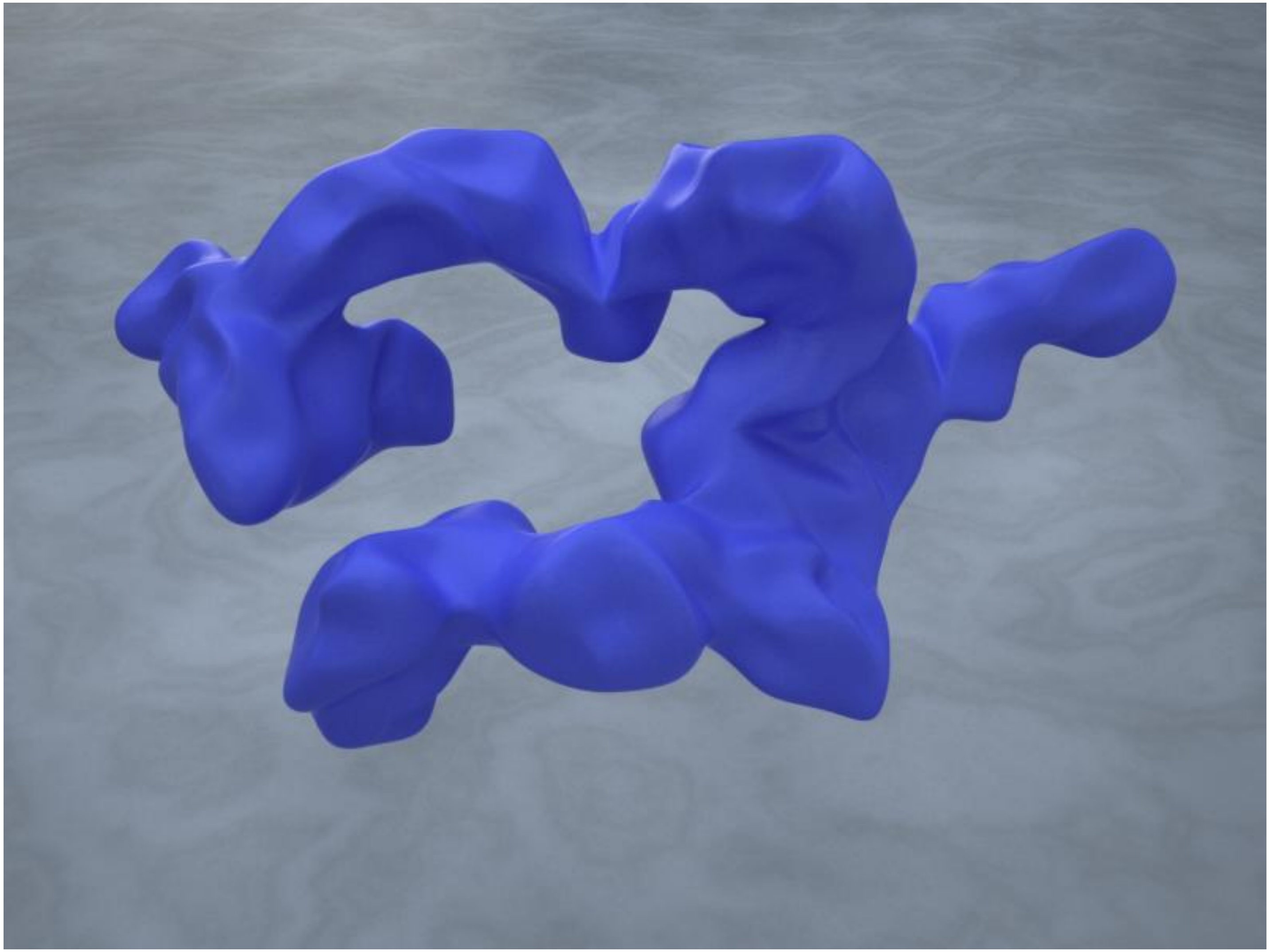

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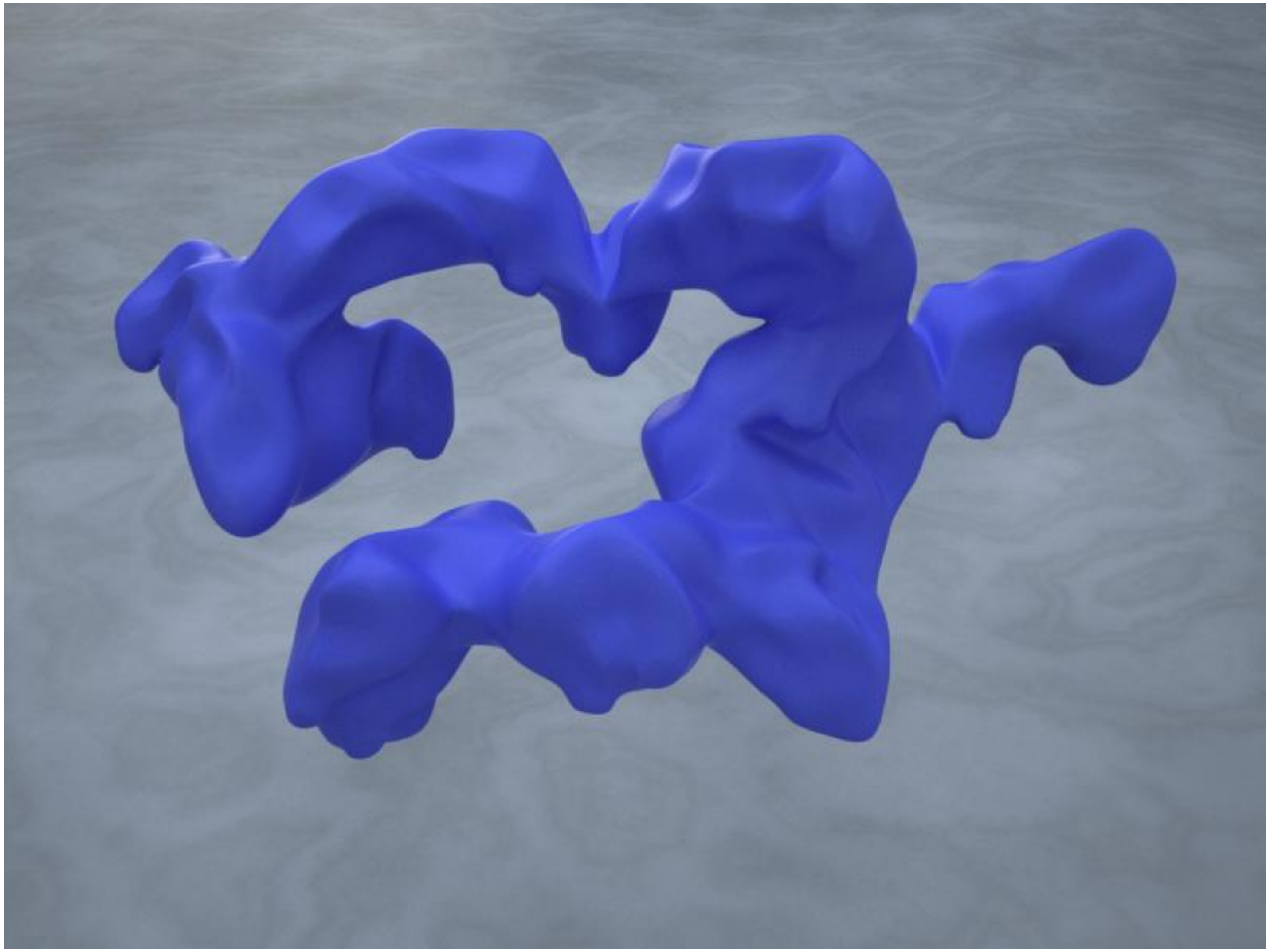

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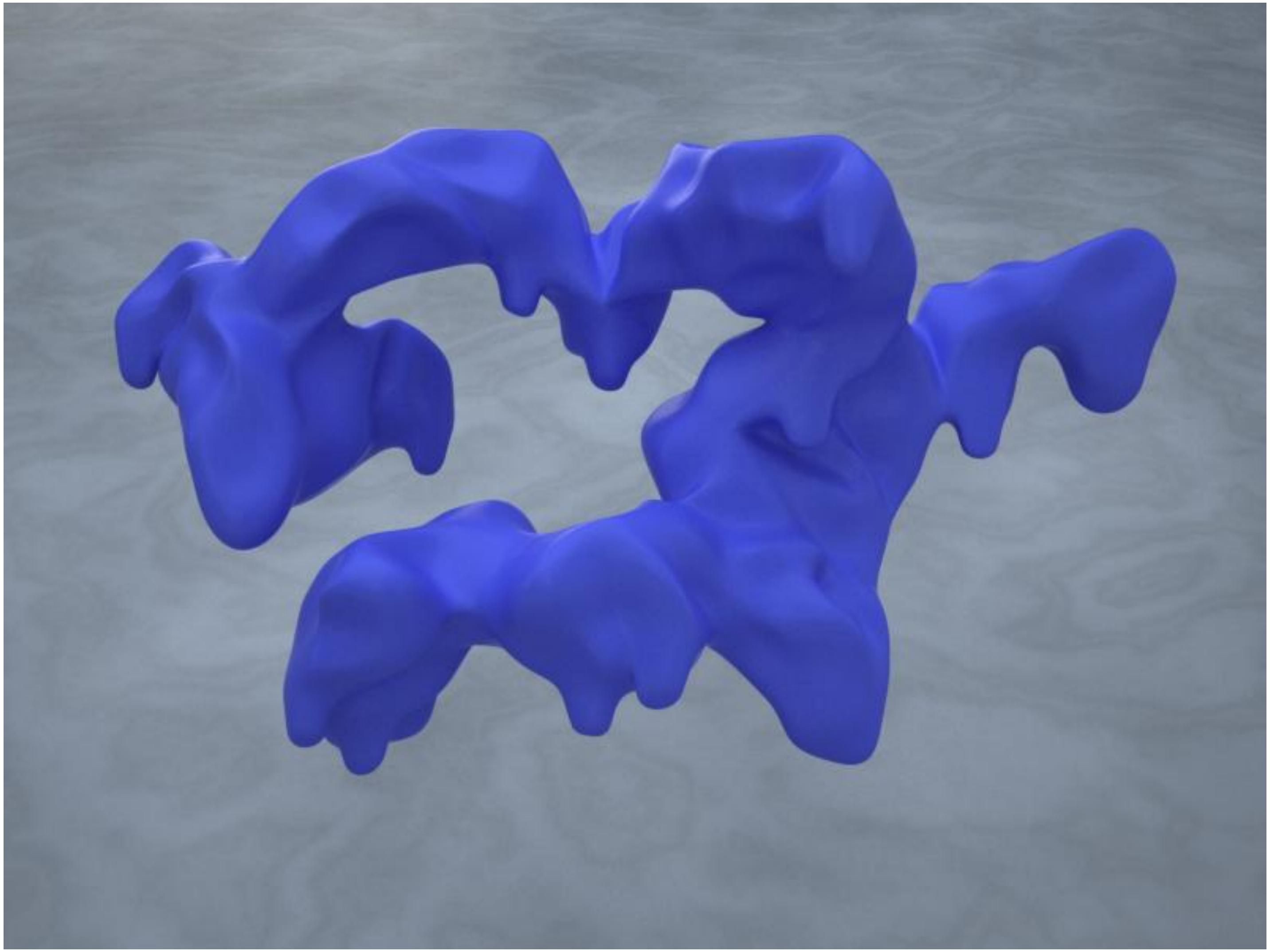

