Multimodal Devices: Learnings from Multisensory Perception and Plasticity

Microsoft Research . September 28, 2017

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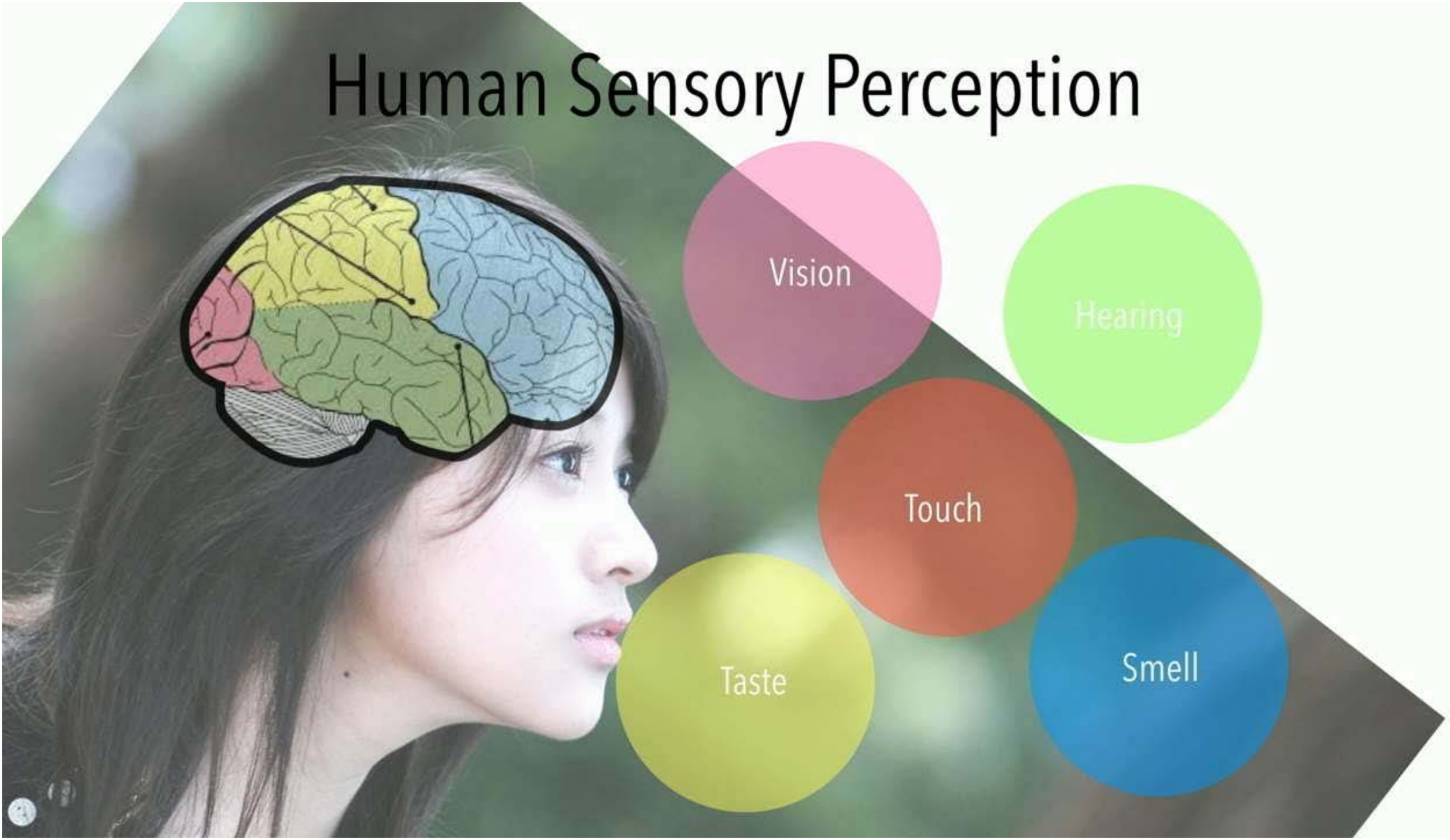
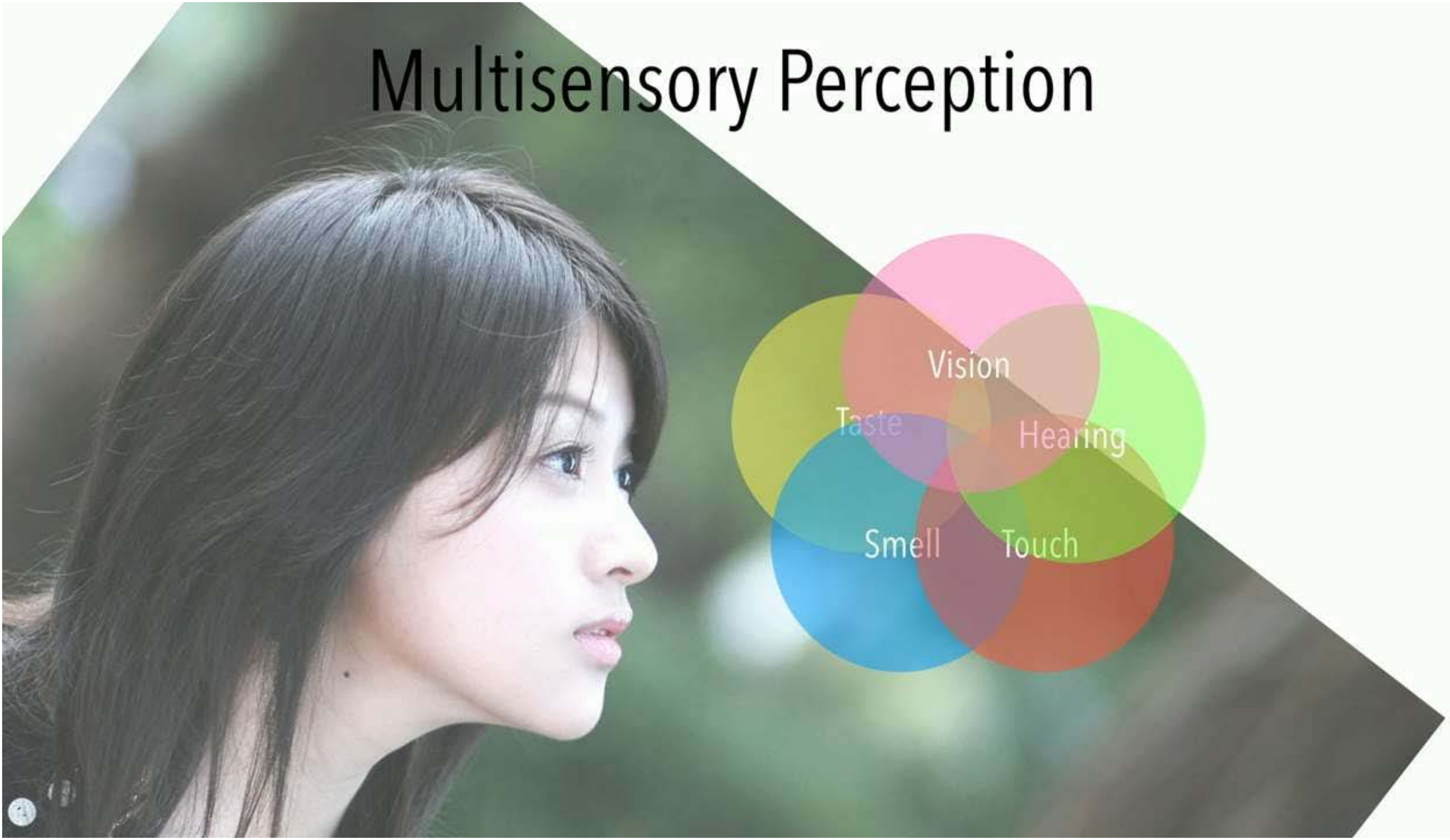
Researcher, California Institute of Technology (Caltech)

How Can We Get the Most Out of Multimodal Devices?

