



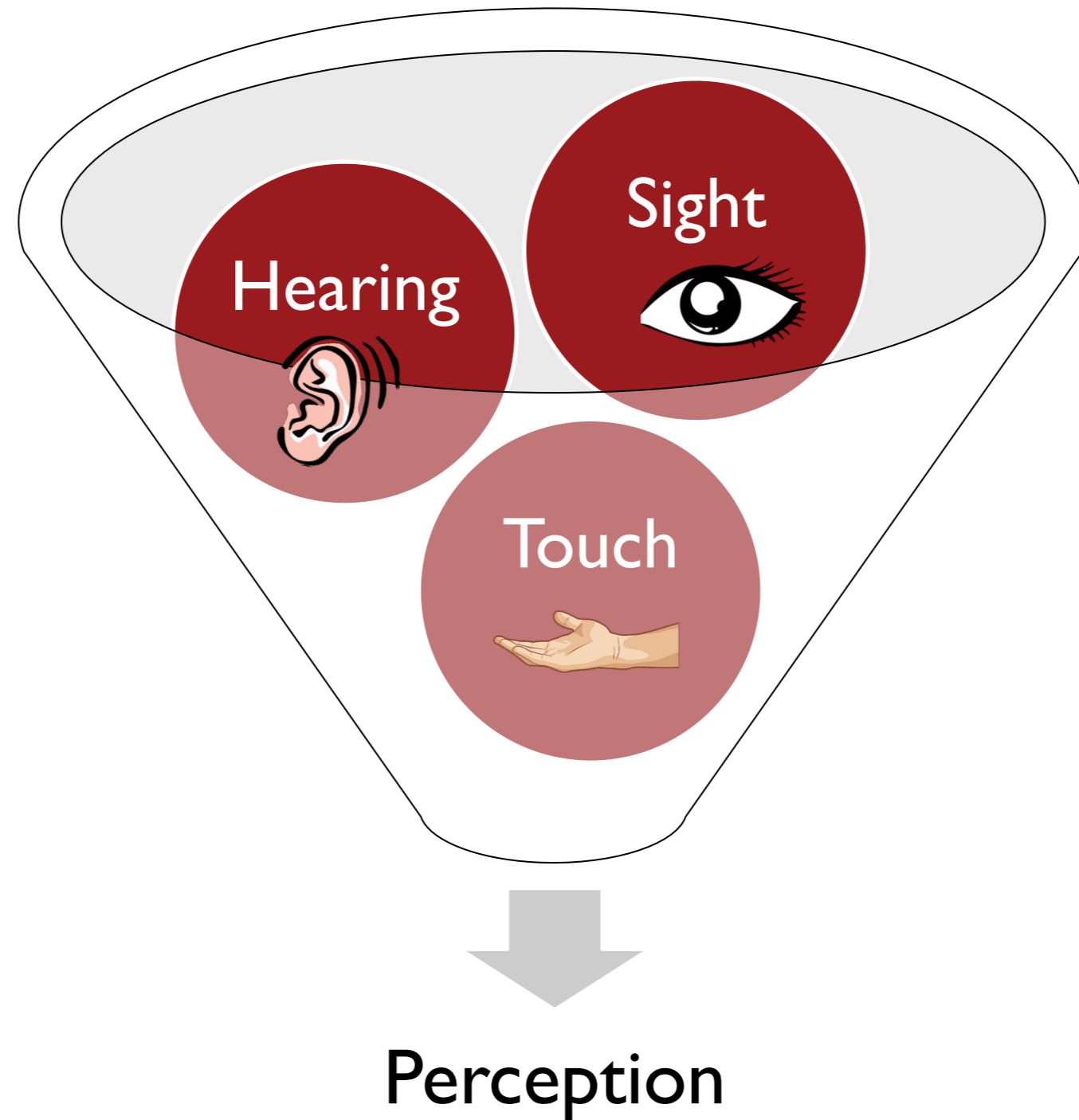
ME 327: Design and Control of Haptic Systems

Spring 2020

Lecture 6: Haptic Illusions

Allison M. Okamura
Stanford University

Interplay of Senses



Slide courtesy Heather Culbertson (USC)