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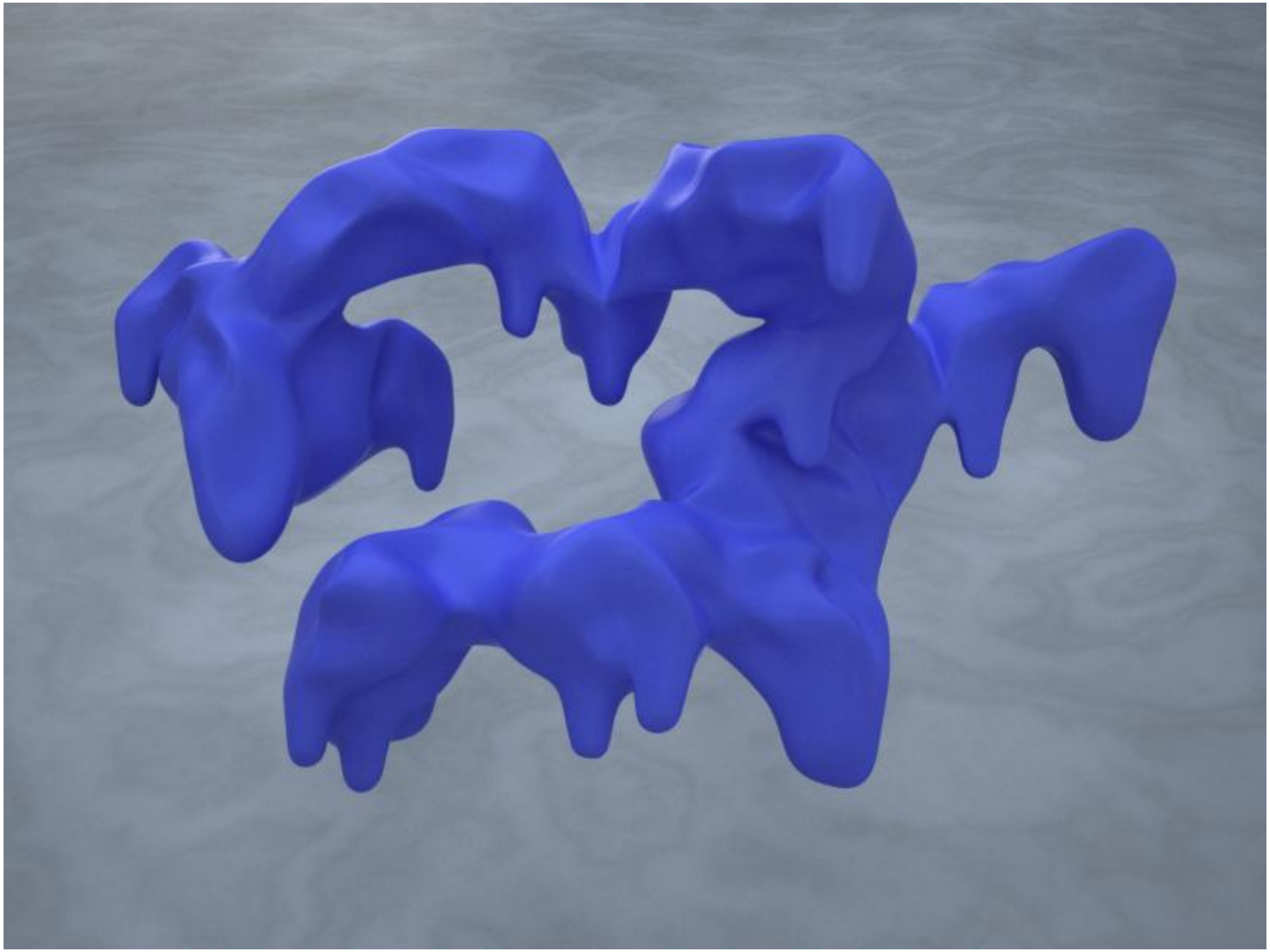

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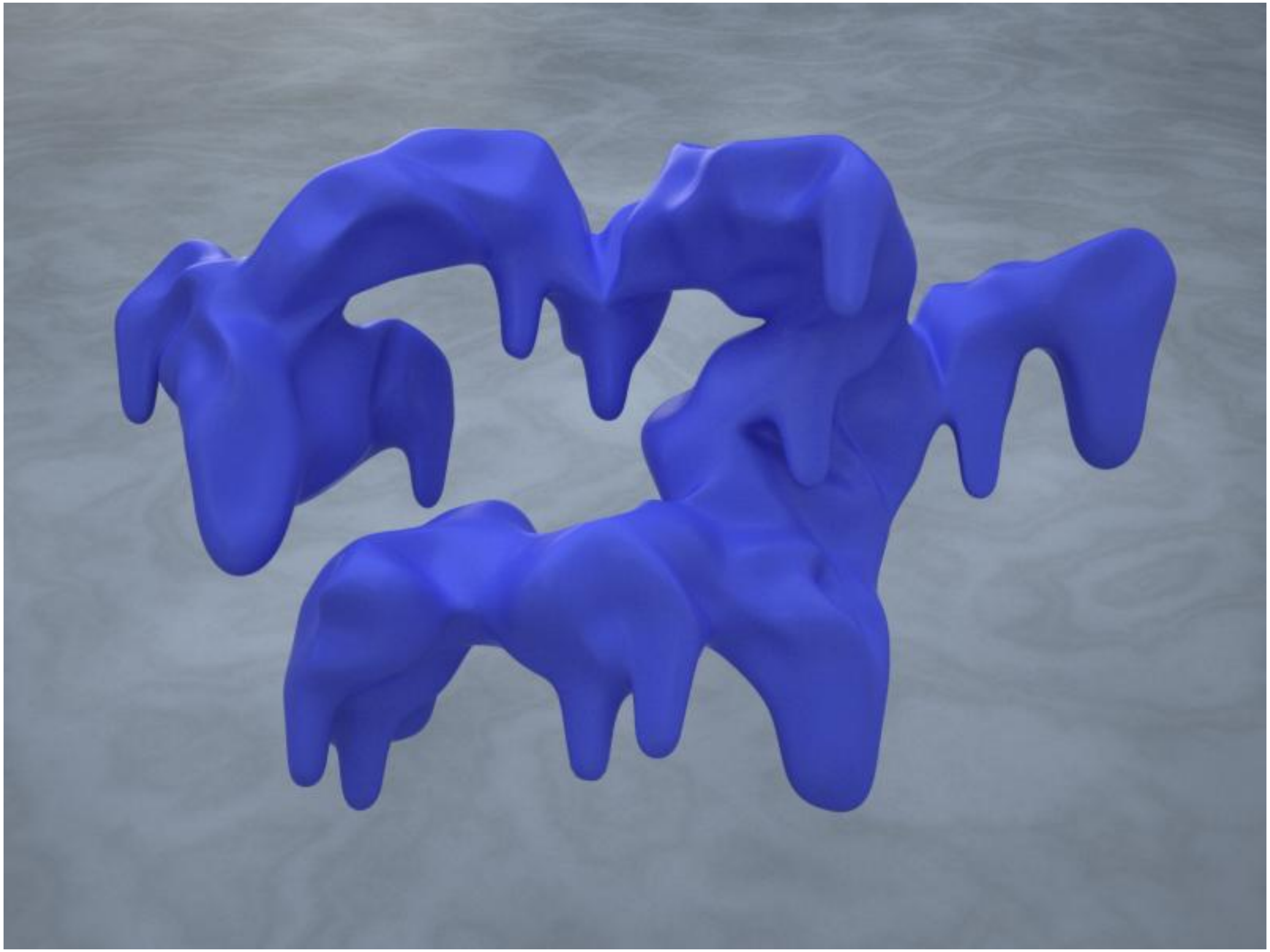