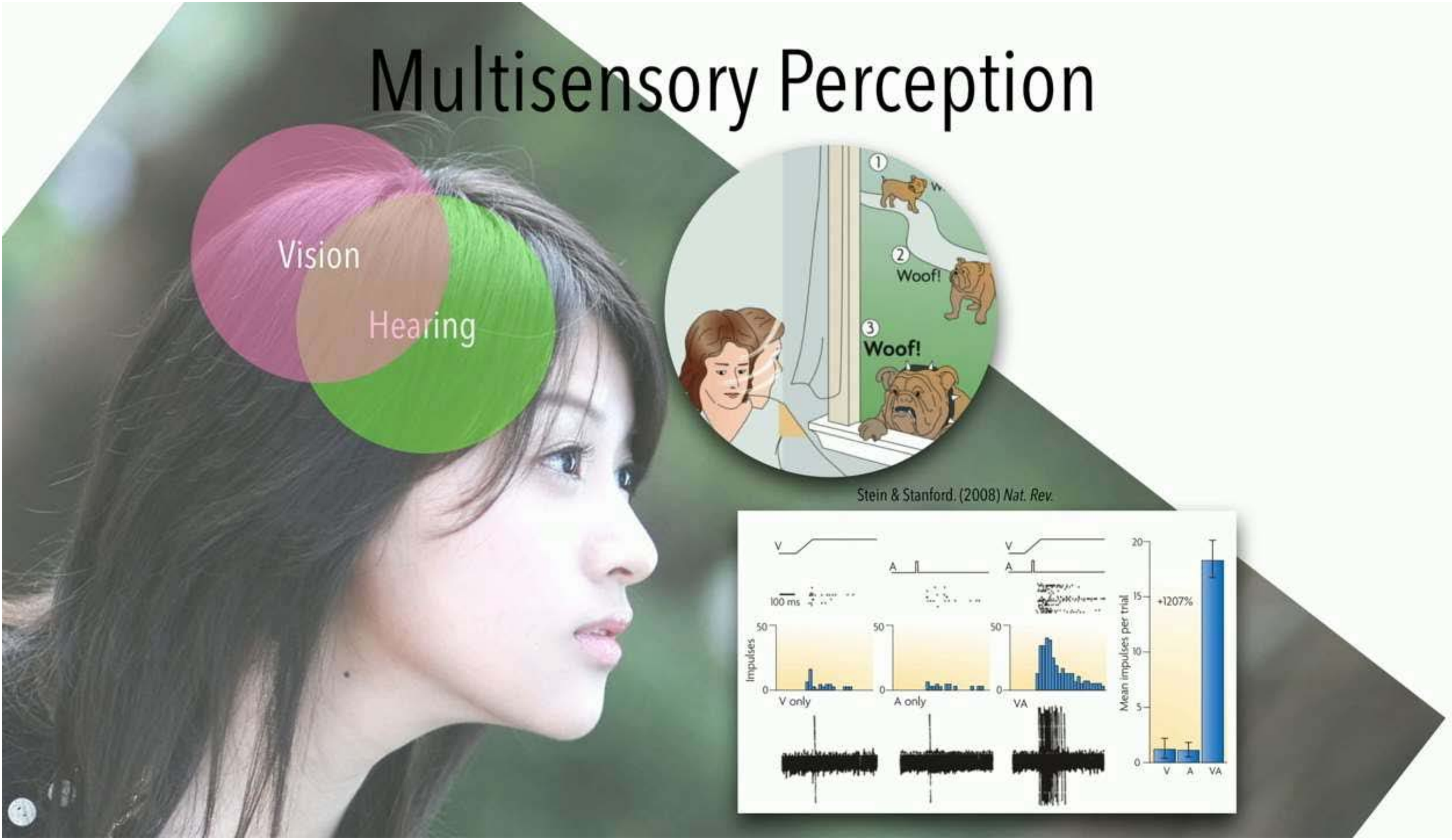
Human Sensory Perception



Multisensory Perception

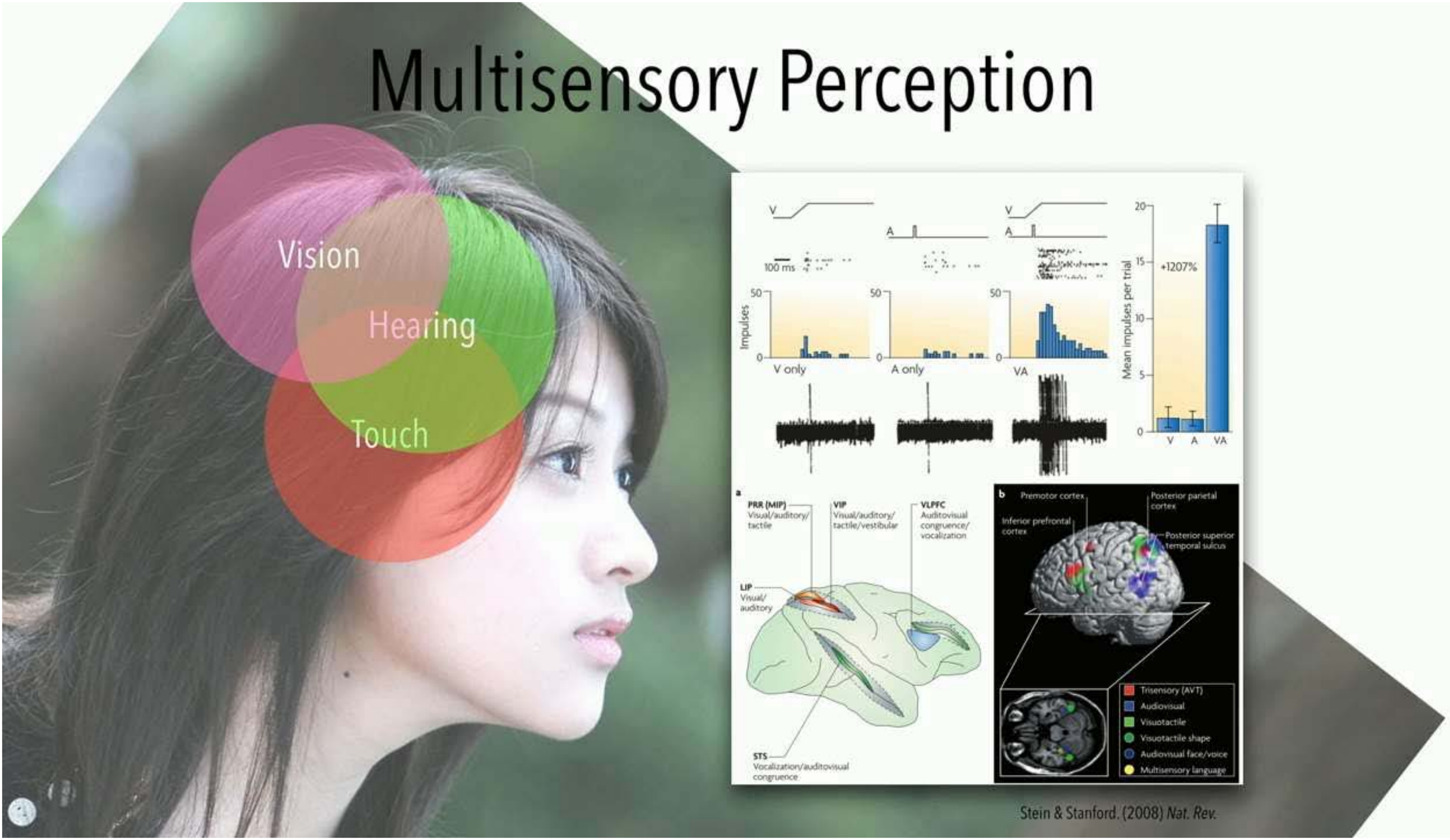


Multisensory Perception



Stein & Stanford. (2008) *Nat. Rev.*

Multisensory Perception



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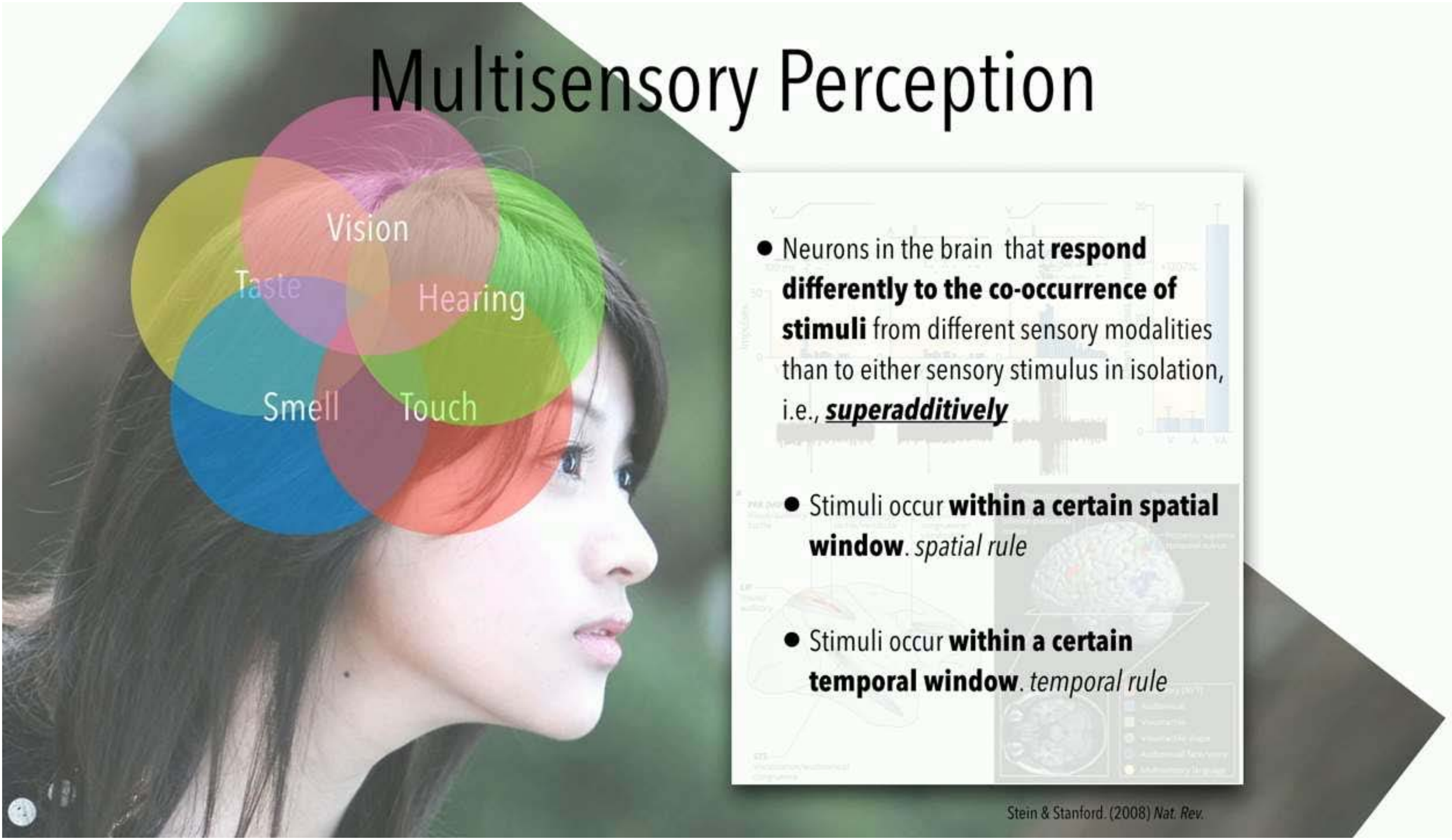