Pseudohaptics

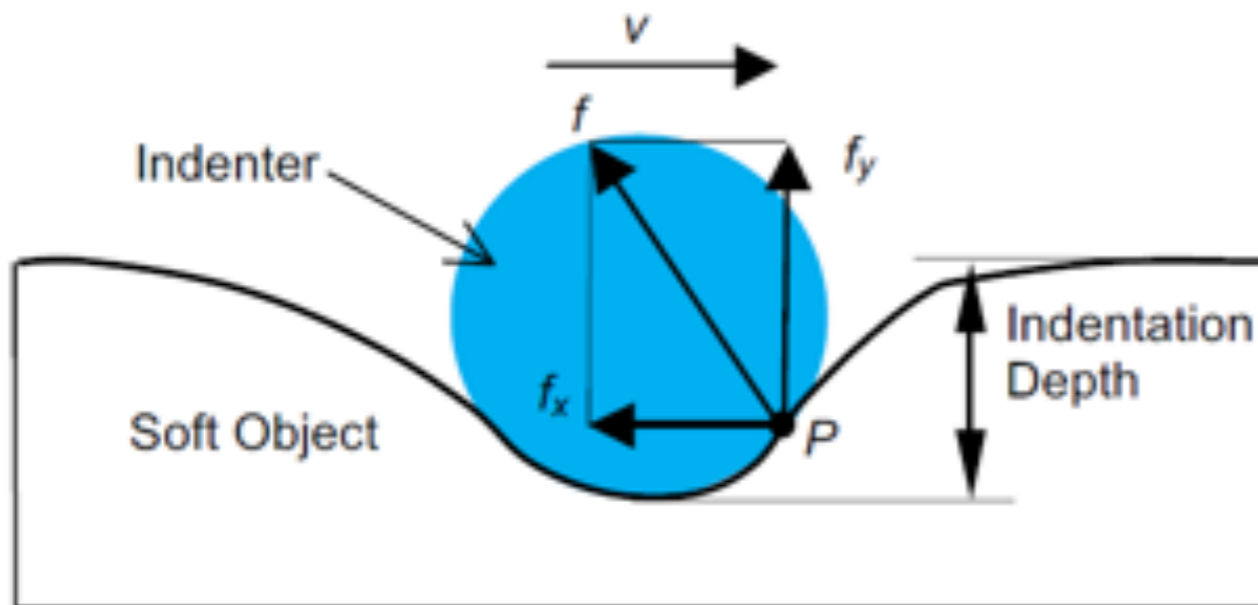


Sight



Touch

Stiffness



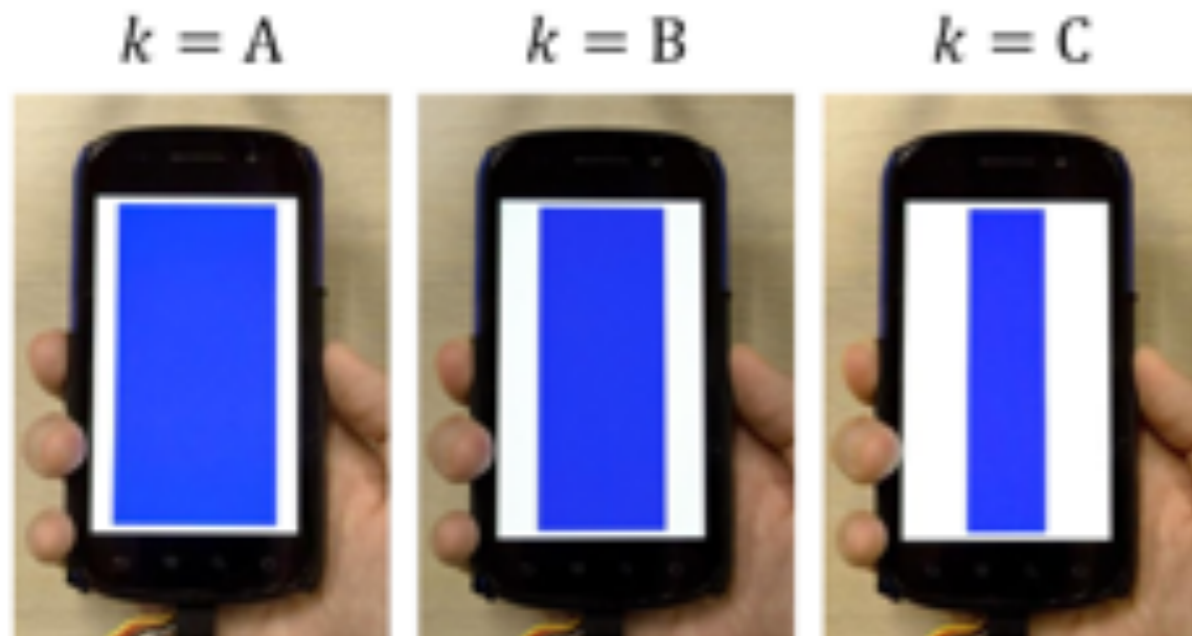
Li, M., Ridzuan, M. B., Sareh, S., Seneviratne, L. D., Dasgupta, P., & Althoefer, K. (2014). Pseudo-haptics for rigid tool/soft surface interaction feedback in virtual environments. *Mechatronics*, 24(8), 1092-1100.



<https://youtu.be/oijhqAzr5ql>

Slide courtesy Heather Culbertson (USC)

Stiffness



Yabe, Shin-ichiro, et al. "Pseudo-haptic feedback on softness induced by squeezing action." *2017 IEEE World Haptics Conference (WHC)*. IEEE, 2017.

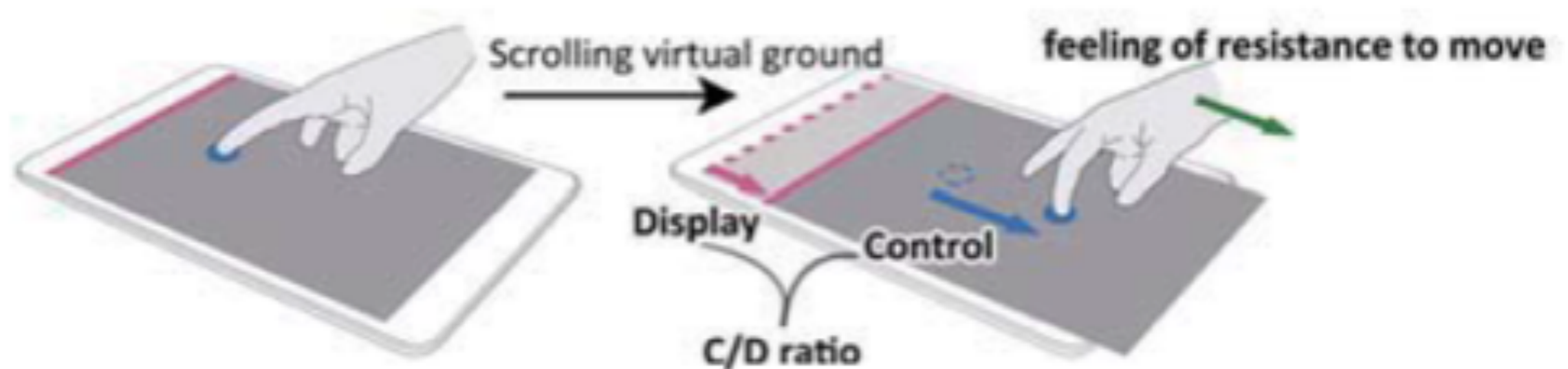
<https://youtu.be/Caw-Ragv52I>

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Scrolling (friction)

- $C/D = \text{Control} / \text{Display}$ ratio
- Maps physical displacement of user input (control) to the on-screen movement (display)

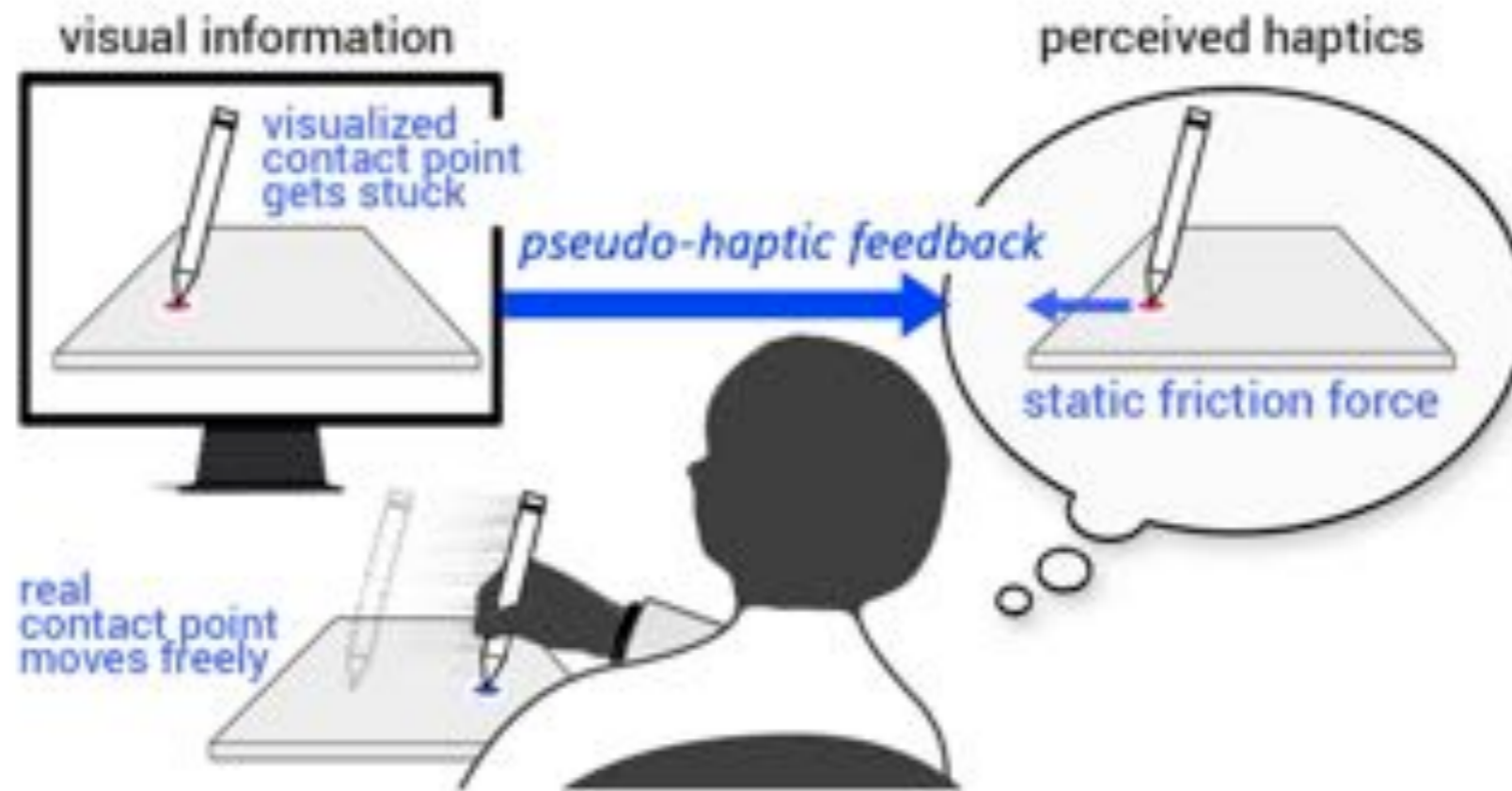


Narumi, T., Ujitoko, Y., Ban, Y., Tanikawa, T., Hirota, K., & Hirose, M. (2017). Resistive swipe: Visuo-haptic interaction during swipe gestures to scroll background images on touch interfaces. In *2017 IEEE World Haptics Conference (WHC)* (pp. 334-339). IEEE.