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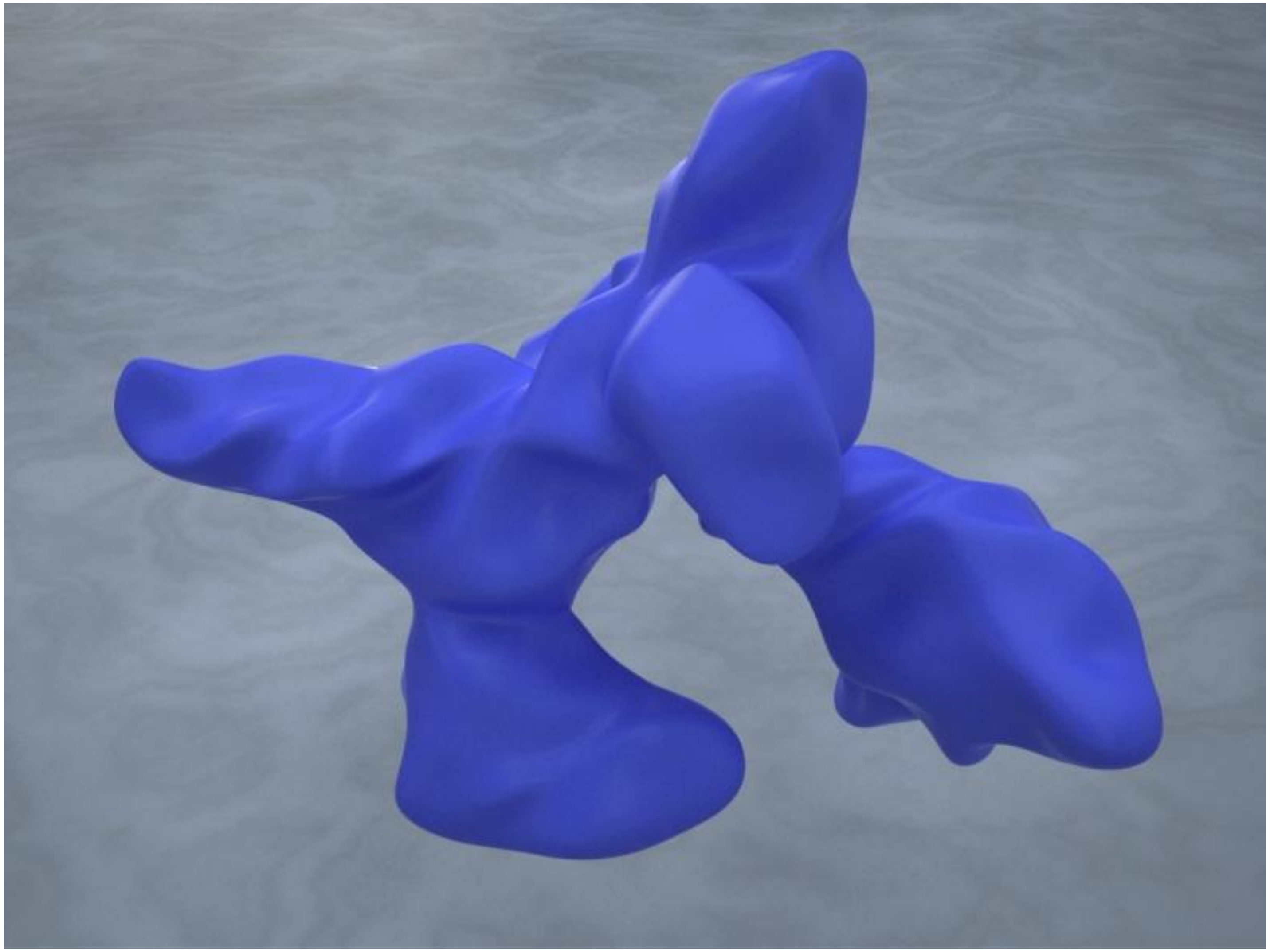

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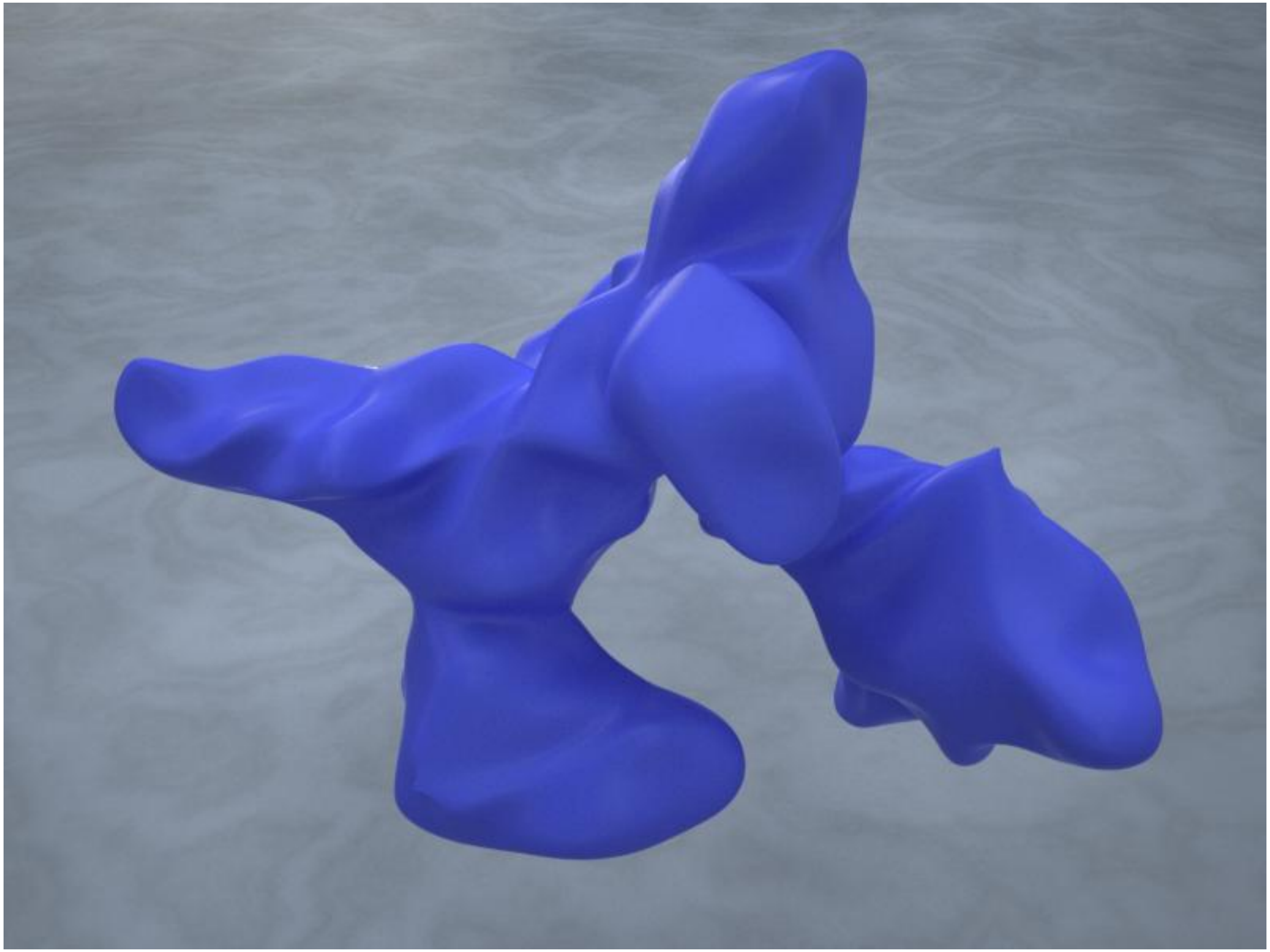

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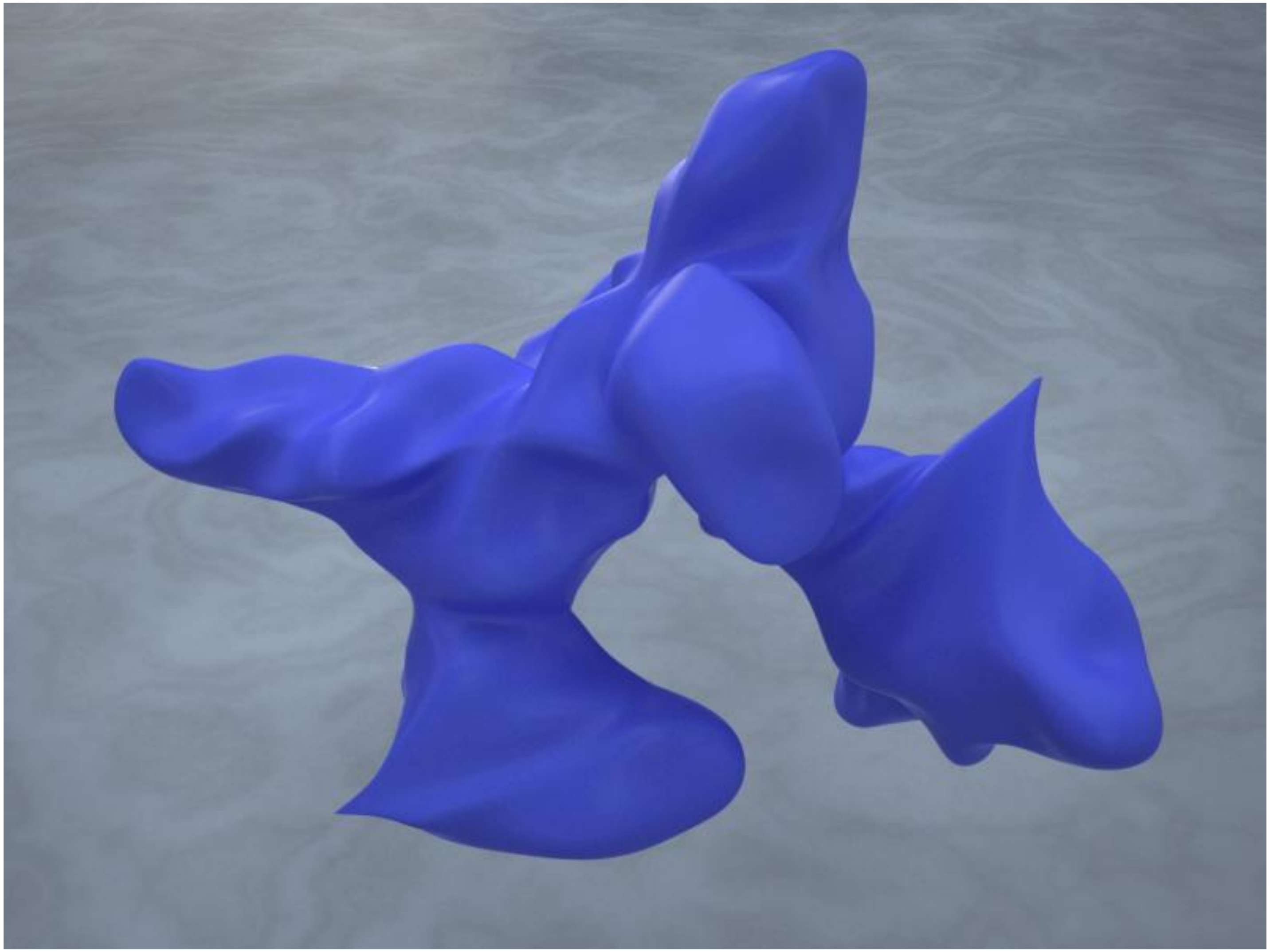