Multisensory Perception



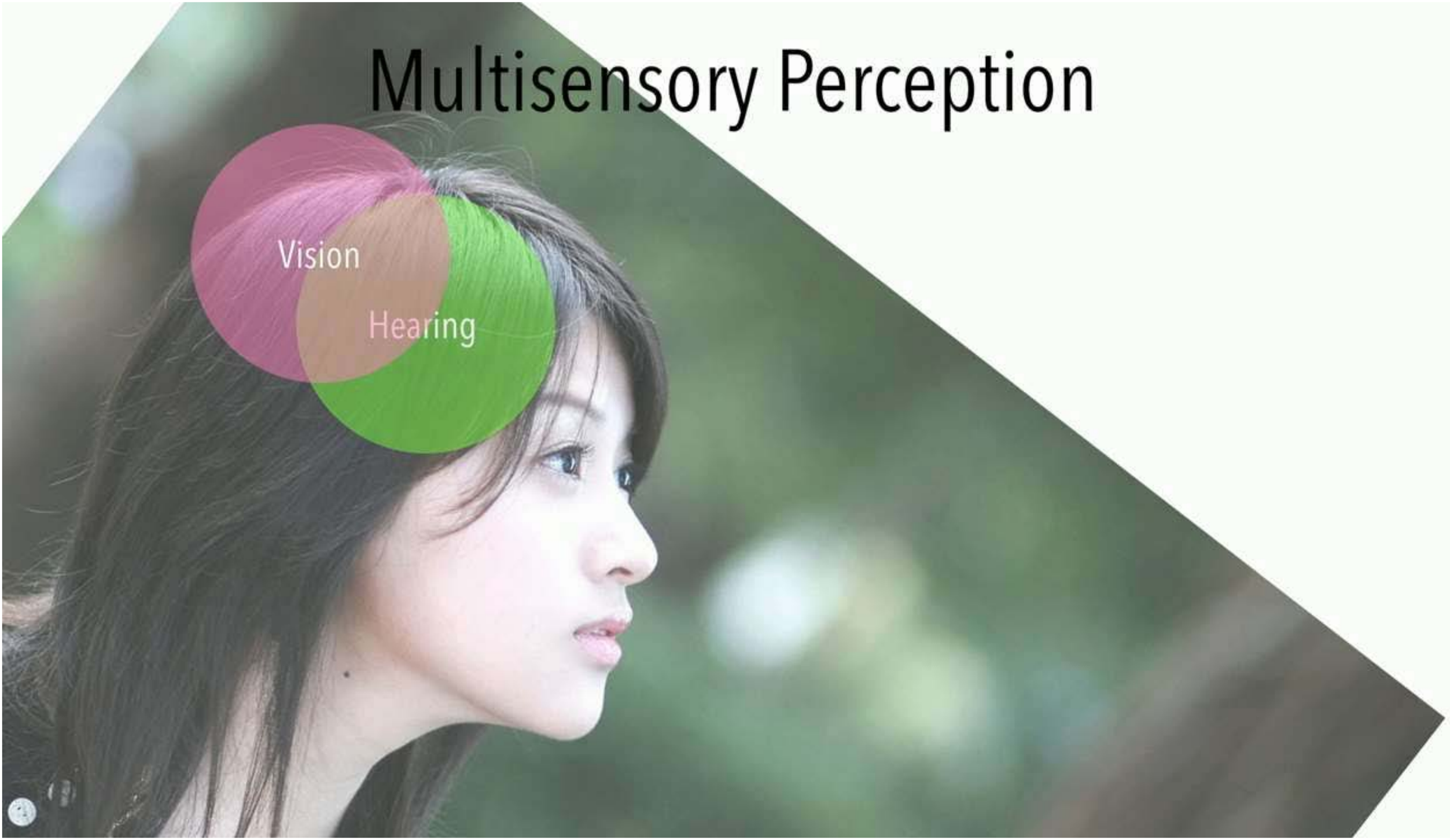
- Neurons in the brain that **respond differently to the co-occurrence of stimuli** from different sensory modalities than to either sensory stimulus in isolation, i.e., ***superadditively***