Slide courtesy Heather Culbertson (USC)

Stick-Slip

Presenting Static Friction Sensation at Stick-slip Transition using Pseudo-haptic Effect



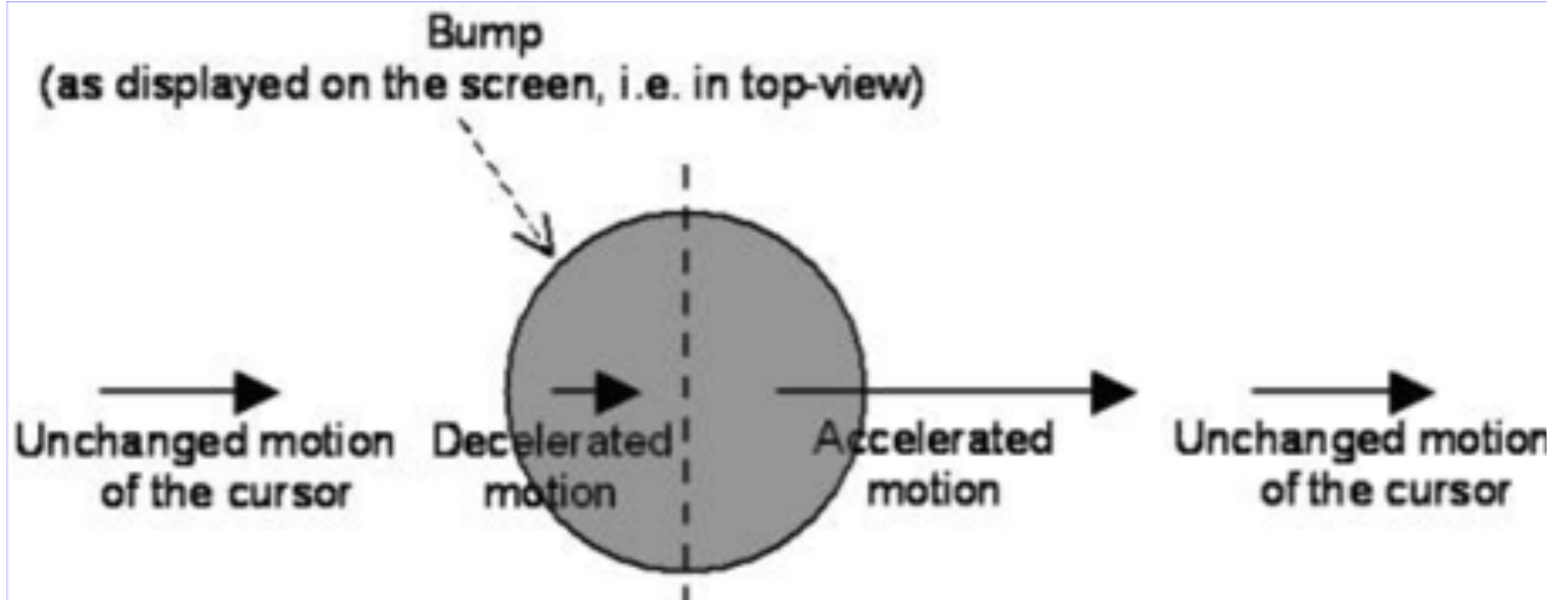
Yusuke Ujitoko
Yuki Ban
Koichi Hirota

Hitachi, Ltd.
The University of Tokyo
The University of Electro-Communications

<https://youtu.be/iFK798zVM0w>

Slide courtesy Heather Culbertson (USC)

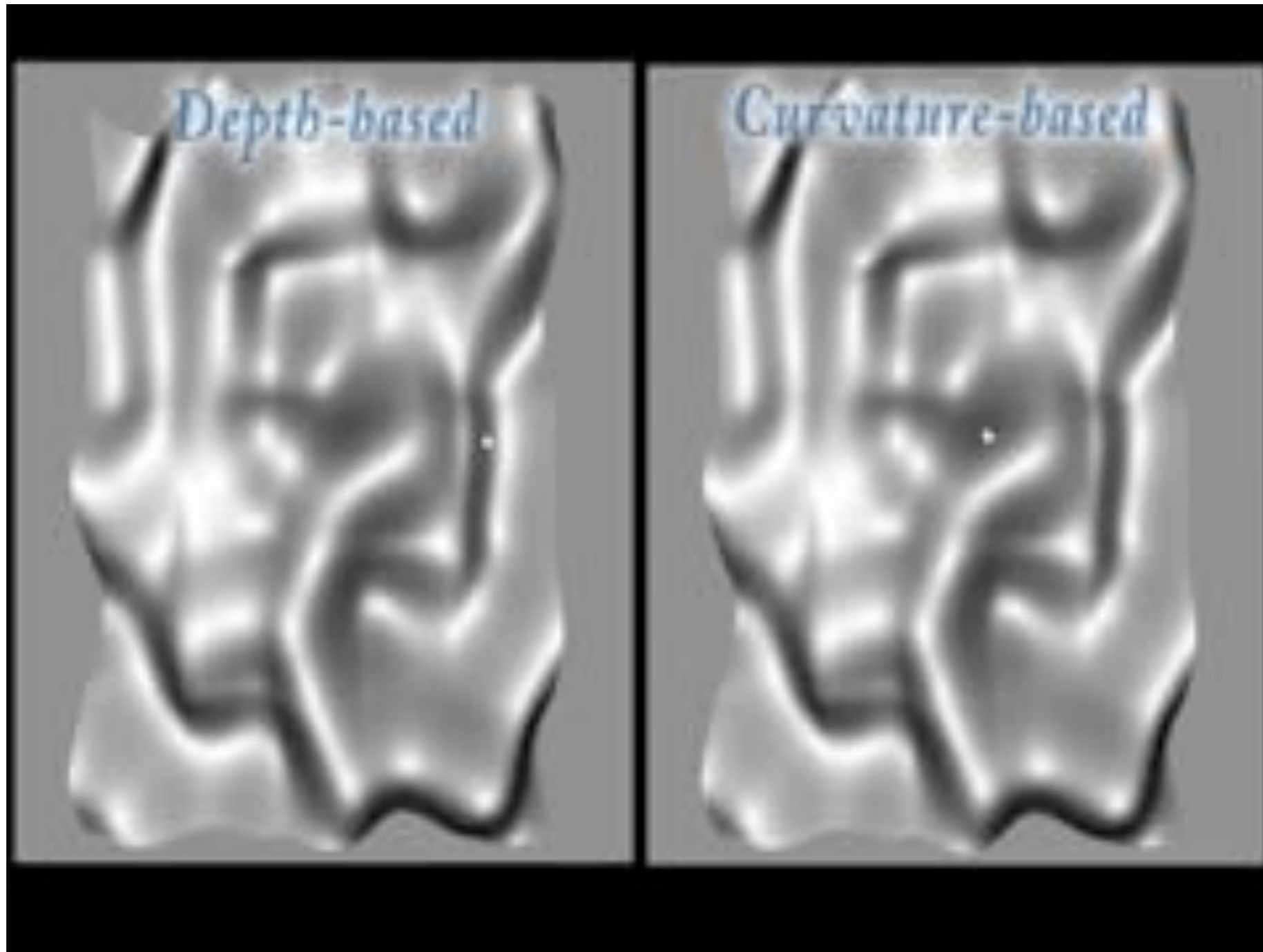
Texture



Lecuyer, A., Burkhardt, J. M., & Etienne, L. (2004). Feeling bumps and holes without a haptic interface: The perception of pseudo-haptic textures. *Proceedings of the ACM CHI International Conference in Human Factors in Computing Systems*.