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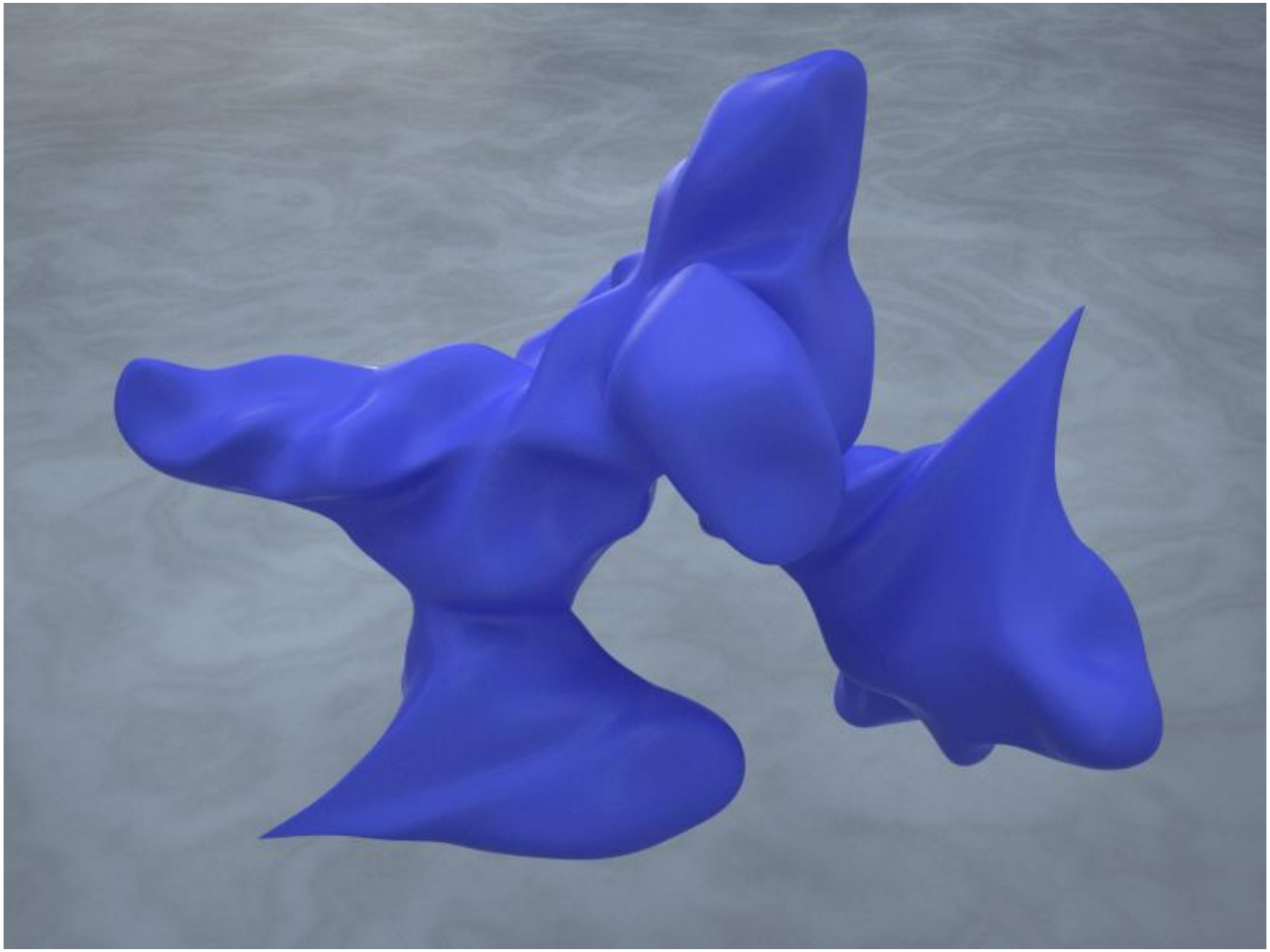

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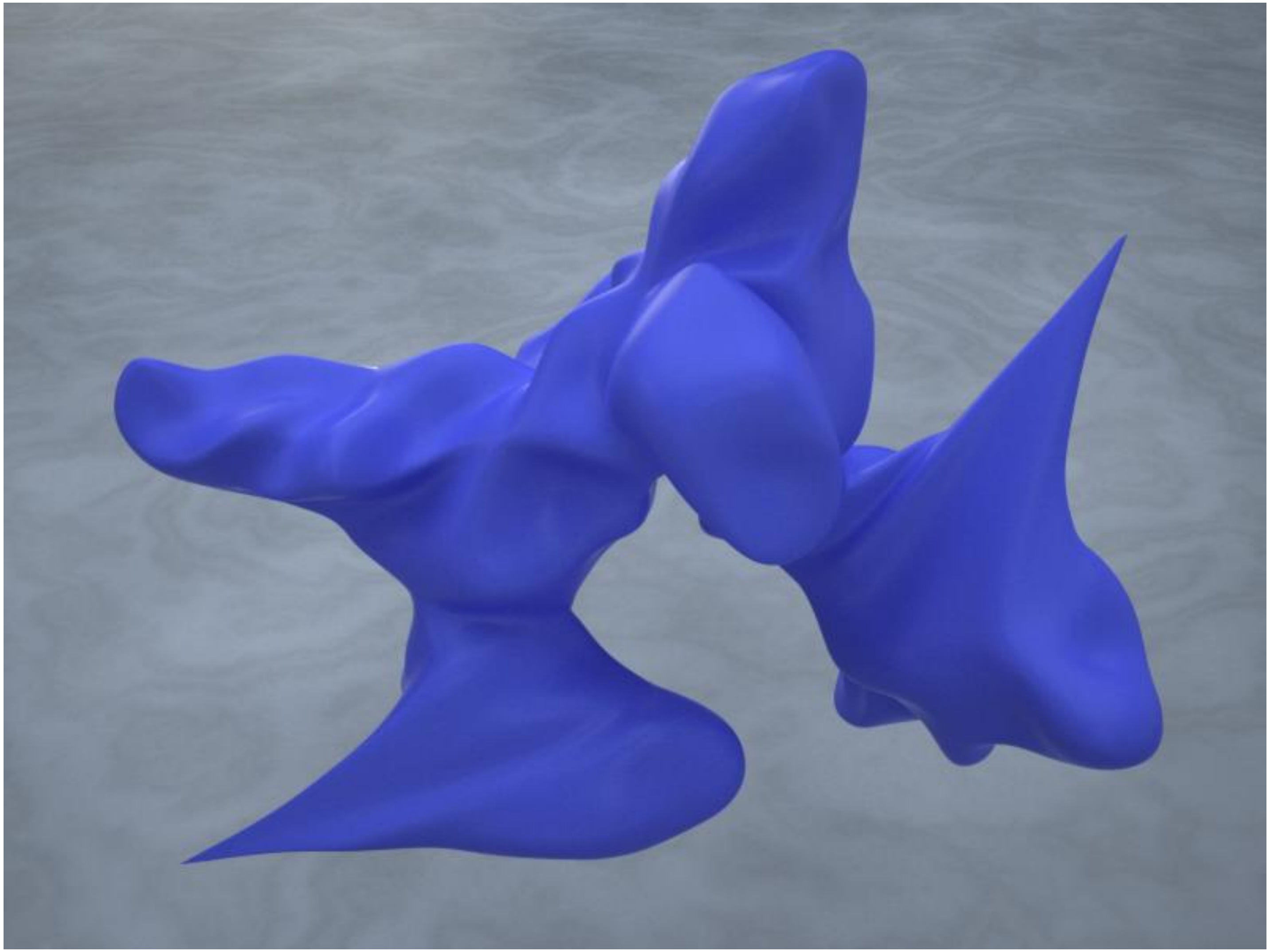
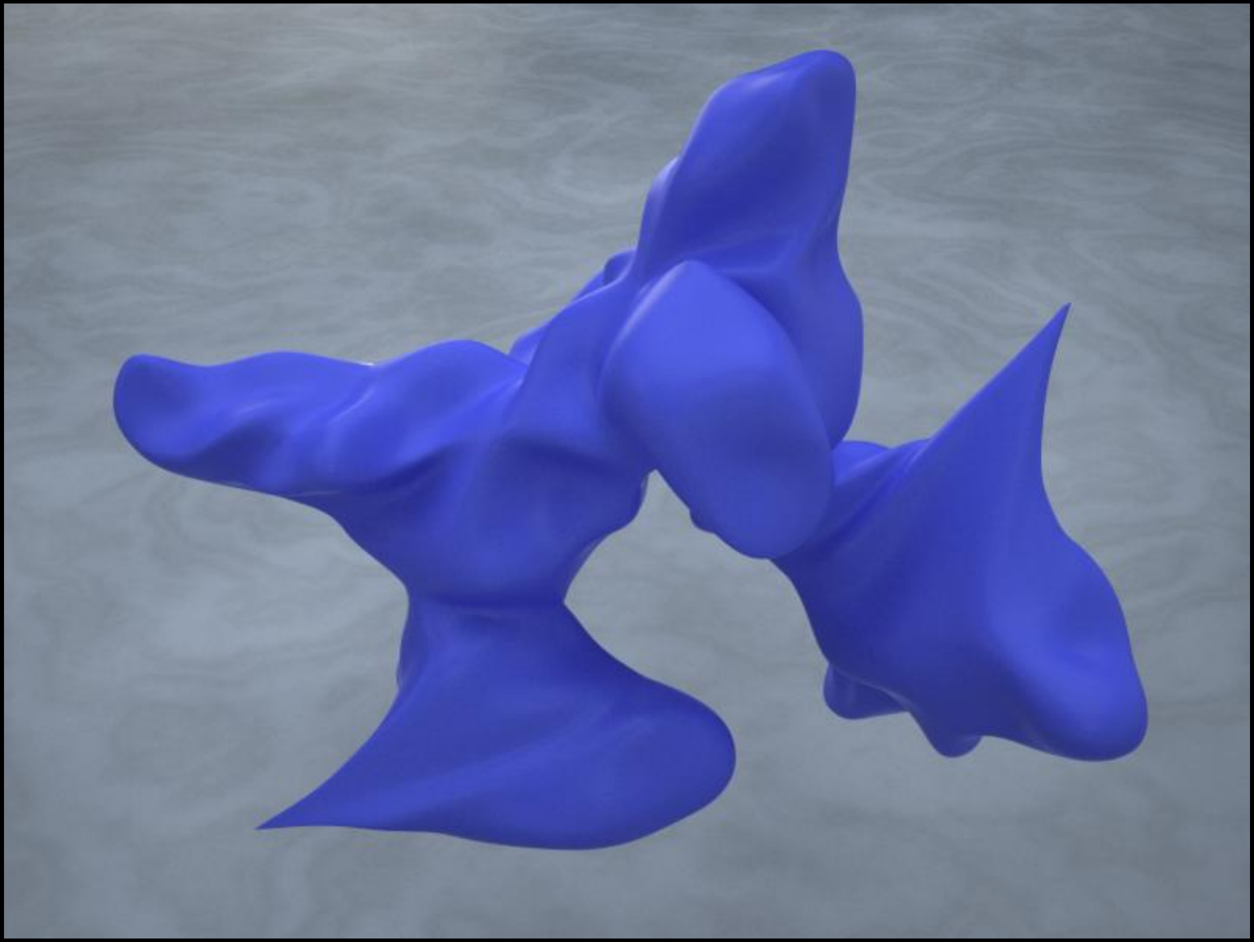