- Stimuli occur **within a certain spatial window**. *spatial rule*

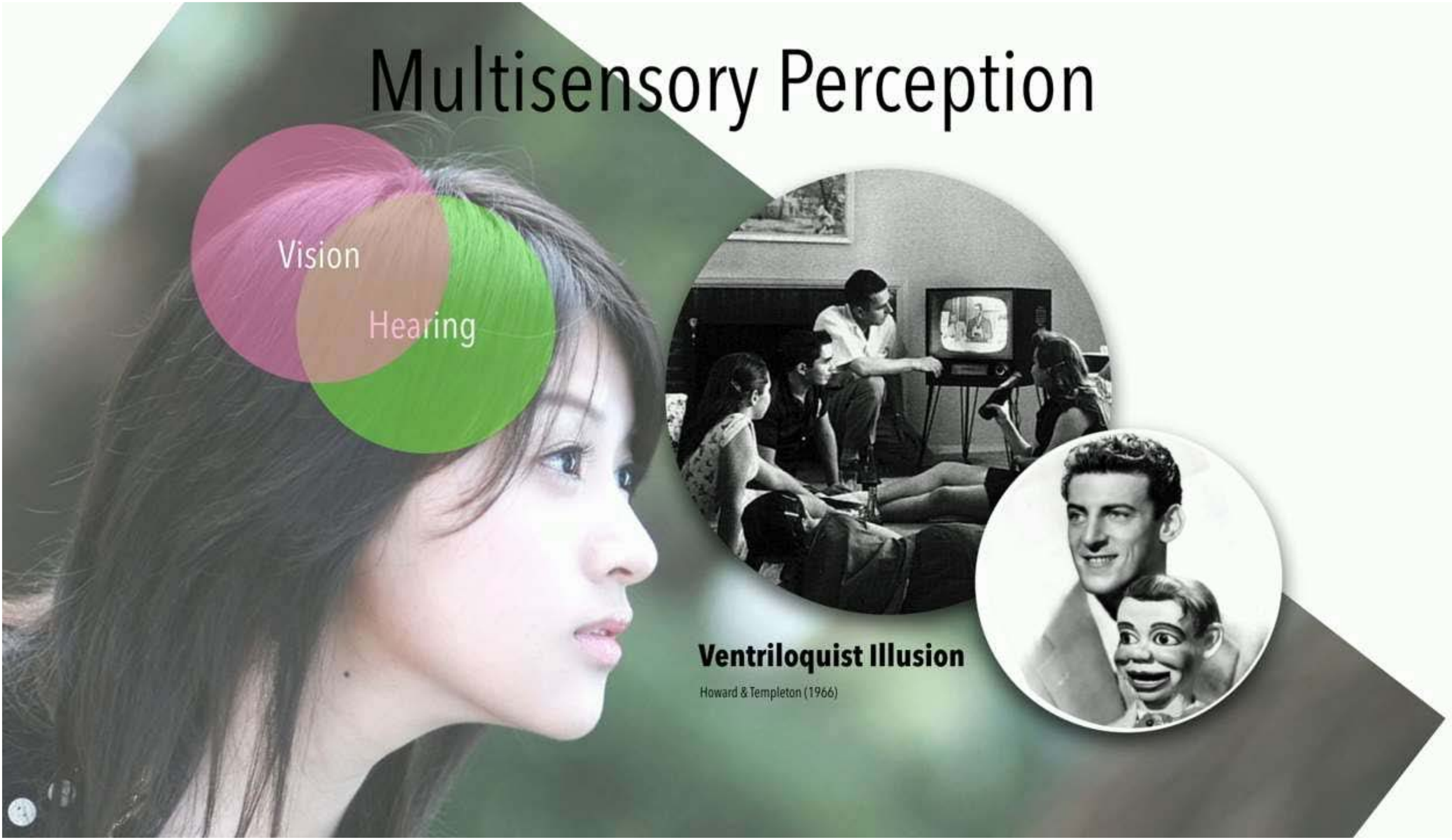
- Stimuli occur **within a certain temporal window**. *temporal rule*