Slide courtesy Heather Culbertson (USC)

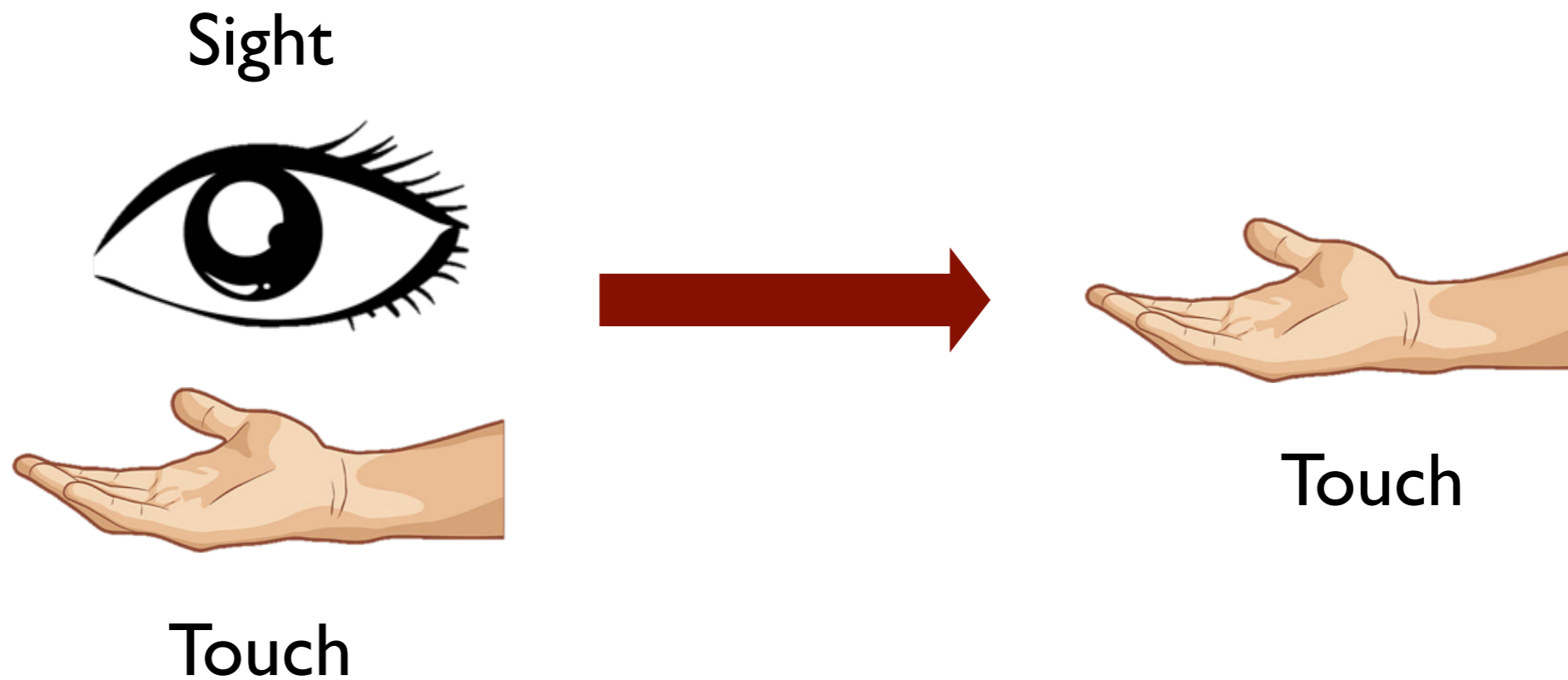
Texture



<https://youtu.be/zZZuZlbtjPs>

Slide courtesy Heather Culbertson (USC)

Haptic Retargeting



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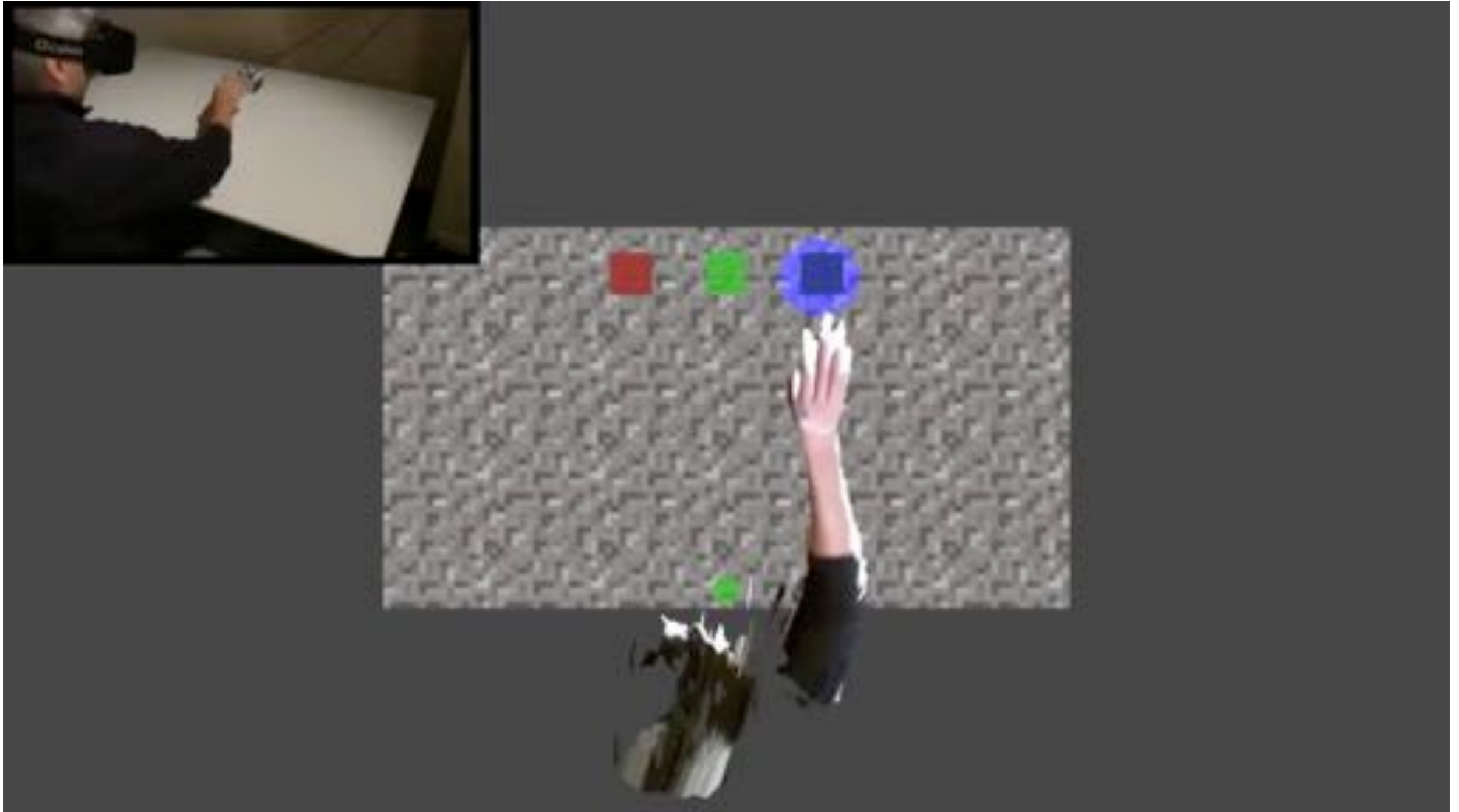
Passive Haptics



Azmandian, M., Hancock, M., Benko, H., Ofek, E., & Wilson, A. D. (2016, May). Haptic retargeting: Dynamic repurposing of passive haptics for enhanced virtual reality experiences. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 1968-1979). ACM.