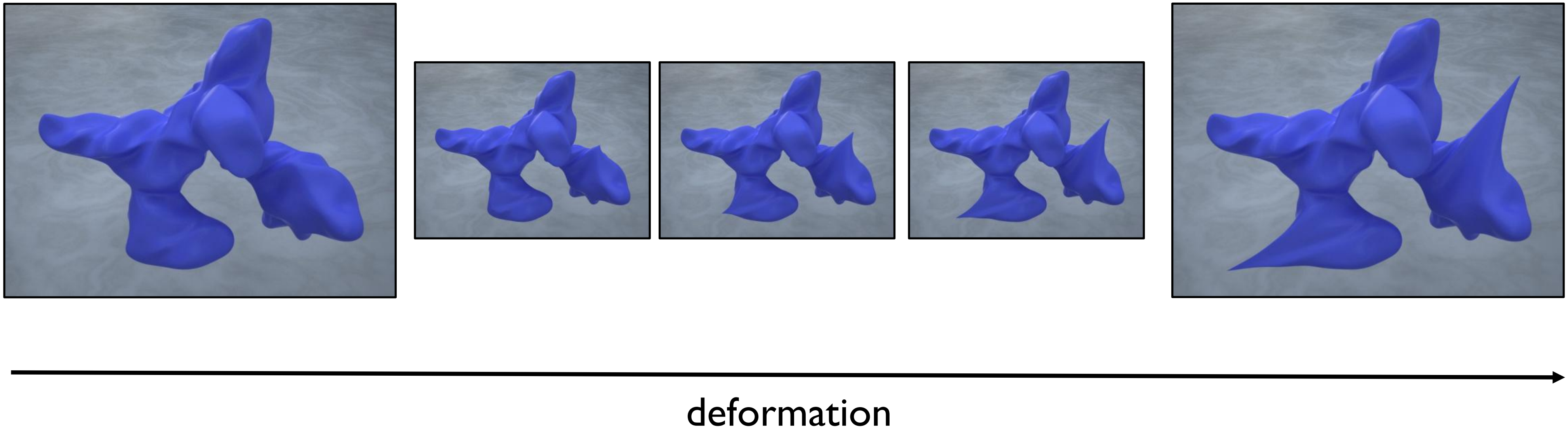
Experiment 3: Magnitude



Not deformed Strongly deformed

Experiment 3: Magnitude

- Analysis



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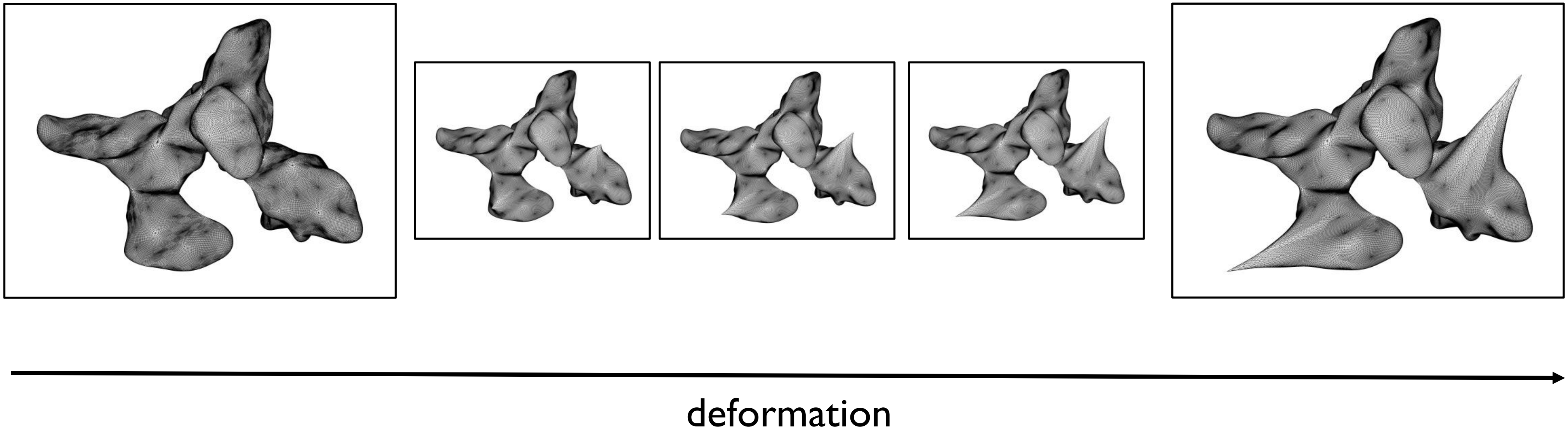

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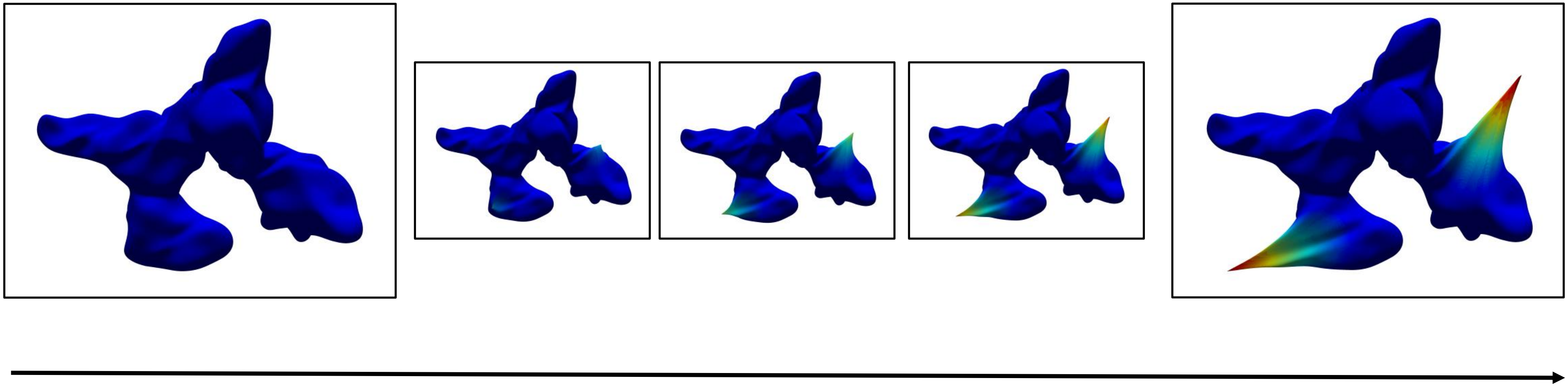
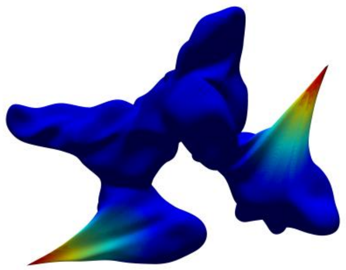


deformation

Experiment 3: Magnitude

- Mesh measures
  - **magnitude of deformation**: average distance of each deformed vertex from non-deformed vertex location (per stimulus)



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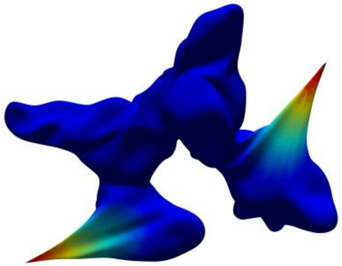
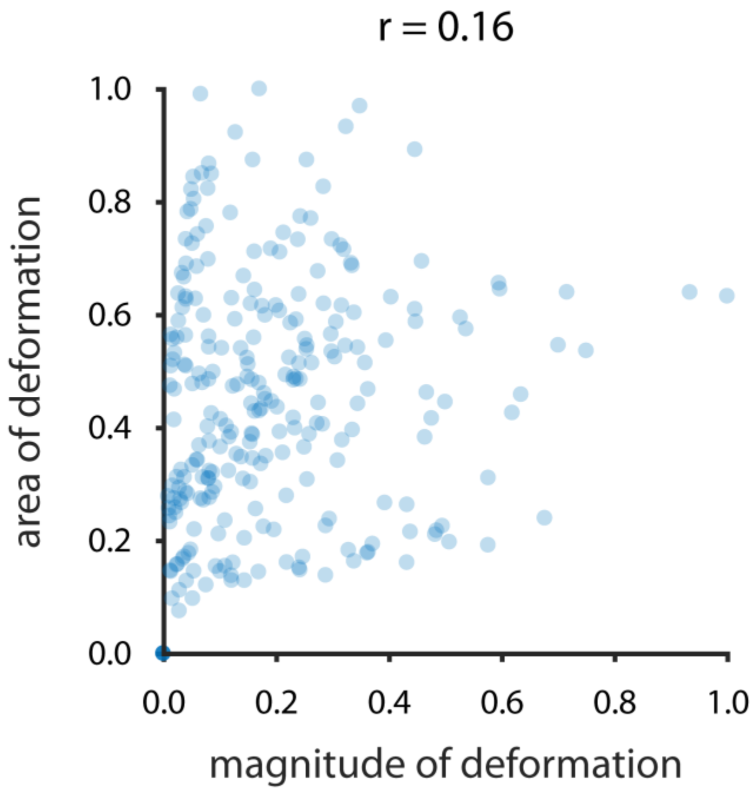
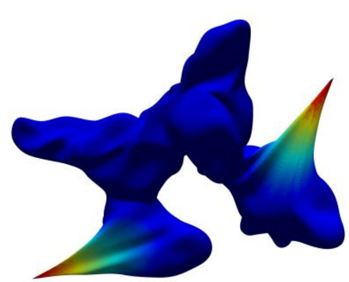