Stein & Stanford. (2008) *Nat. Rev.*

Multisensory Perception



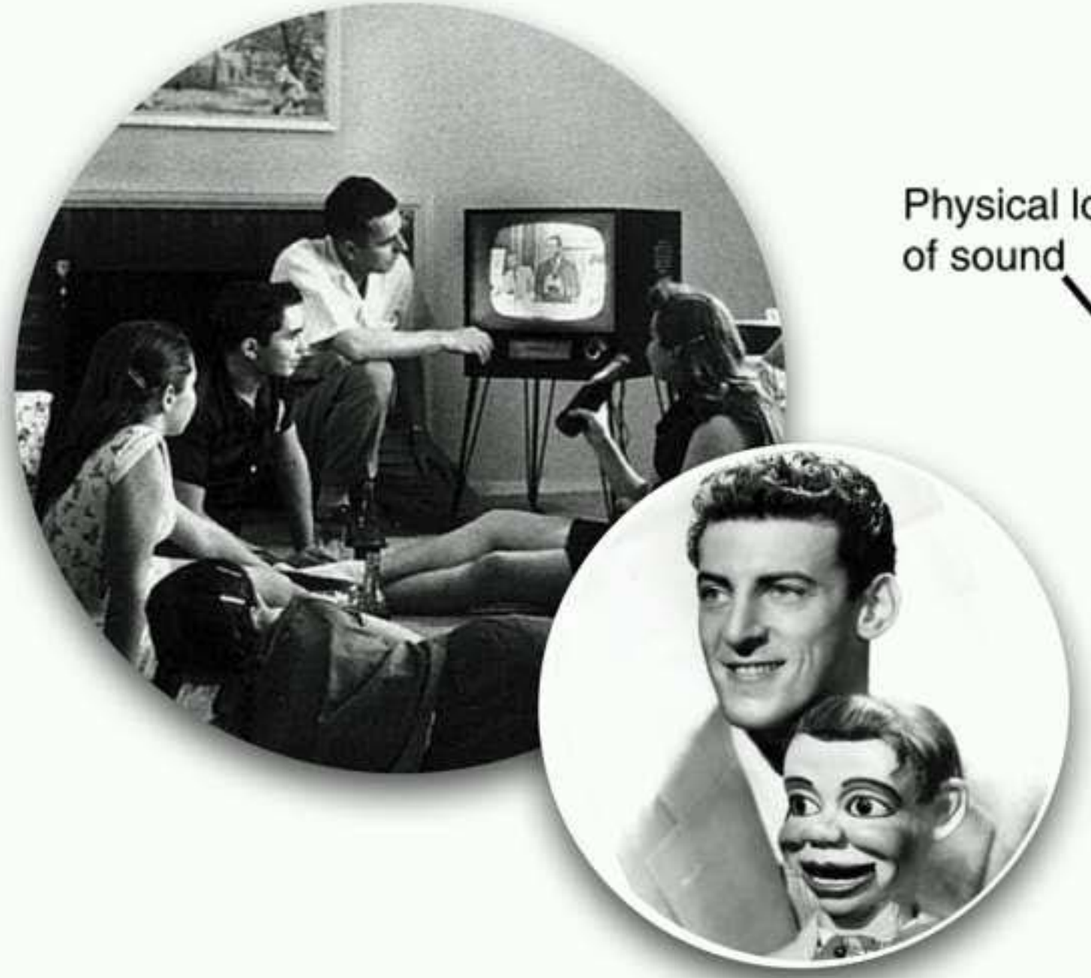
Multisensory Perception

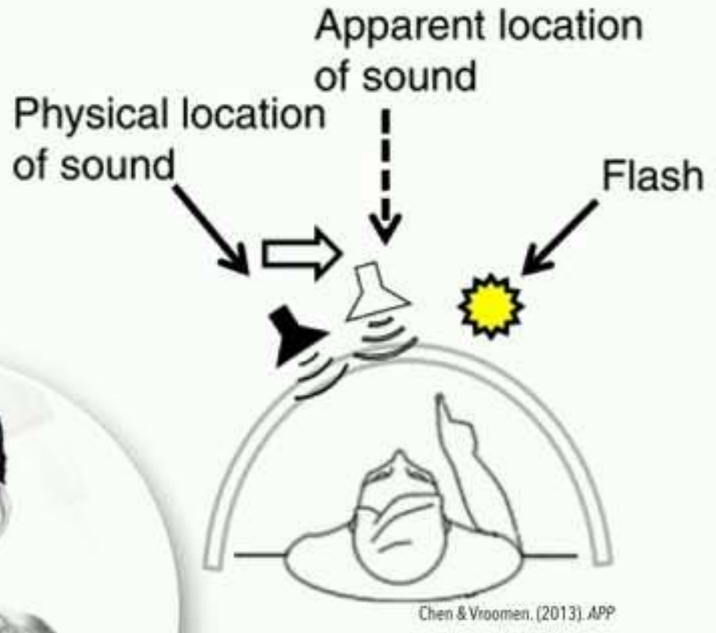


Ventriloquist Illusion

Howard & Templeton (1966)

Where is the sound?





Chen & Vroomen. (2013). *APP*

Ventriloquist Illusion

Howard & Templeton (1966)

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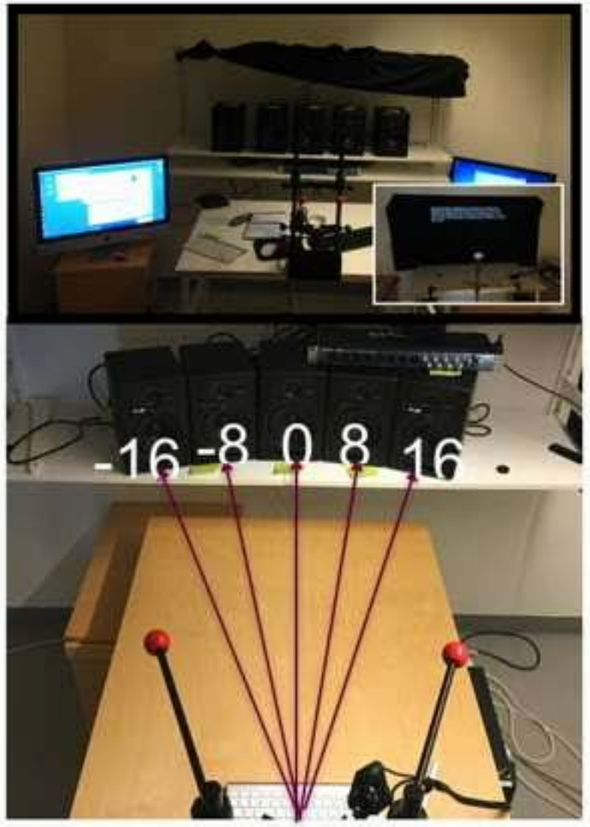
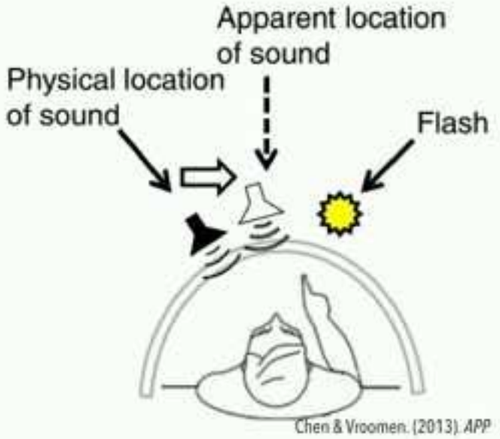


Berger, C. C. & Ehrsson, H. H. (2013). *Current Biology*



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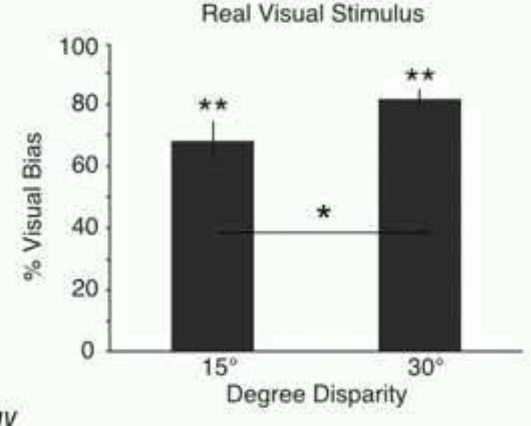
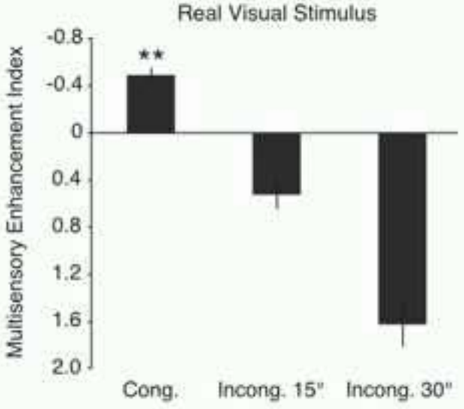
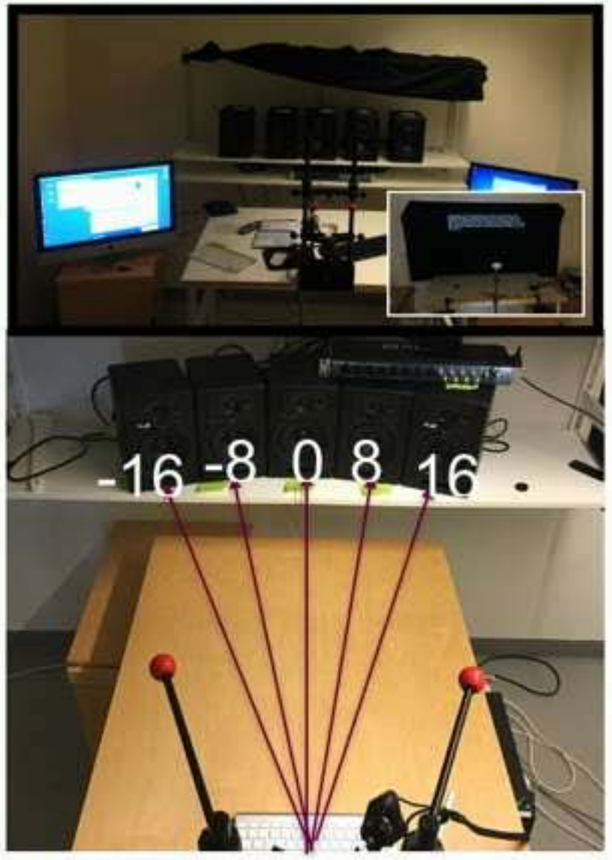
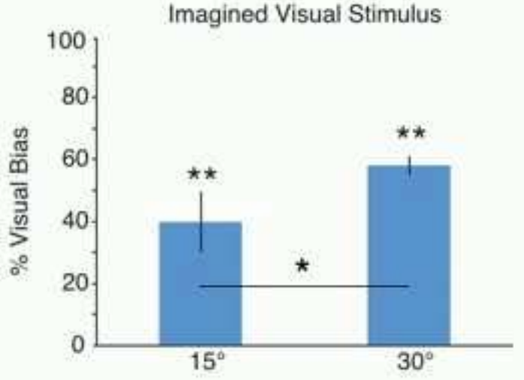