Slide courtesy Heather Culbertson (USC)

Passive Haptics



https://youtu.be/v-5u0z4zA_8

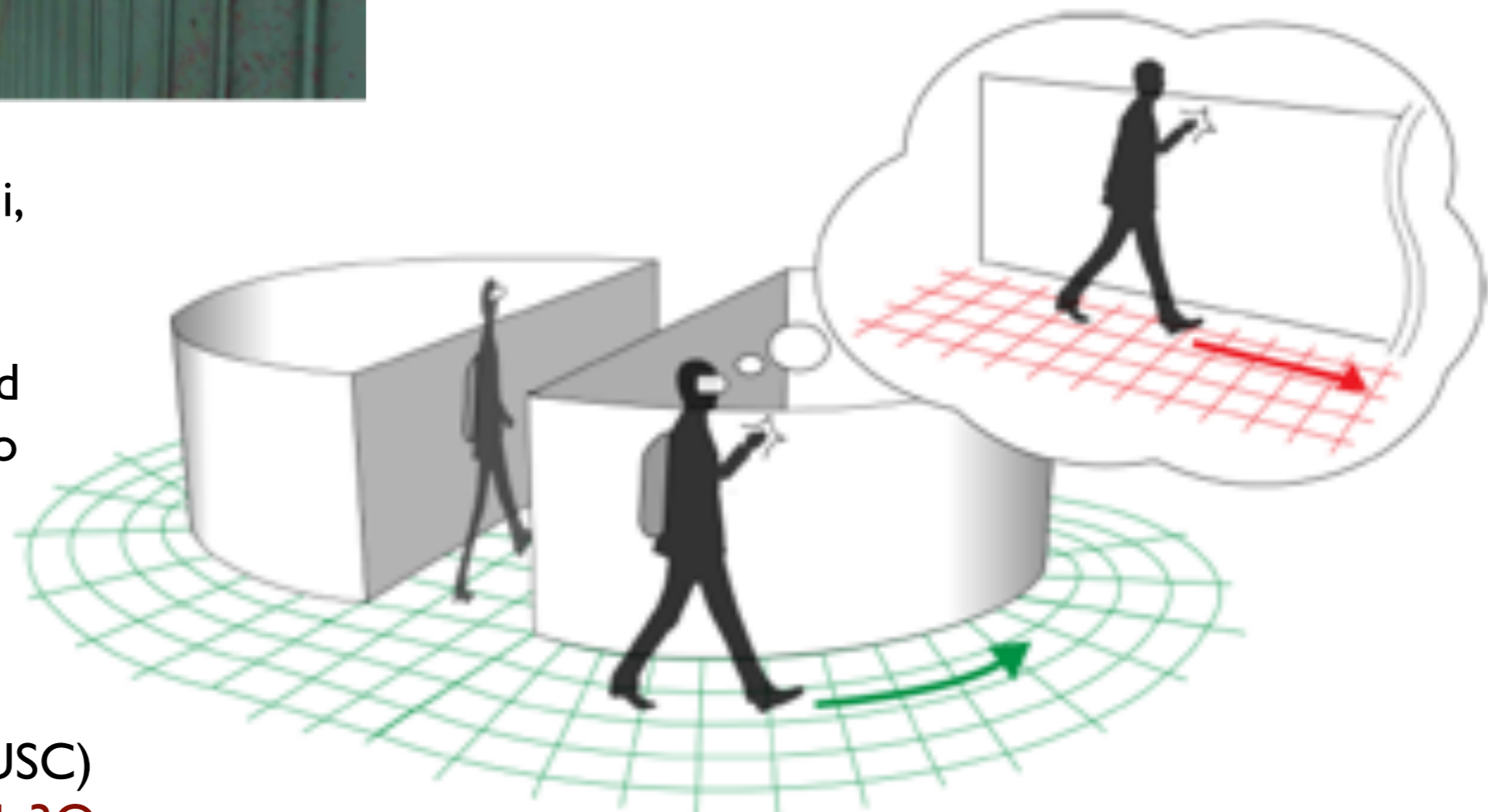
Slide courtesy Heather Culbertson (USC)

Redirected Walking



<https://youtu.be/u8pw8IVbMUU>

Matsumoto, K., Ban, Y., Narumi, T., Yanase, Y., Tanikawa, T., & Hirose, M. (2016, July). Unlimited corridor: redirected walking techniques using visuo haptic interaction. In *ACM SIGGRAPH 2016 Emerging Technologies* (p. 20). ACM.



Also, at Adam Savage's Lab (USC)
<https://youtu.be/XOxmMurUv3Q>

Slide courtesy Heather Culbertson (USC)

Haptic Illusions

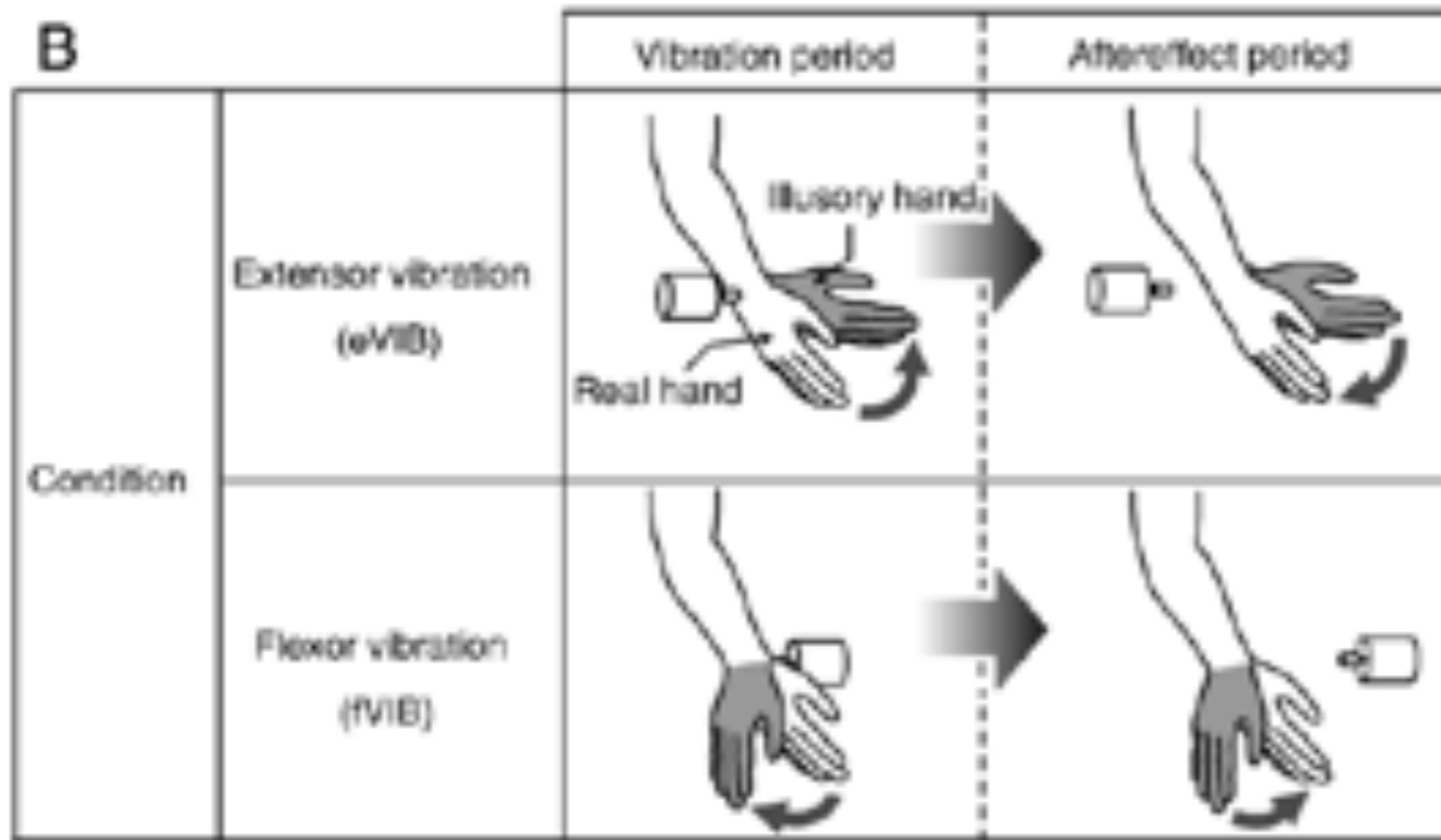


Touch



Touch

Tendon Vibration Illusion



Allison doing the Pinocchio illusion on Brain Games, S7 E5 “Super Senses”
<https://www.imdb.com/title/tt5606054/>



G.M. Goodwin, D.I. McCloskey, and P.B.C. Matthews, “The Contribution of Muscle Afferents to Kinesthesia Shown by Vibration Induced Illusions of Movement and by the Effects of Paralyzing Joint Afferents,” *Brain*, vol. 95, pp. 705-748, 1972.