  - **area of deformation**: average area of deformed faces (per stimulus)

Experiment 3: Magnitude

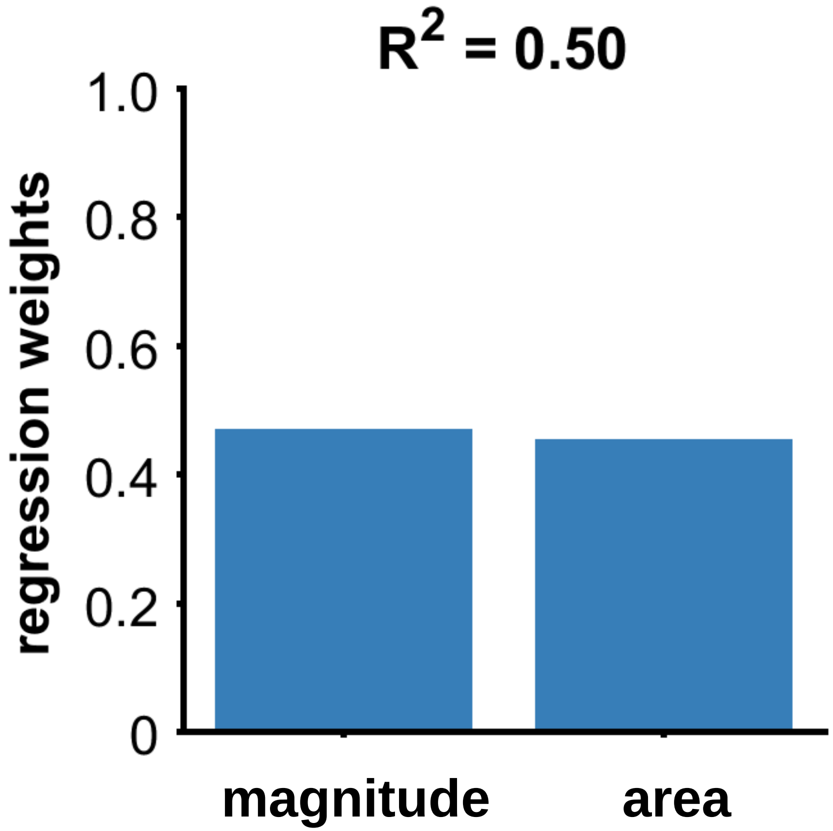
- Mesh measures





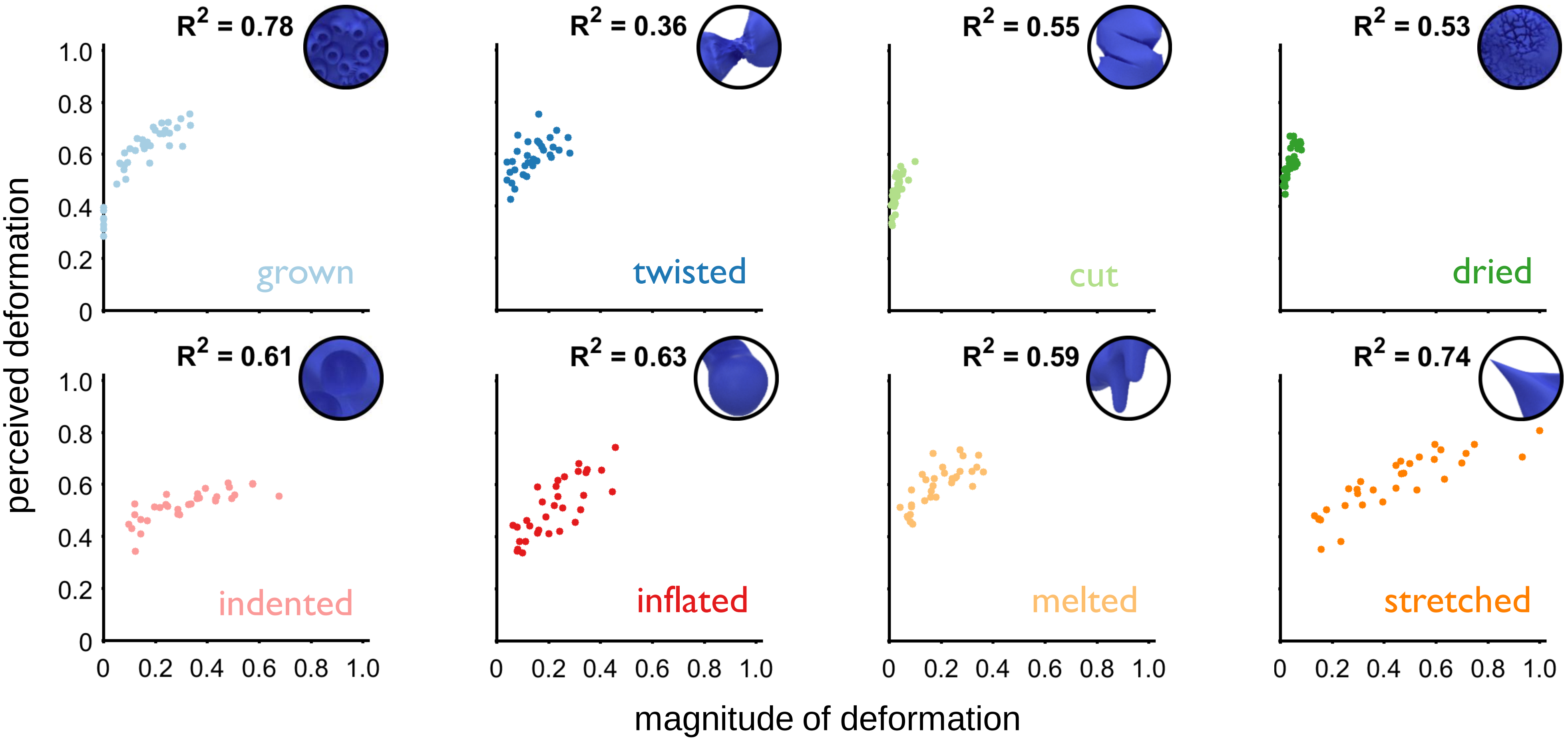
Experiment 3: Magnitude

- Multiple linear regression
  - Explained variance: $R^2 = 0.50$
  - Regression weights
    - Magnitude of deformation: 0.47
    - Area of deformation: 0.45