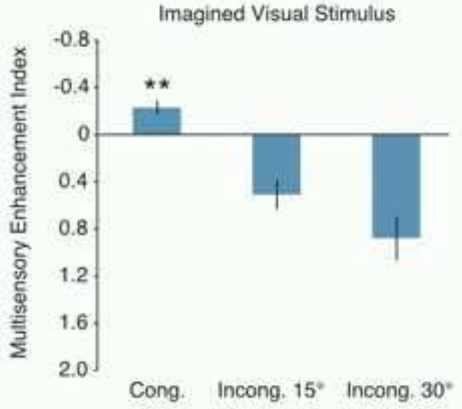


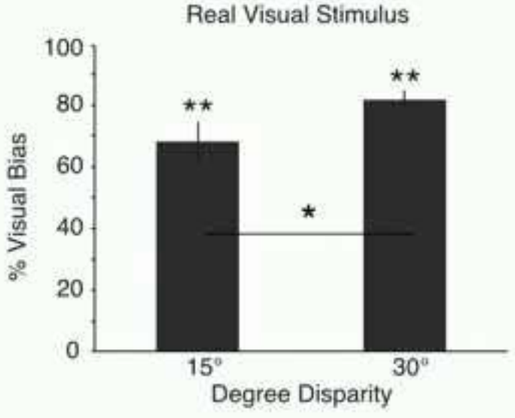
Multisensory Integration of Mental Imagery and Veridical Perception

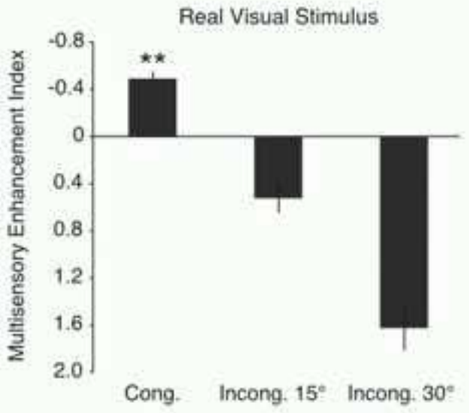
Berger, C. C. & Ehrsson, H. H. (2013). *Current Biology.*





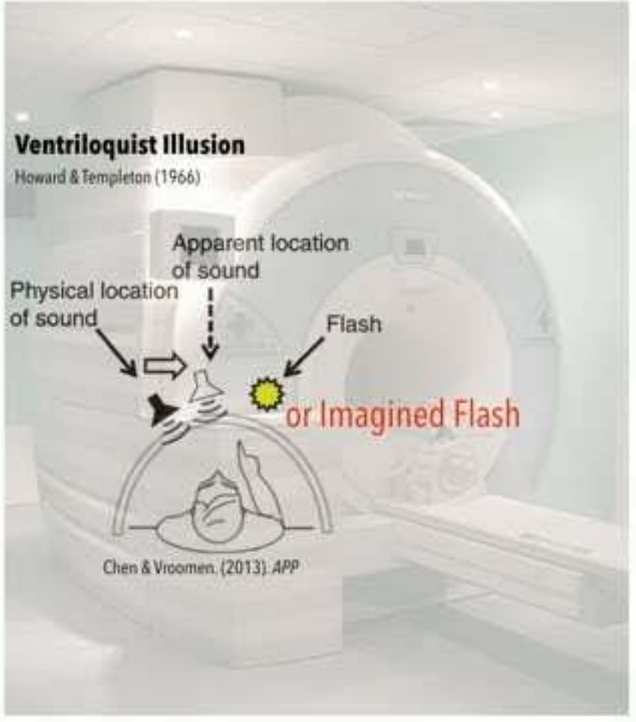


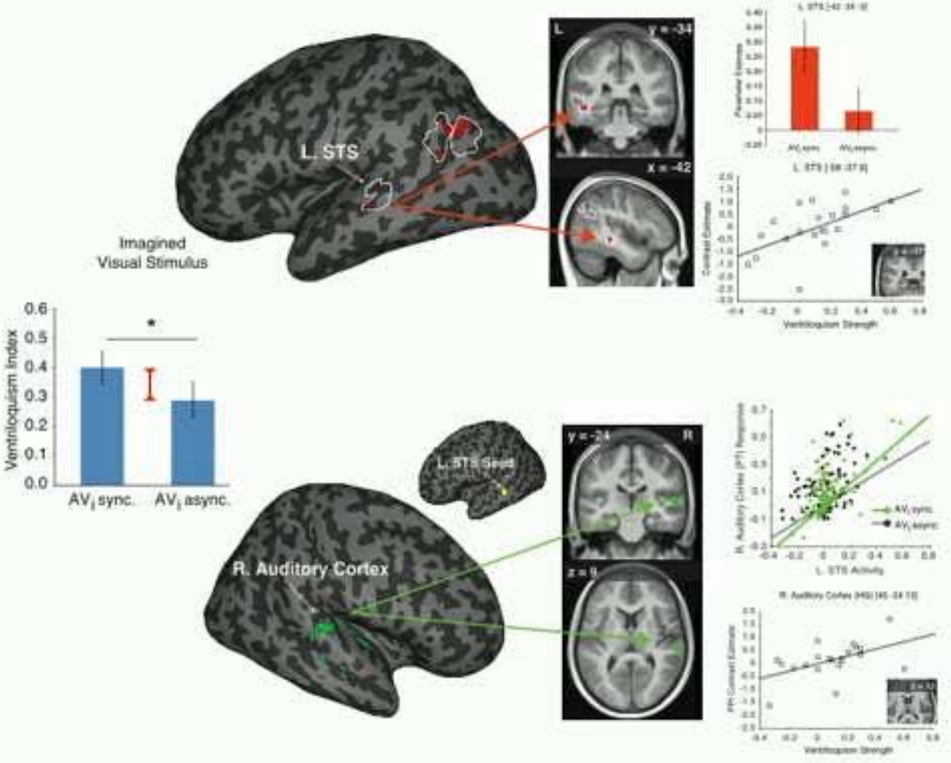




The fusion of mental imagery and sensation in the temporal association cortex

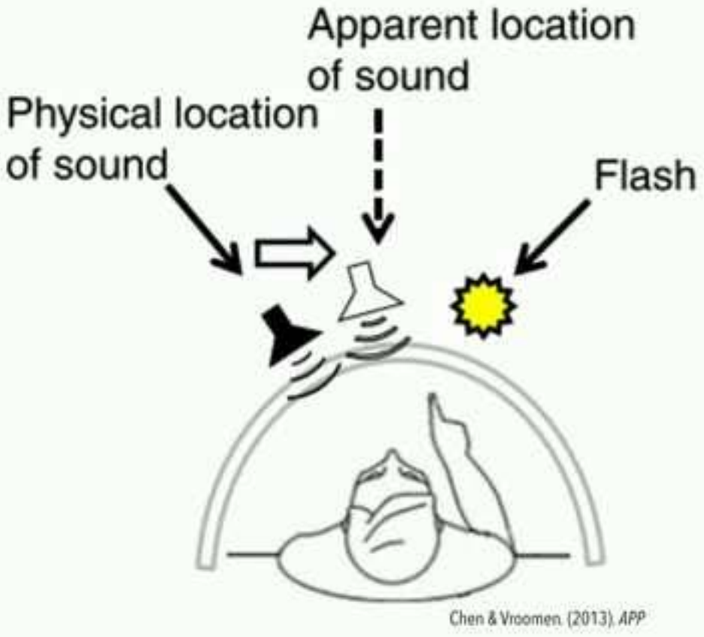
Berger, C. C. & Ehrsson, H. H. (2014). *Journal of Neuroscience.*



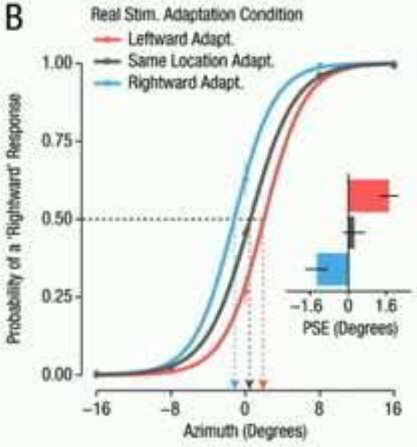


Visual Perception and Imagery Can Remap Acoustic Space

Berger, C. C. & Ehrsson, H. H. (under review). *Psychological Science*.