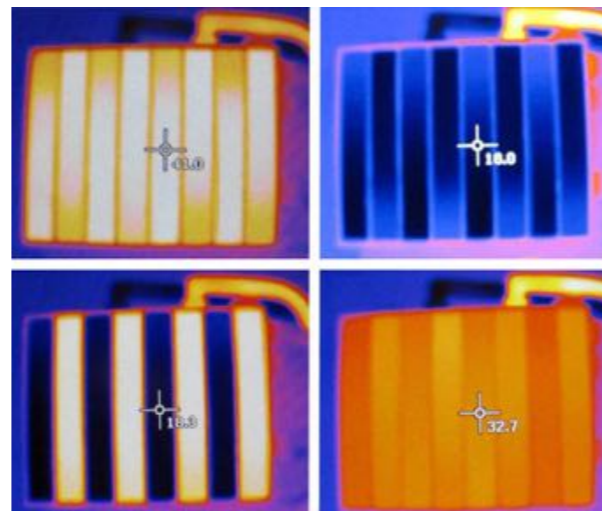
Kito, T., Hashimoto, T., Yoneda, T., Katamoto, S., & Naito, E. (2006). Sensory processing during kinesthetic aftereffect following illusory hand movement elicited by tendon vibration. *Brain research*, 1114(1), 75-84.

Thermal Grill Illusion

- Originally demonstrated in 1896 by Torsten Thunberg
- When you press a hand against the grill (alternating cool and warm bars), you experience the illusion of burning heat.

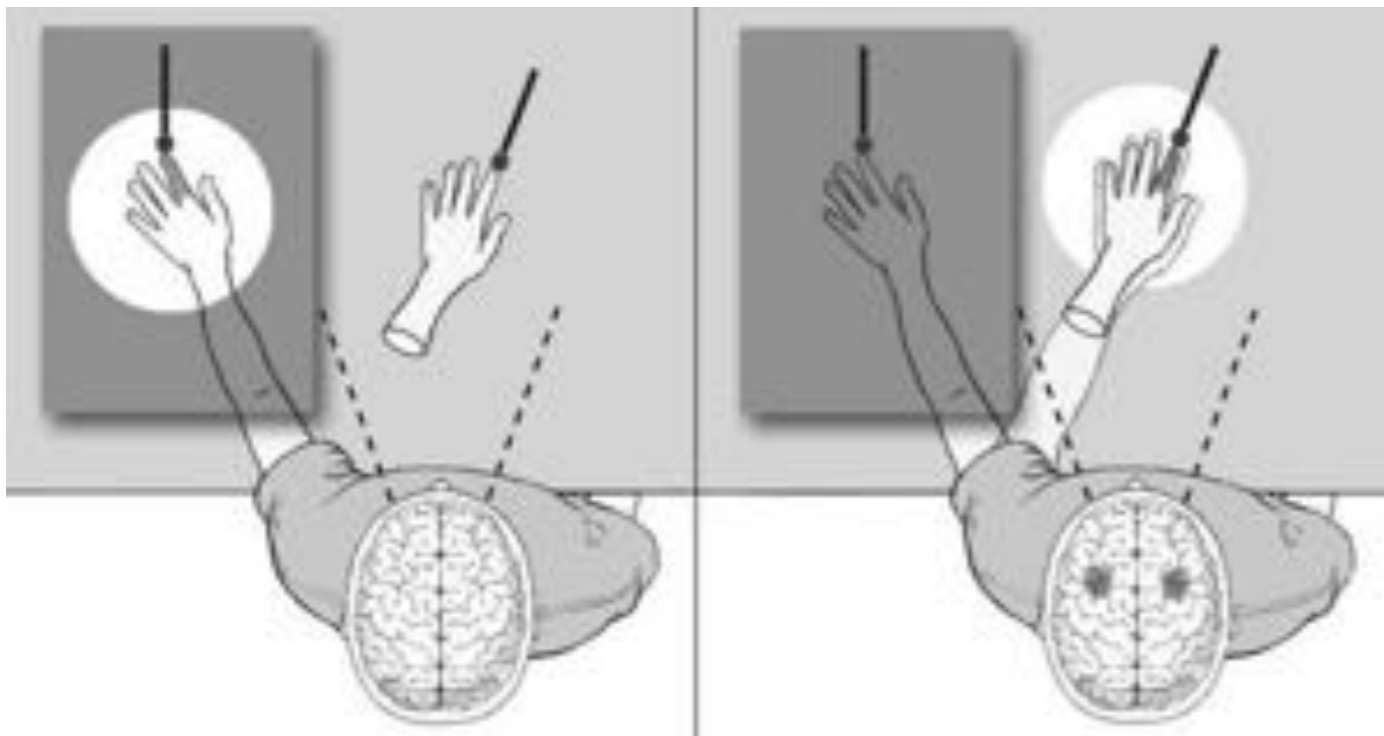


AD Craig et al., “The thermal grill illusion: unmasking the burn of cold pain”, Science Vol. 265, 1994



Slide courtesy Tania Morimoto (UCSD)

Rubber Hand Illusion

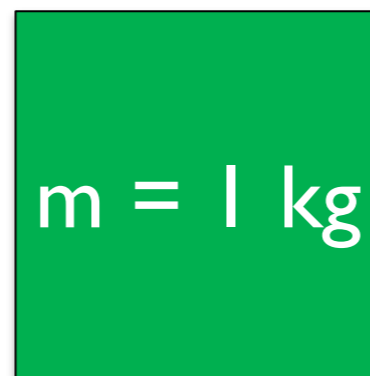
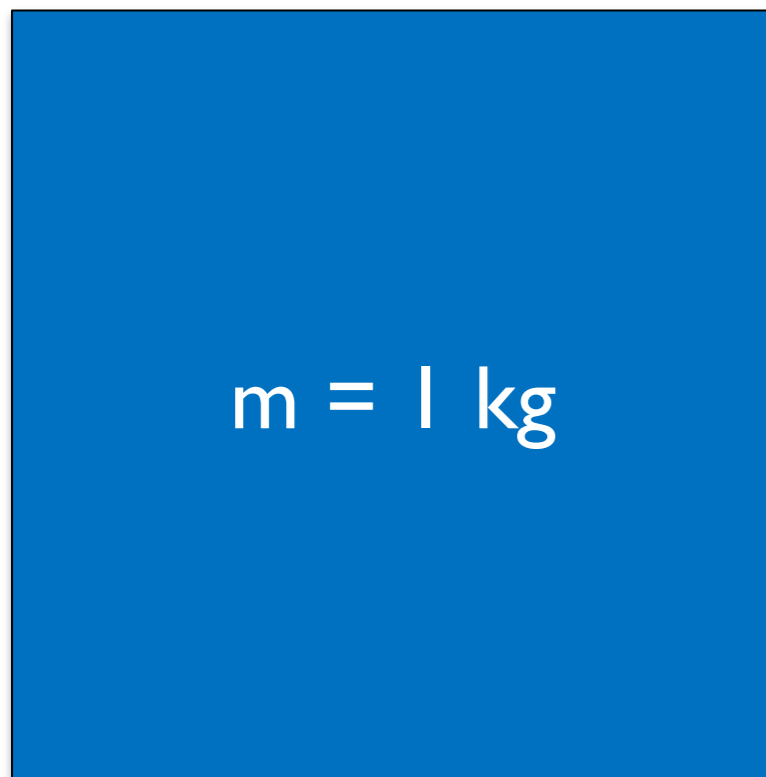


M. Botvinick and J. Cohen, "Rubber hands 'feel' touch that eyes see," *Nature*, vol. 391, no. 6669, pp. 756–756, 1998.

Size-Weight Illusion

When two objects with same mass are lifted, the smaller object is perceived to be heavier

more Brain Games, S7 E5:
<https://youtu.be/dciVH2ufj2g>



Stevens, Joseph C., and Lee L. Ruben. "Psychophysical scales of apparent heaviness and the size-weight illusion." *Perception & Psychophysics* 8.4 (1970): 225-230.