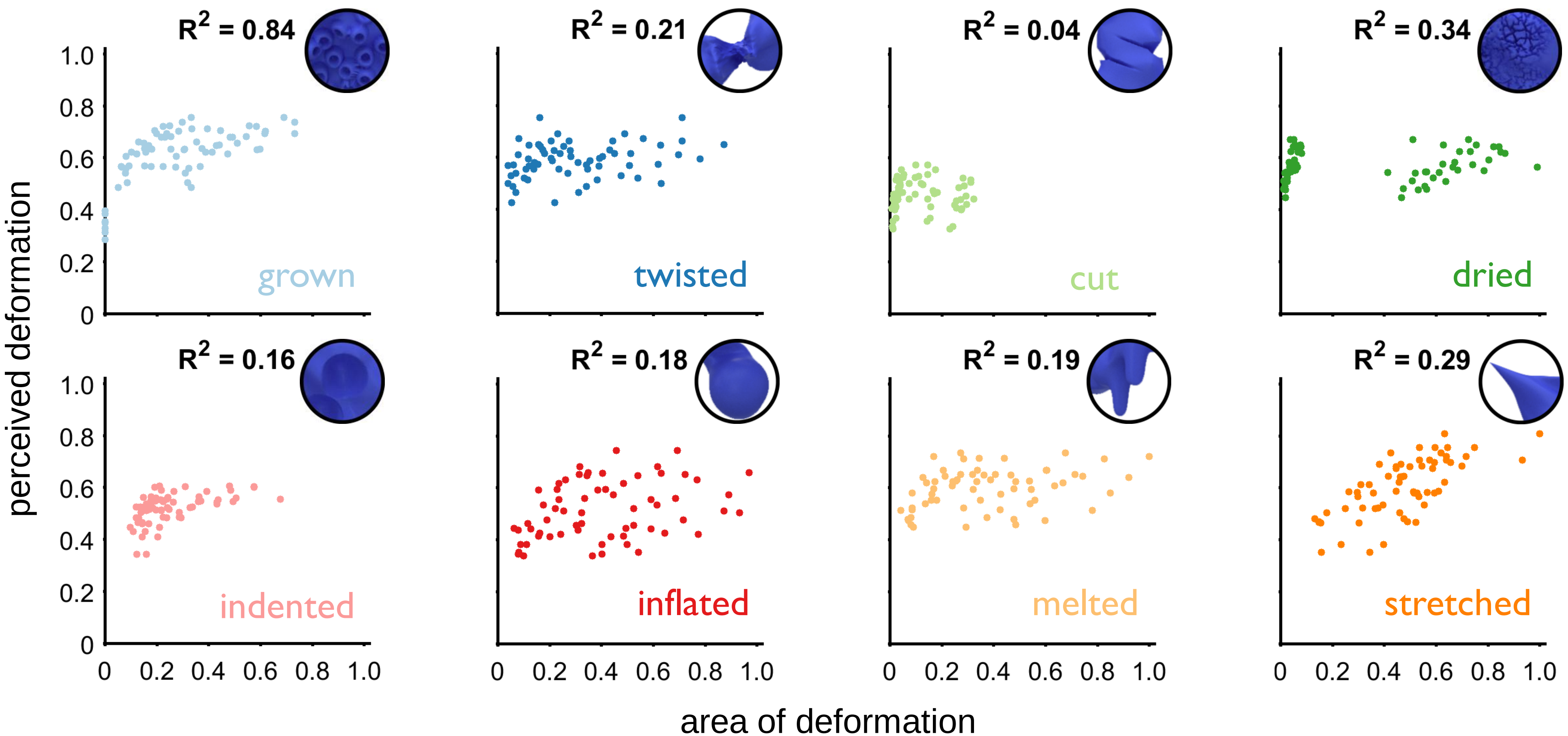
Experiment 3: Magnitude

- Analysis: magnitude of deformation per transformation



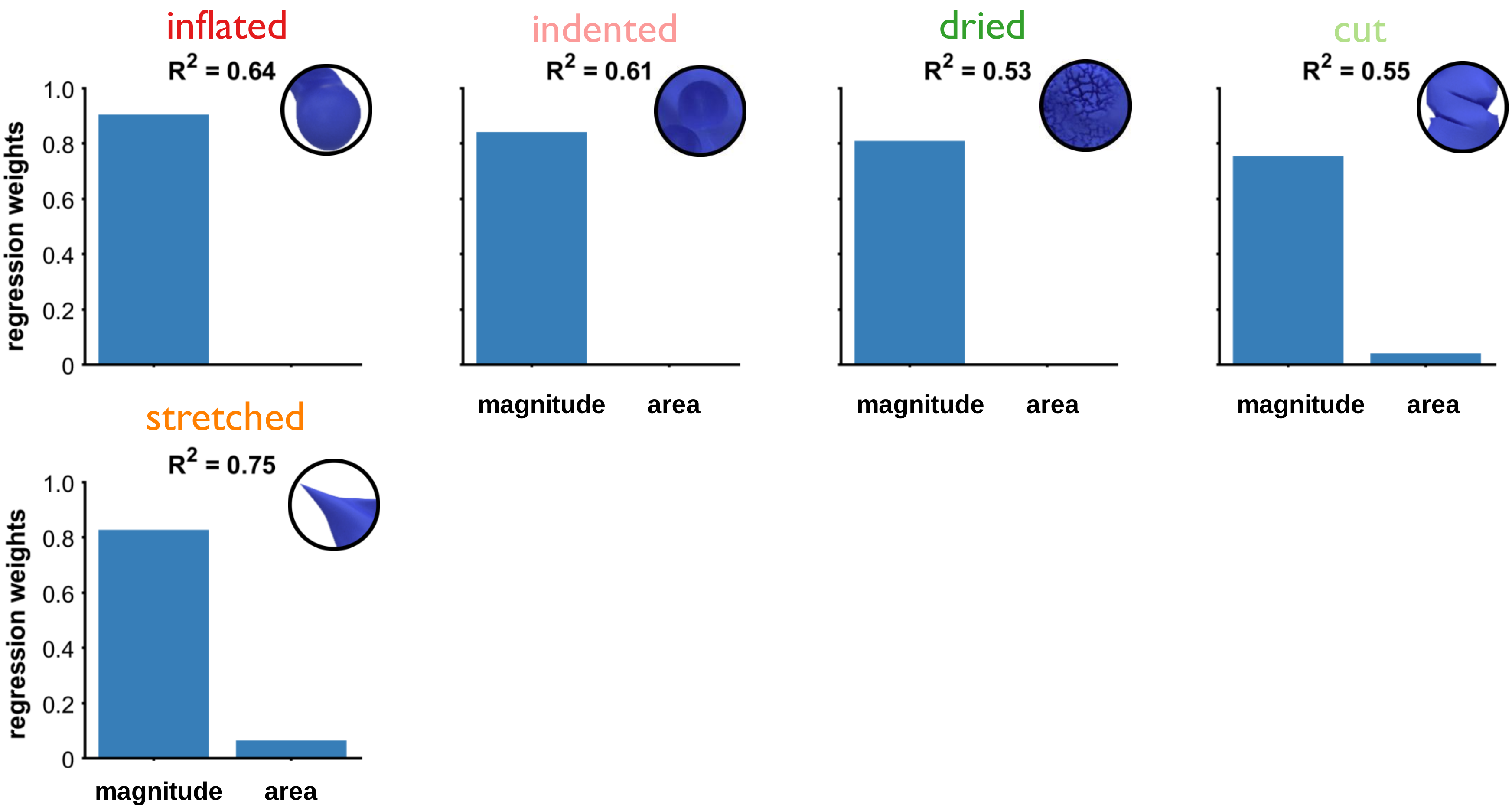
Experiment 3: Magnitude

- Analysis: area of deformation per transformation



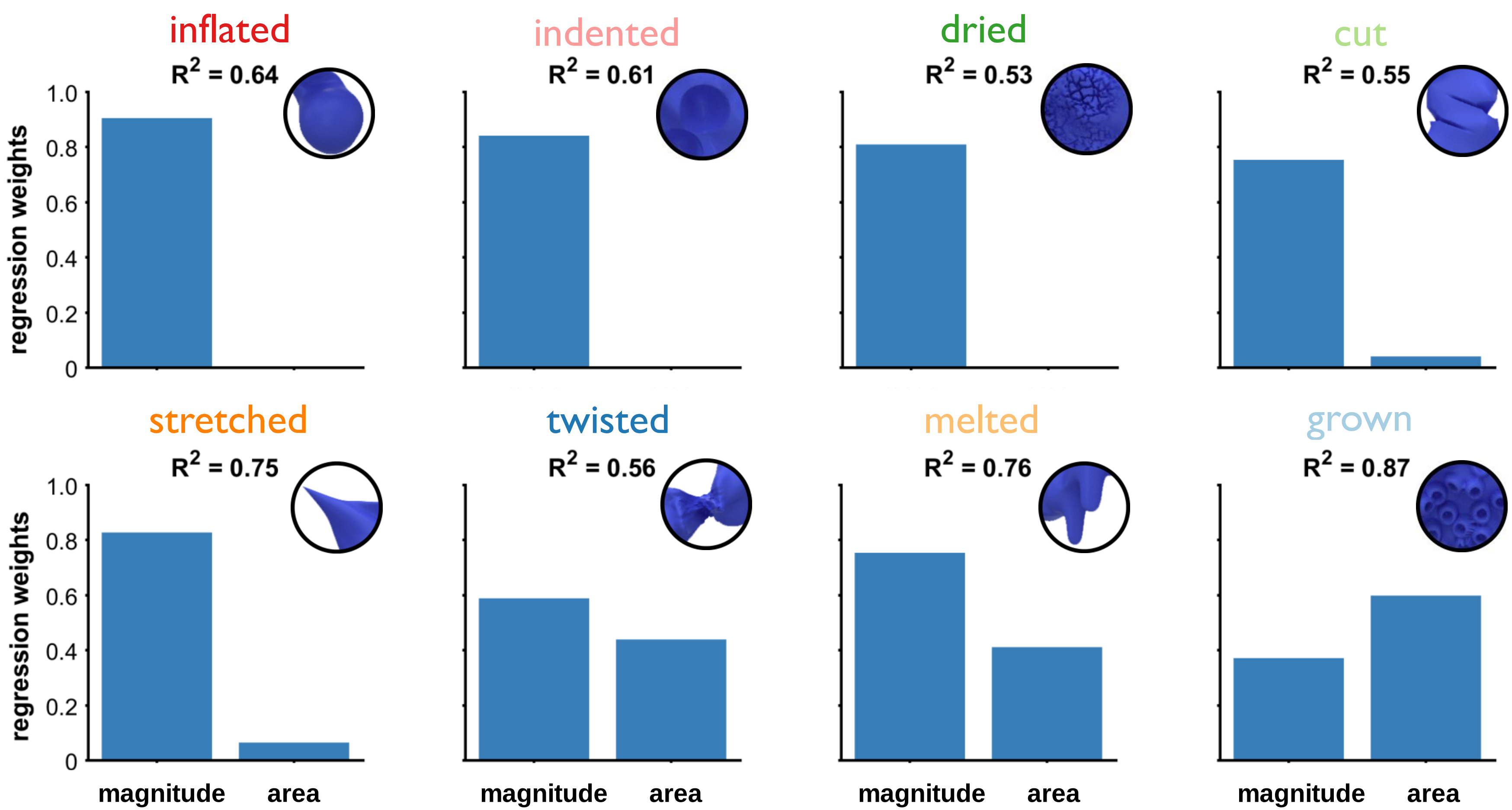
Experiment 3: Magnitude

- Multiple linear regression per transformation
  - Average explained variance: $R^2 = 0.66$



Experiment 3: Magnitude

- Multiple linear regression per transformation
  - Average explained variance: $R^2 = 0.66$



Conclusion

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- This allows us to make inferences about...
  - …what other members of the same class might look like (classification)
  - …how objects have been altered by forces in their past (meaning, location, and magnitude of transformations)
- Shape features to build these inferences are chosen depending on transformation

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- Main challenges
  - Identify perceptual information used to separate causal layers

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- Main challenges
  - Identify perceptual information used to separate causal layers
  - Identify neural representation of this information
  - Define computations that extract properties of the layers

JUSTUS LIEBIG-UNIVERSITÄT GIESSEN

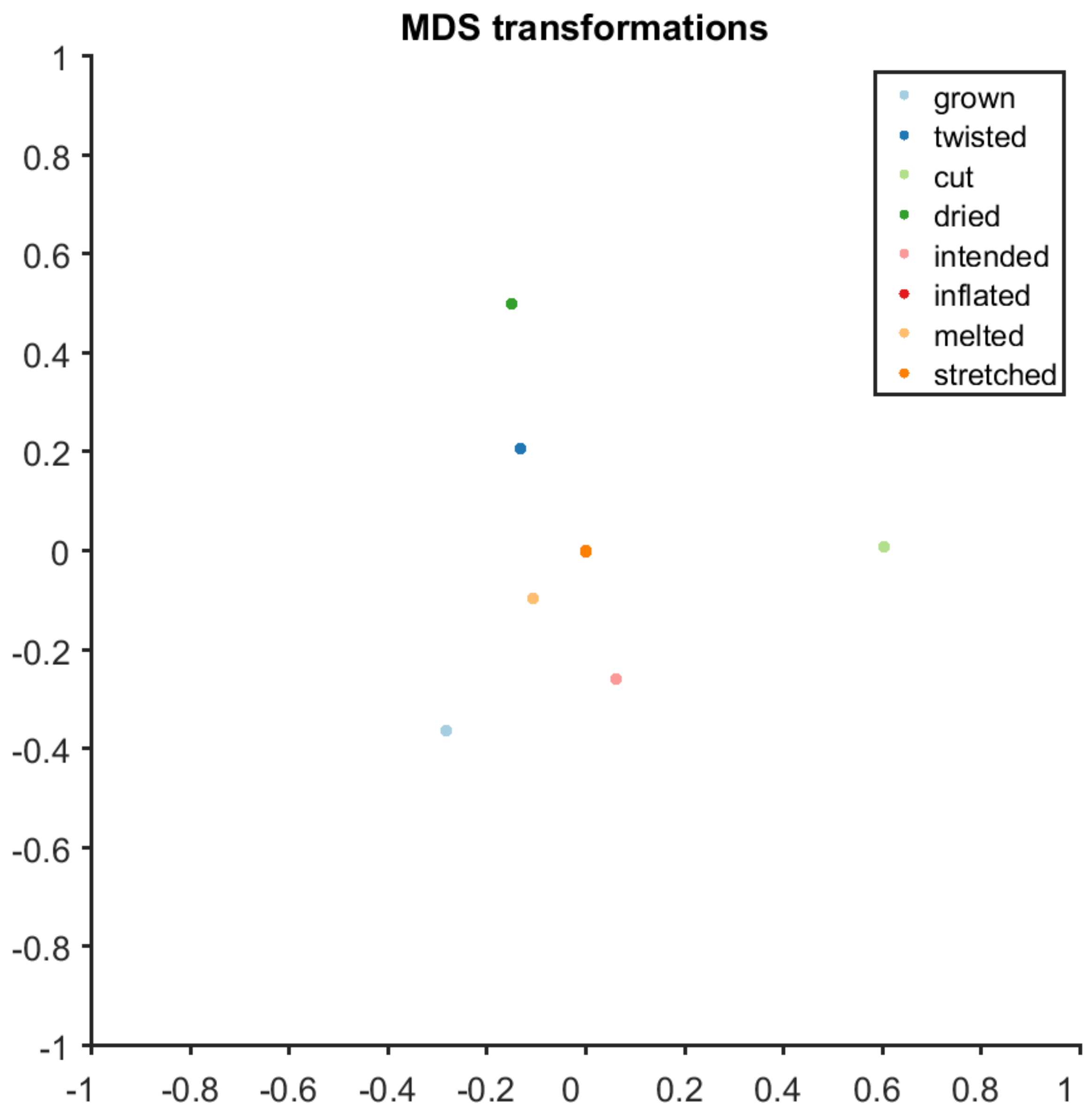
Thank you for your attention!