Chen & Vroomen. (2013). *APP*



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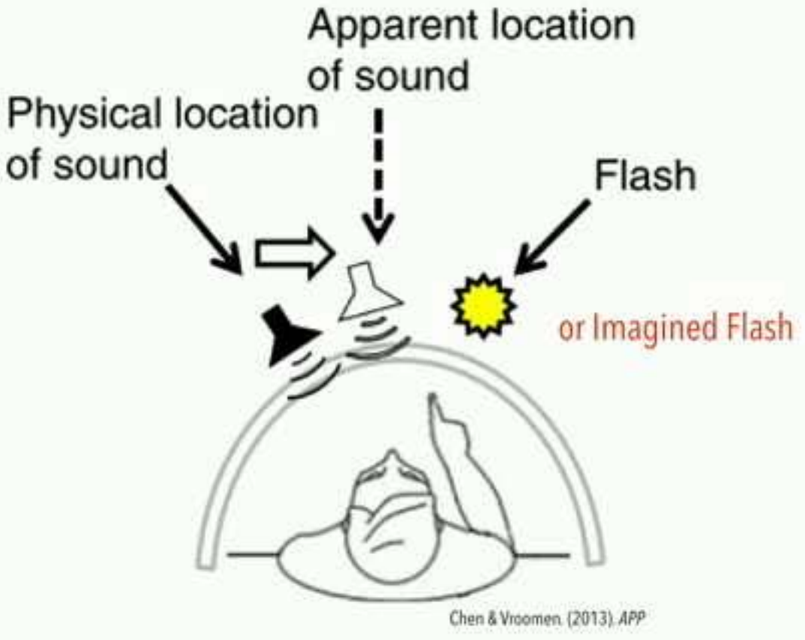
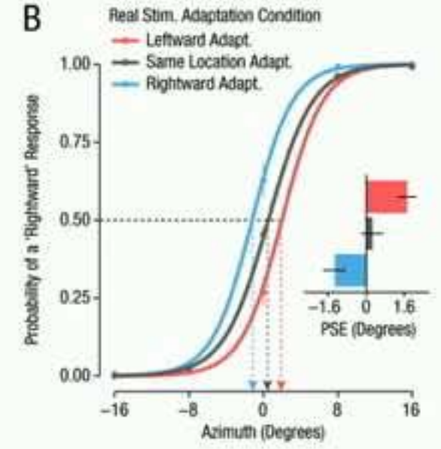
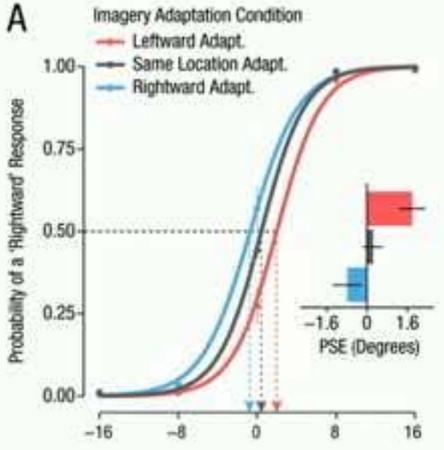
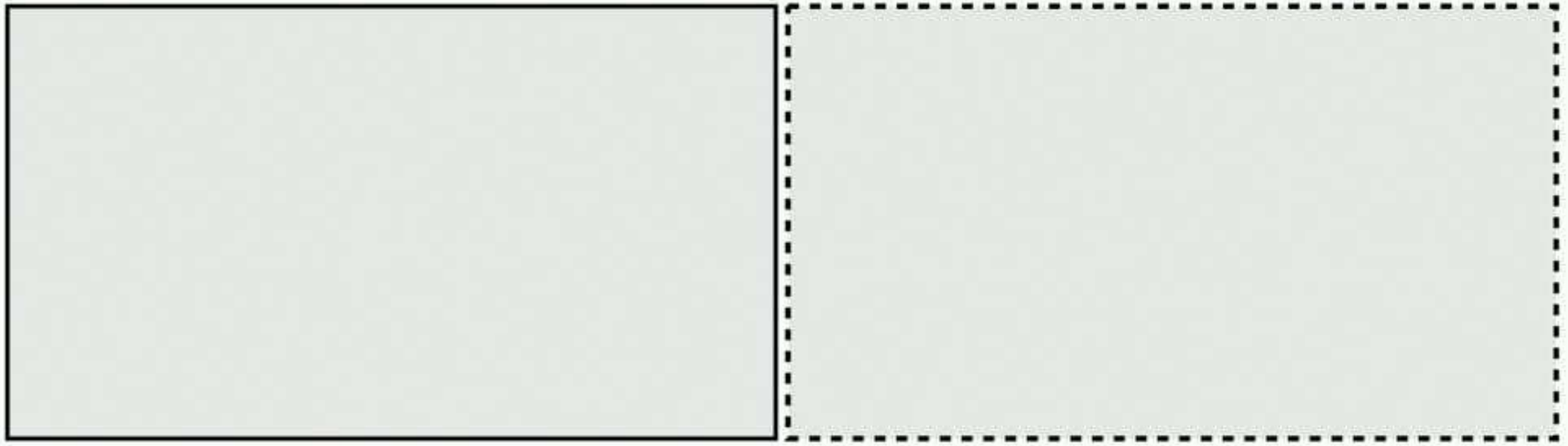




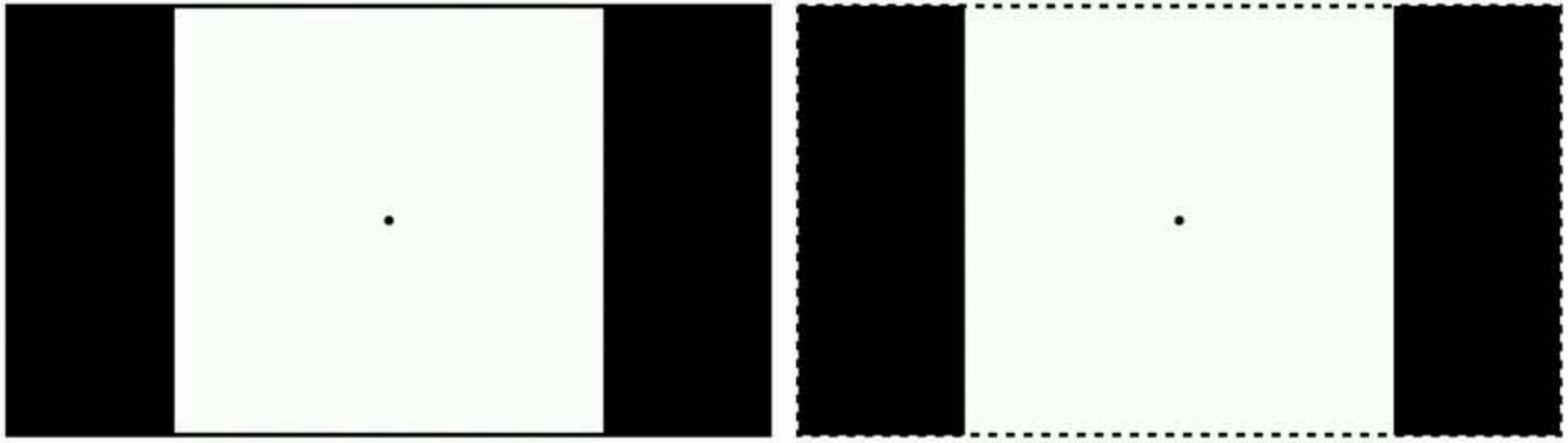


How Many Flashes?