Other Weight Illusions

Perception of weight can also be affected by:

- Material (lighter when material “should be” heavier)
- Surface texture (lighter when texture rougher)
- Color (lighter when darker)
- Temperature (cold objects feel heavier)

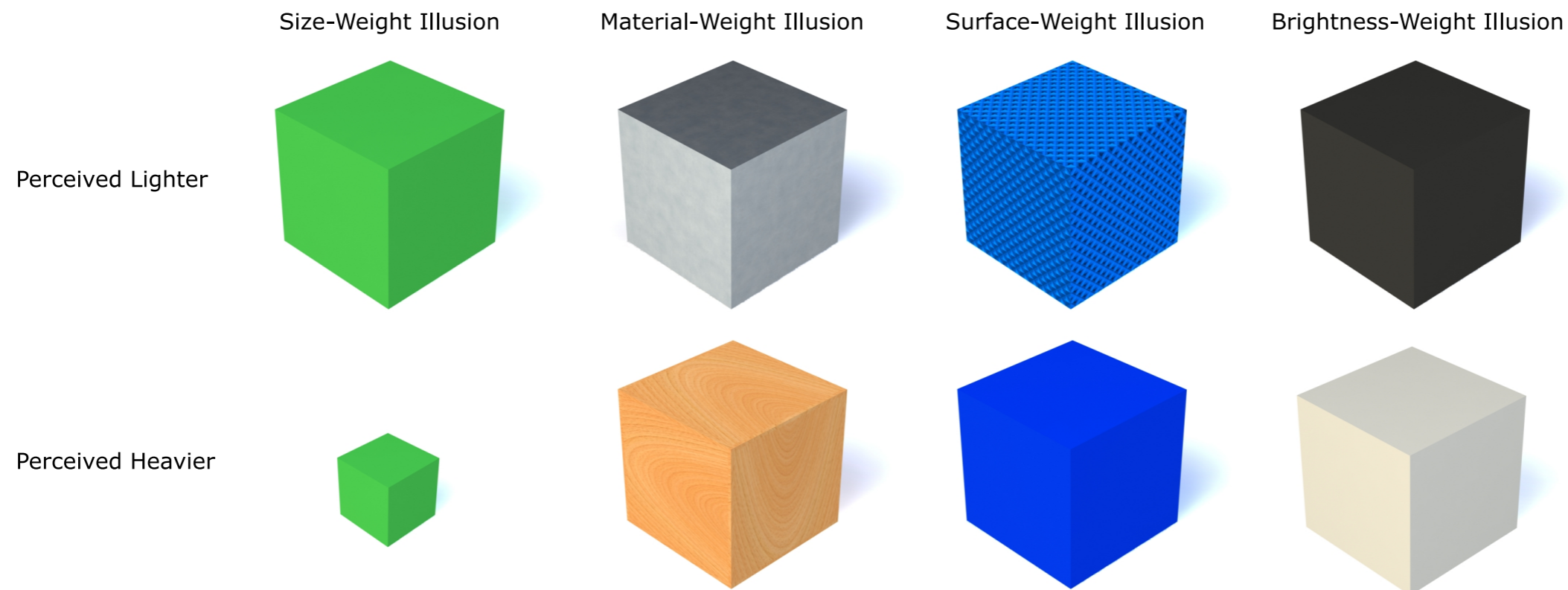
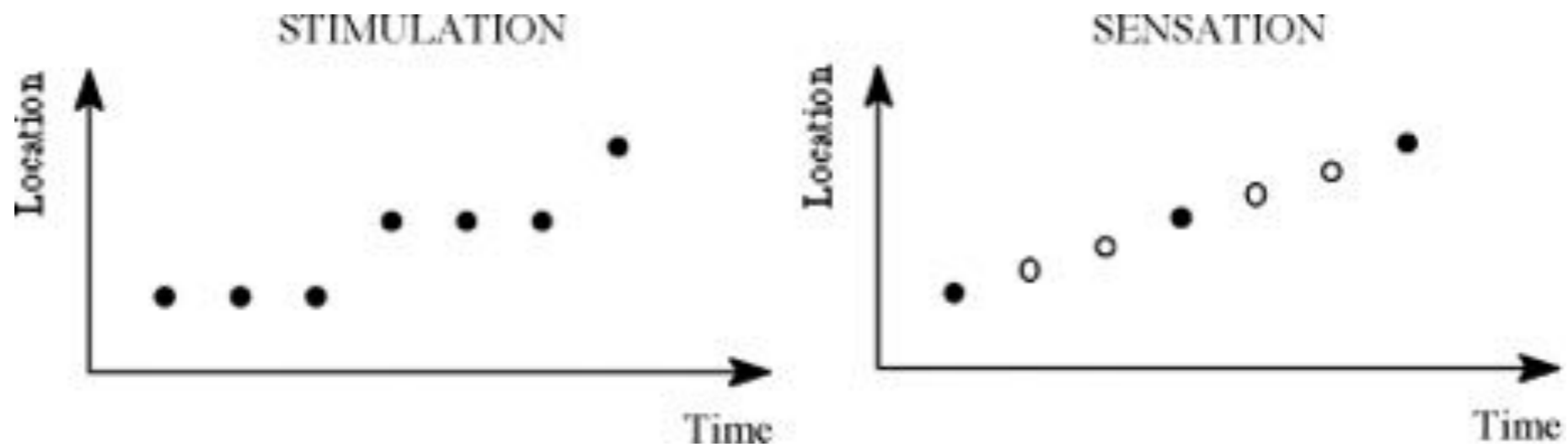
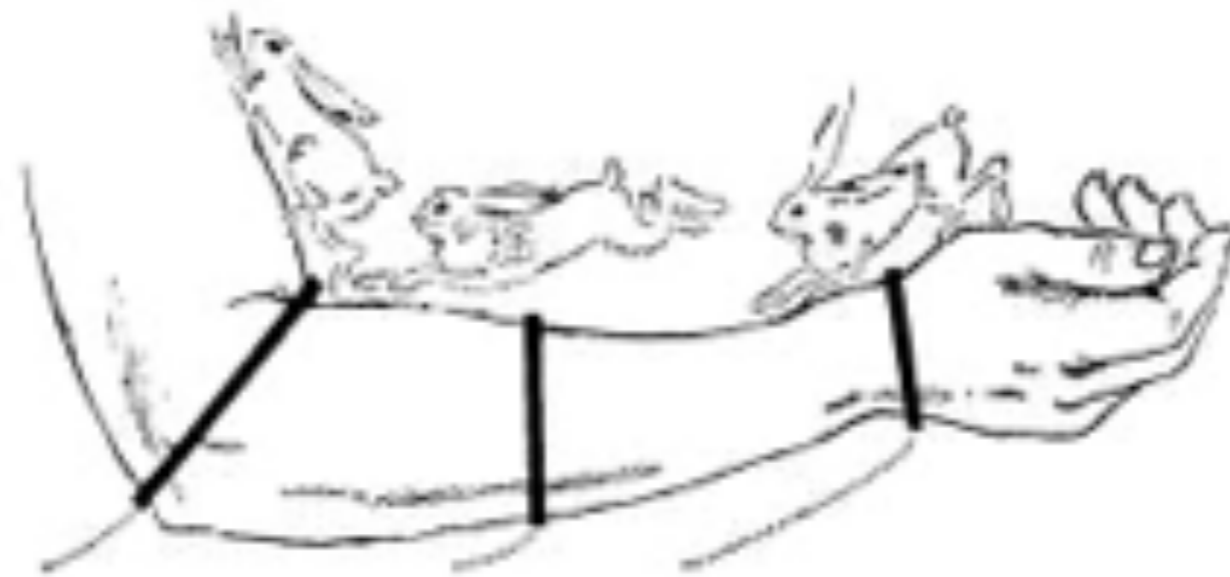