…and thanks to my colleagues from Gießen

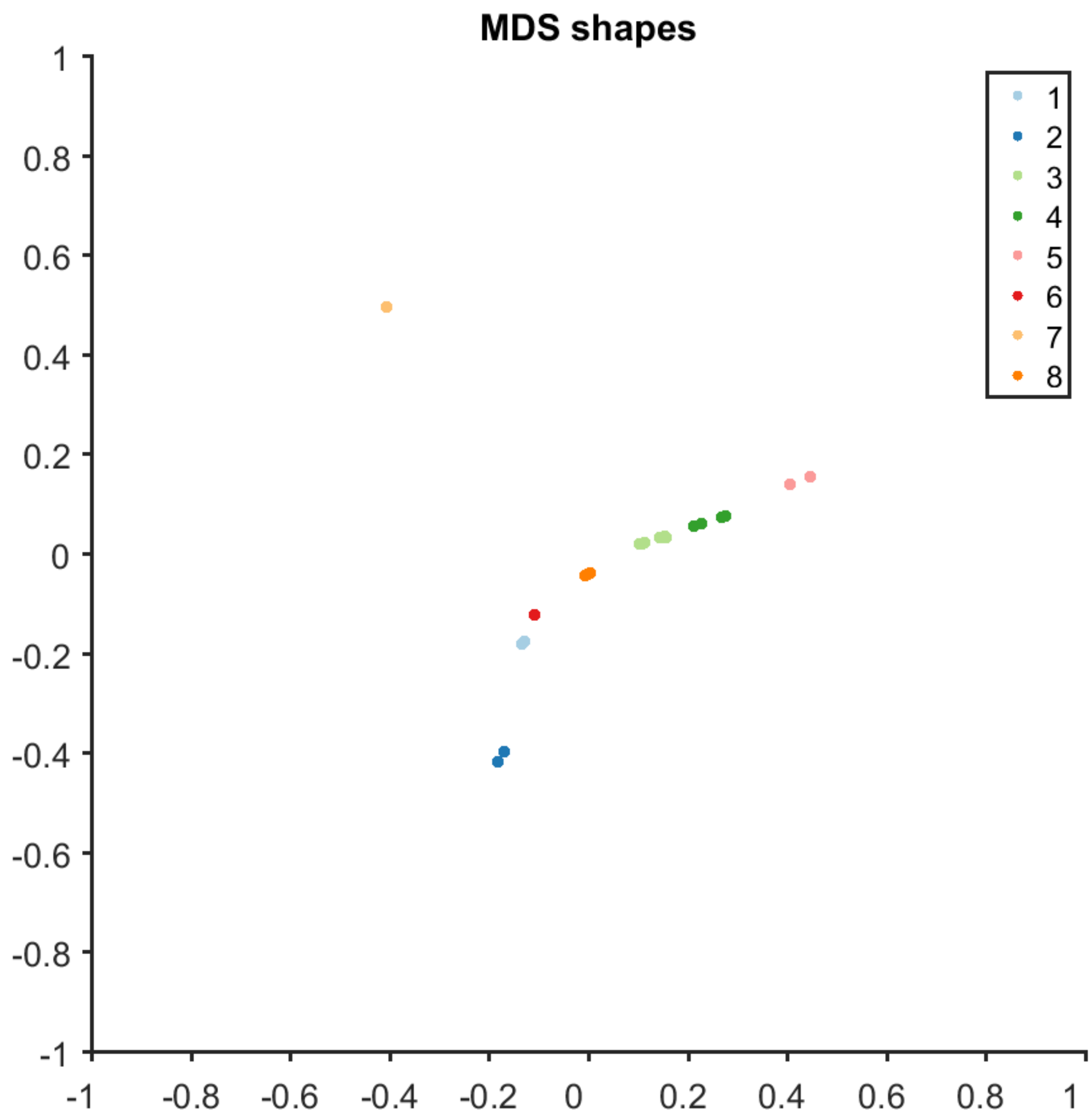
Cardinal Mechanisms of Perception

DFG

MDS transformation classification

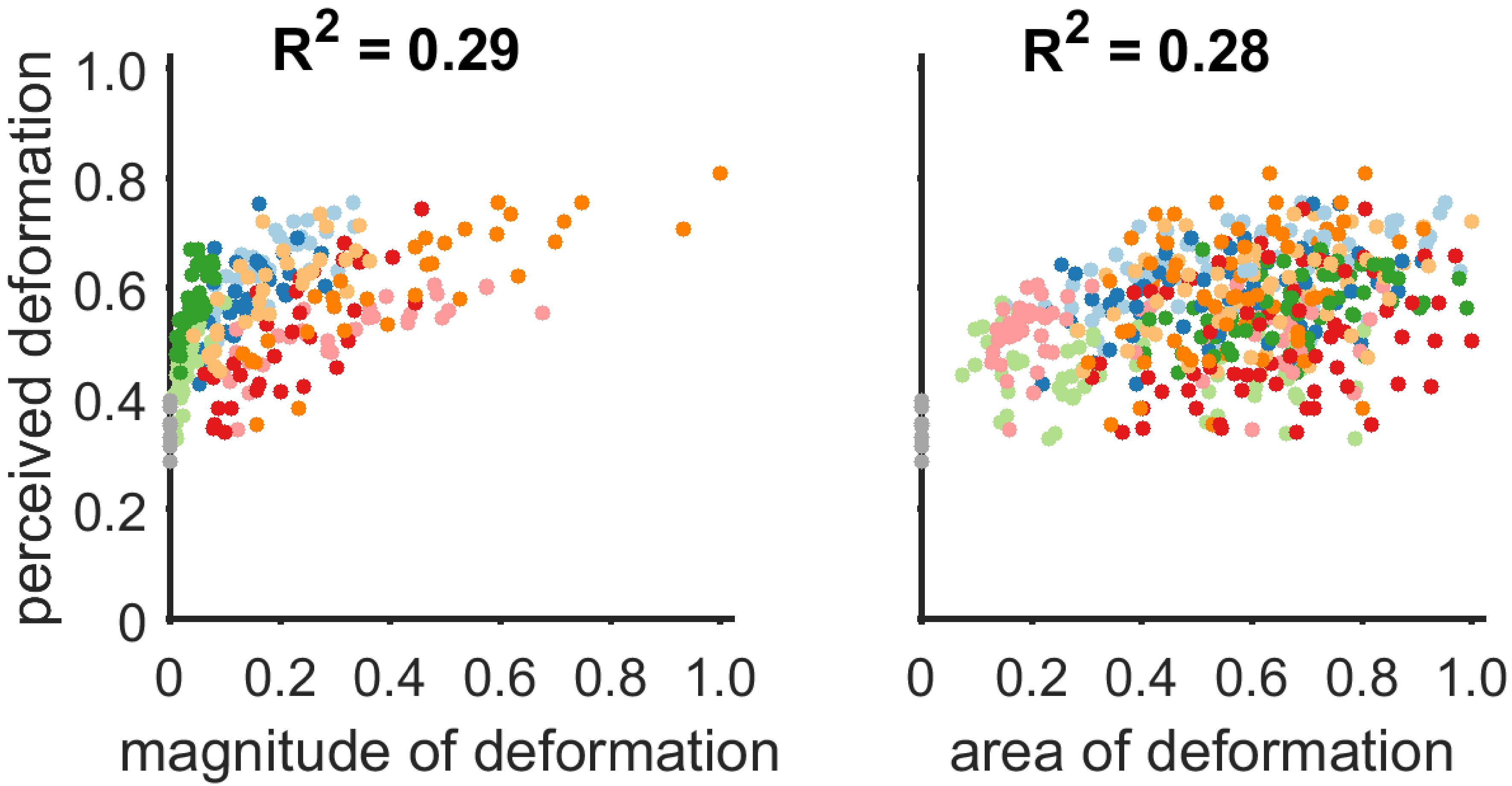


MDS shape classification



Experiment 3: Magnitude

- Mesh measures



In the limits...

We should not think about recovering causal history as an all or nothing process, but as a process that can take place on different levels of abstraction and resolution.

Depending on the specific stimulus and task, the inferences presumably span both perceptual and cognitive abilities.

At one extreme, detecting crumples, dents or cracks in objects is presumably primarily a perceptual process.

At the other extreme, inferring the culprit of a crime from a bloody dagger and some crumbs of mud on the floor is clearly a taxing cognitive task.

Many other causal history inferences fall somewhere between these two extremes, presumably enabling different levels of detail in the inference about the sequence of events that led to the observed state of the object.

Spröte & Fleming (2006)