Abstract

- Although we use our visual and tactile sensory systems interchangeably daily, little is known about the mechanism underlying this ability.

- The ability to recognize objects in both sensory modalities brings up two main questions:
  1- How do humans build up representations of their surroundings using visual or tactile system?
  2- Which common features describe the properties of human perceptions that mediate interchangeability between visual and tactile modalities?

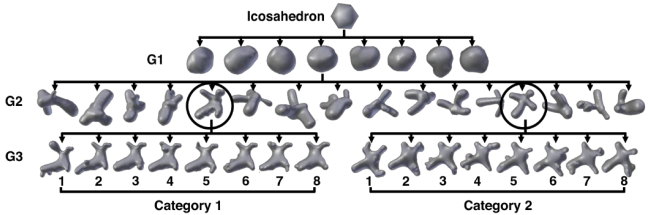
- In this study on both sexes of human participants, we examined how 3D shape features of objects form two congruent and interchangeable visual and tactile perceptual spaces.

Related publications:

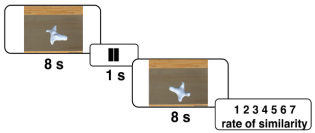
– Lee Masson et al., Cereb Cortex (26), Visual and Haptic Shape Processing in the Human Brain: Unisensory Processing, Multisensory Convergence (2016)
– Gaissert and Wallraven, Exp Brain Res (216), Categorizing natural objects: A comparison of the visual and the haptic modalities.(2012)

Techniques & Methods

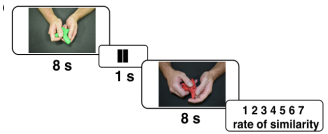
Performing a virtual phylogenesis algorithm
to create a unique set of “digital embryos”.



Visual similarity rating task was performed in the virtual office environment.

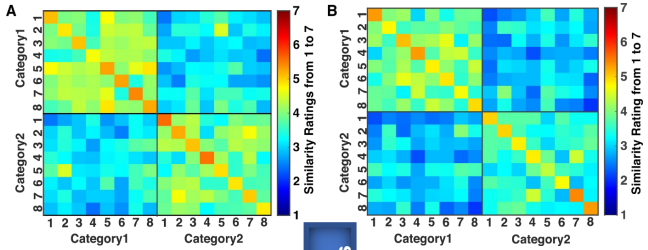


Plastic 3D printout objects were explored by blindfolded participants in the tactile experiment.



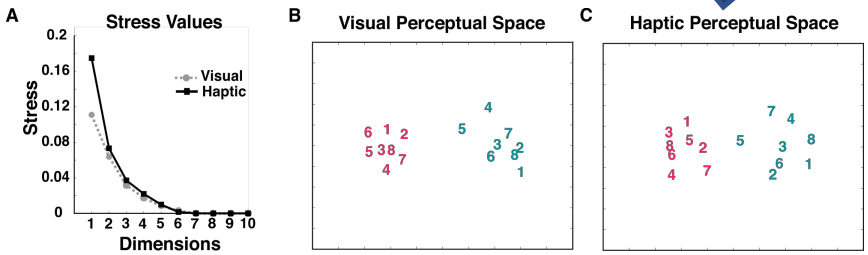
Results

Average group similarity matrix for visual and tactile similarity judgments



MDS analysis

Feature Extraction



	Fit quality between physical and visual perceptual spaces	Fit quality between physical and tactile perceptual spaces
Minimum d-values for n-combination of features(n=1-17)	d=0.158 (F13)	d=0.266 (F13)
	d=0.120 (F2, F13)	d=0.215 (F2, F9)
	d=0.098 (F5, F13, F14)	d=0.158 (F2, F4, F13)
	d=0.072 (F2, F11, F13, F14)	d=0.135 (F2, F4, F11, F16)
	d=0.061 (F2, F5, F11, F13, F14)	d=0.126 (F2, F4, F9, F15, F17)
	d=0.062 (F2, F3, F6, F12, F14, F15)	d=0.118 (F2, F4, F5, F10, F11, F17)
	d=0.053 (F2, F5, F6, F11, F13, F14, F15)	d=0.101 (F2, F4, F5, F11, F13, F15, F17)
	d=0.052 (F2, F3, F4, F8, F11, F13, F14, F15)	d=0.110 (F2, F4, F5, F6, F9, F10, F11, F15)
	d=0.050 (F2, F4, F5, F6, F7, F11, F13, F14, F15)	d=0.116 (F2, F4, F7, F10, F11, F12, F13, F15, F16)
	d=0.048 (F1, F2, F4, F5, F7, F8, F11, F13, F14, F15)	d=0.120 (F2, F4, F5, F7, F9, F10, F11, F14, F15, F17)
	d=0.050 (F2, F4, F5, F6, F7, F10, F11, F12, F13, F14, F15)	d=0.132 (F2, F3, F4, F7, F9, F10, F11, F12, F14, F15, F16)
	d=0.060 (F1, F2, F4, F5, F7, F8, F10, F11, F12, F13, F14, F15)	d=0.145 (F2, F3, F4, F6, F7, F9, F10, F11, F12, F14, F15, F17)
	d=0.078 All features were selected except F6, F9, F12, F17	d=0.150 All features were selected except F1, F6, F8, F13
	d=0.110 All features were selected except F6, F16, F17	d=0.171 All features were selected except F5, F8, F13
	d=0.167 All features were selected except F10, F14	d=0.271 All features were selected except F10, F14
	d=0.168 All features were selected except F14	d=0.272 All features were selected except F14
	d=0.168 All features were selected	d=0.272 All features were selected

F1: gaussian curvature, F2: the distances from all vertices to the center of objects, F4: the volume of objects, F5: the surface area of top view, F7: the surface area of frontal view, F8: the distances of the center from edges on the XY-projection, F11: bounding box size, F13: inertia tensor, F14: principal axes, F15: axis momenta, F17: the number of faces that constructed objects.

To investigate which object features constituted the highly compatible perceptual spaces, seventeen features were extracted such as, Gaussian curvature, volume of objects, inertia tensor.

Results / Conclusions

- Our results indicate even for unfamiliar objects that in the absence of visual perception, a tactile inspection is capable of recovering the same perceptual space as the visual system, and vice versa.
- In addition to the highly congruent perceptual spaces of both visual and tactile exploration, the two clusters represent the two object categories of the VP algorithm.
- We have shown that the visual and tactile sensory systems share common features to identify objects.
- The existence of such a multimodal perceptual mechanism might be the main reason why humans can interchangeably use visual and tactile modalities because the acquired object information can be shared or transferred between modalities.
- Also, our results indicate a link between perceptual spaces of visual and tactile systems which can lead to the assumption that both modalities use a similar cognitive process to represent the shape information.