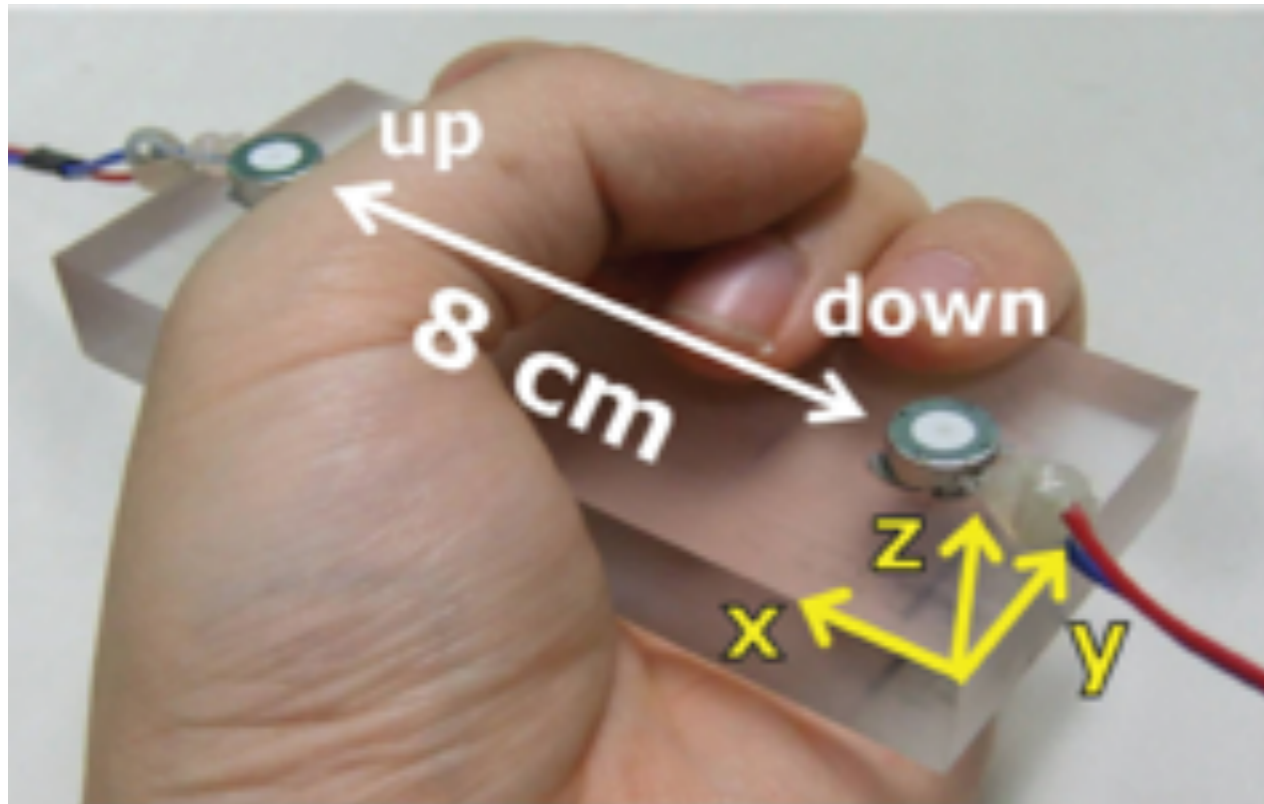
Image by
Jacob Suchoski

Saltation Illusion

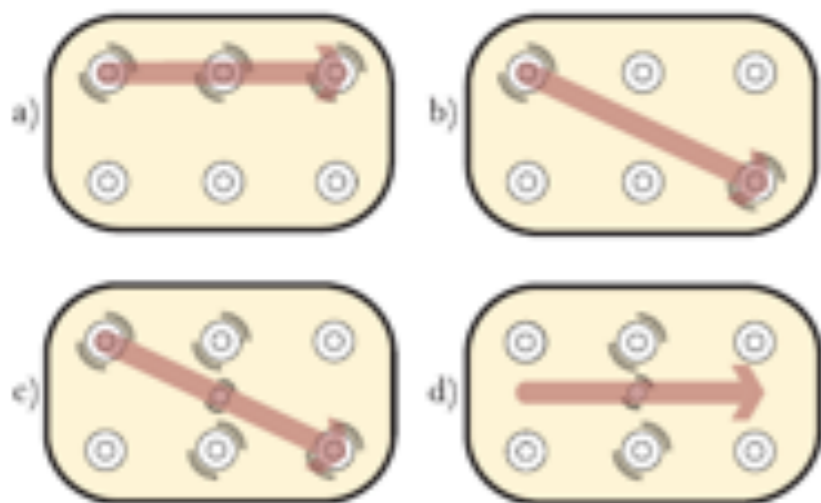


F.A. Geldard and C.E. Sherrick, "The Cutaneous 'Rabbit': A Perceptual Illusion," *Science*, vol. 178, pp. 178-179, 1972.

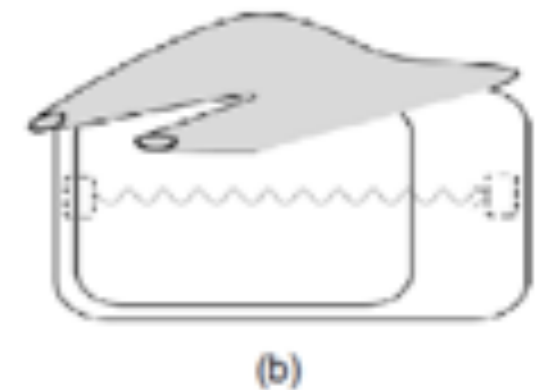
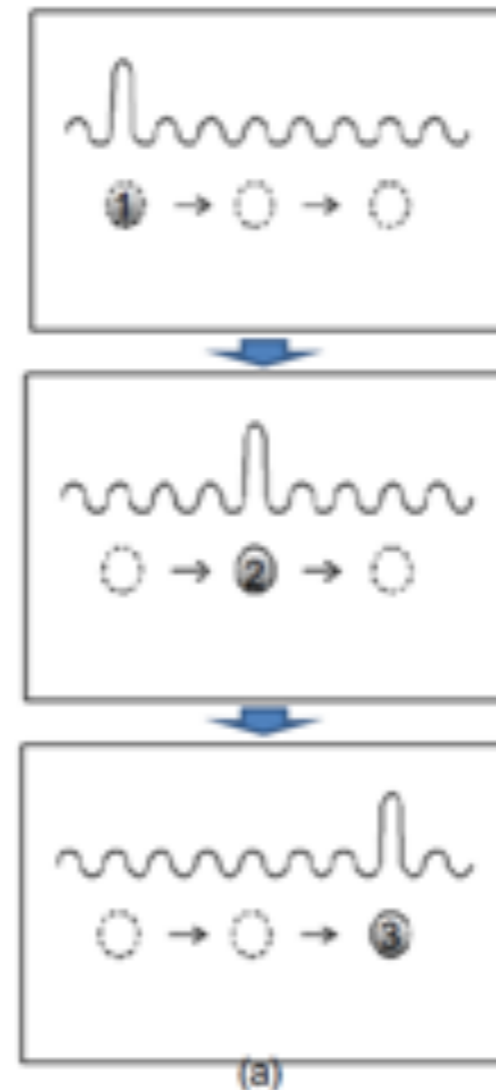
Illusory Motion/Vibration Flow



Seo & Choi 2010



Israr and Poupayev, "Tactile Brush", 2011.



Kim et al. 2009