Shams, Kamitani, & Shimojo (2000). *Nature*

Do the discs bounce or cross?



Berger, C. C. & Ehrsson, H. H. (2017). *Scientific Reports . Nature Publishing Group*

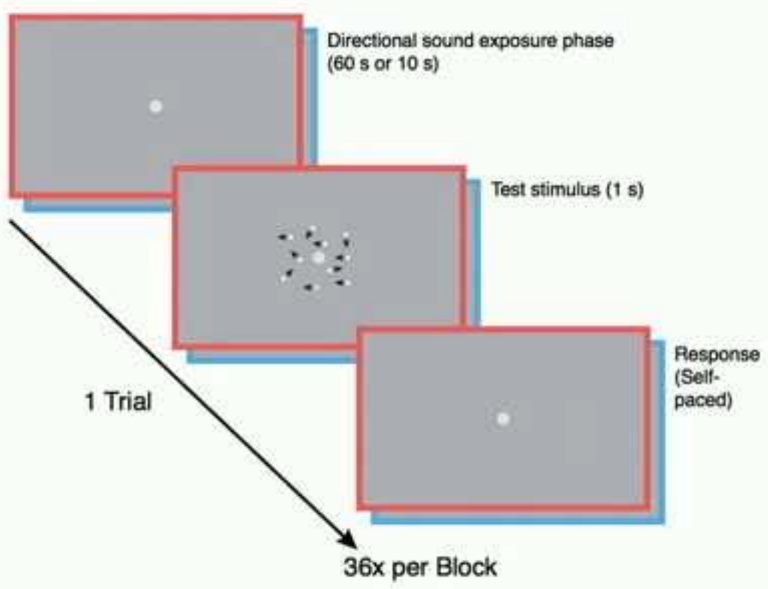
When the animation is shown,
stare at the dot below for 30 seconds.
Continue to fixate on the dot after the
image changes to experience the aftereffect.

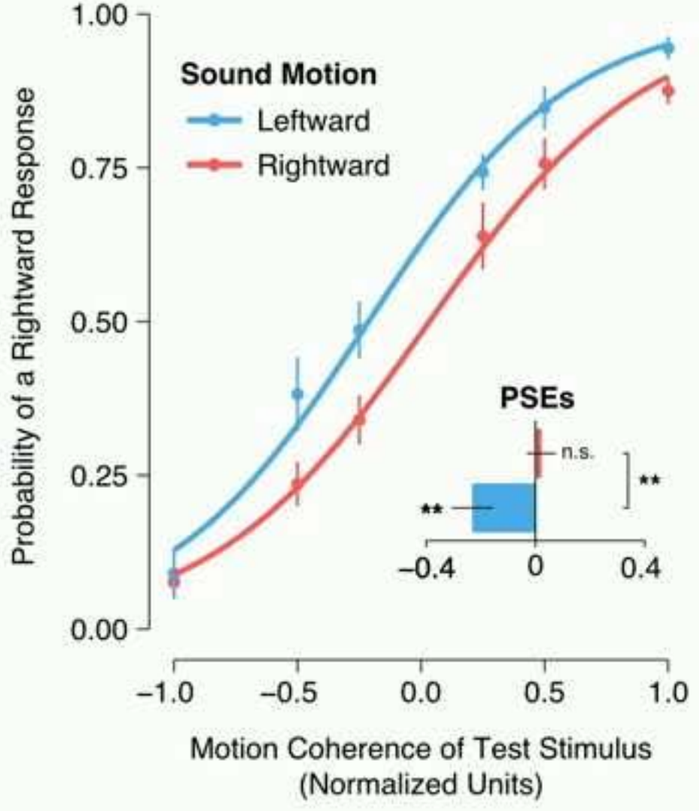
The Waterfall Illusion –i.e., The Visual Motion Aftereffect

The Waterfall Illusion –i.e., The Visual Motion Aftereffect

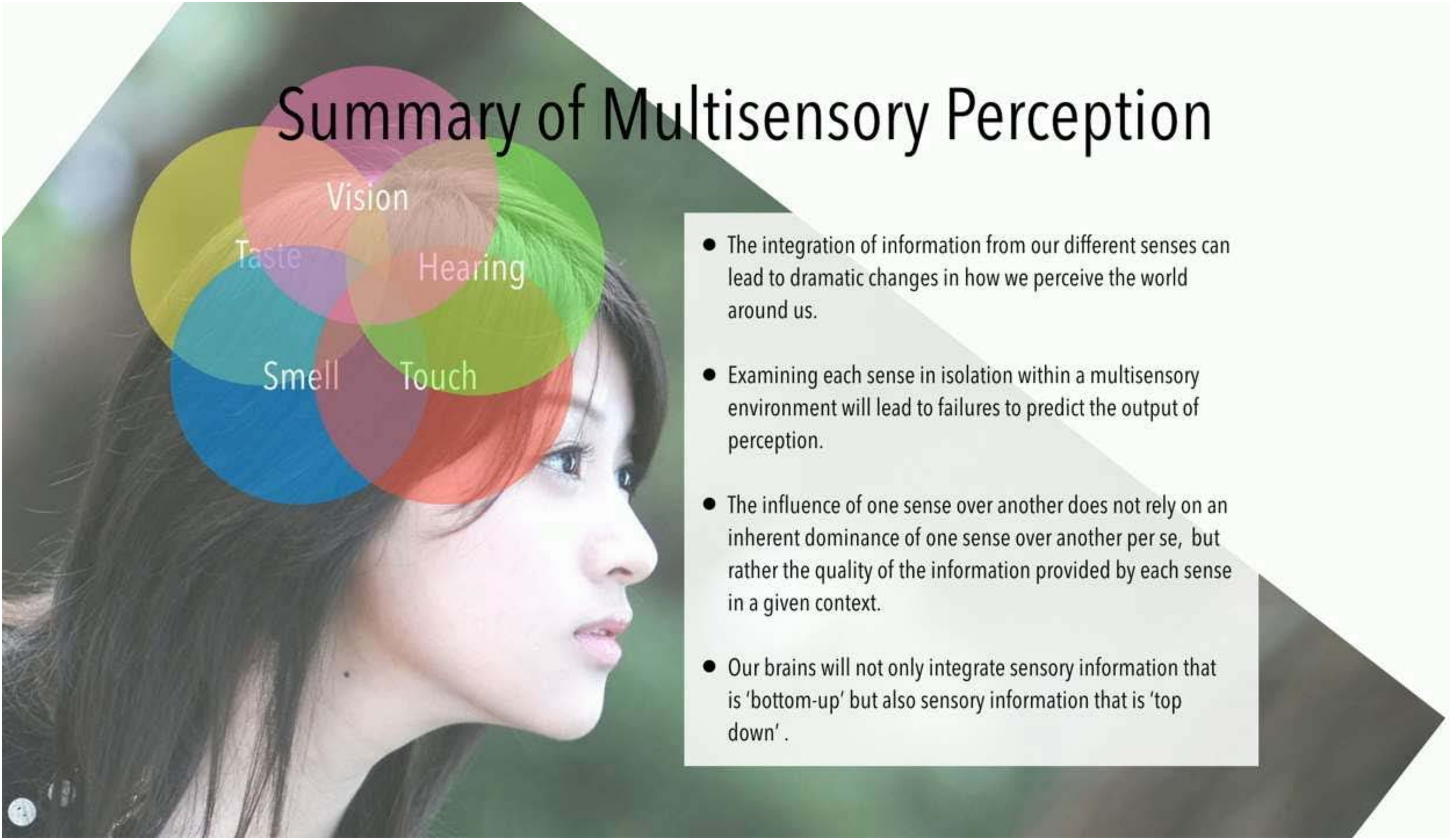
Auditory Motion Elicits a Visual Motion Aftereffect

Berger, C. C. & Ehrsson, H. H. (2016). *Frontiers in Neuroscience*



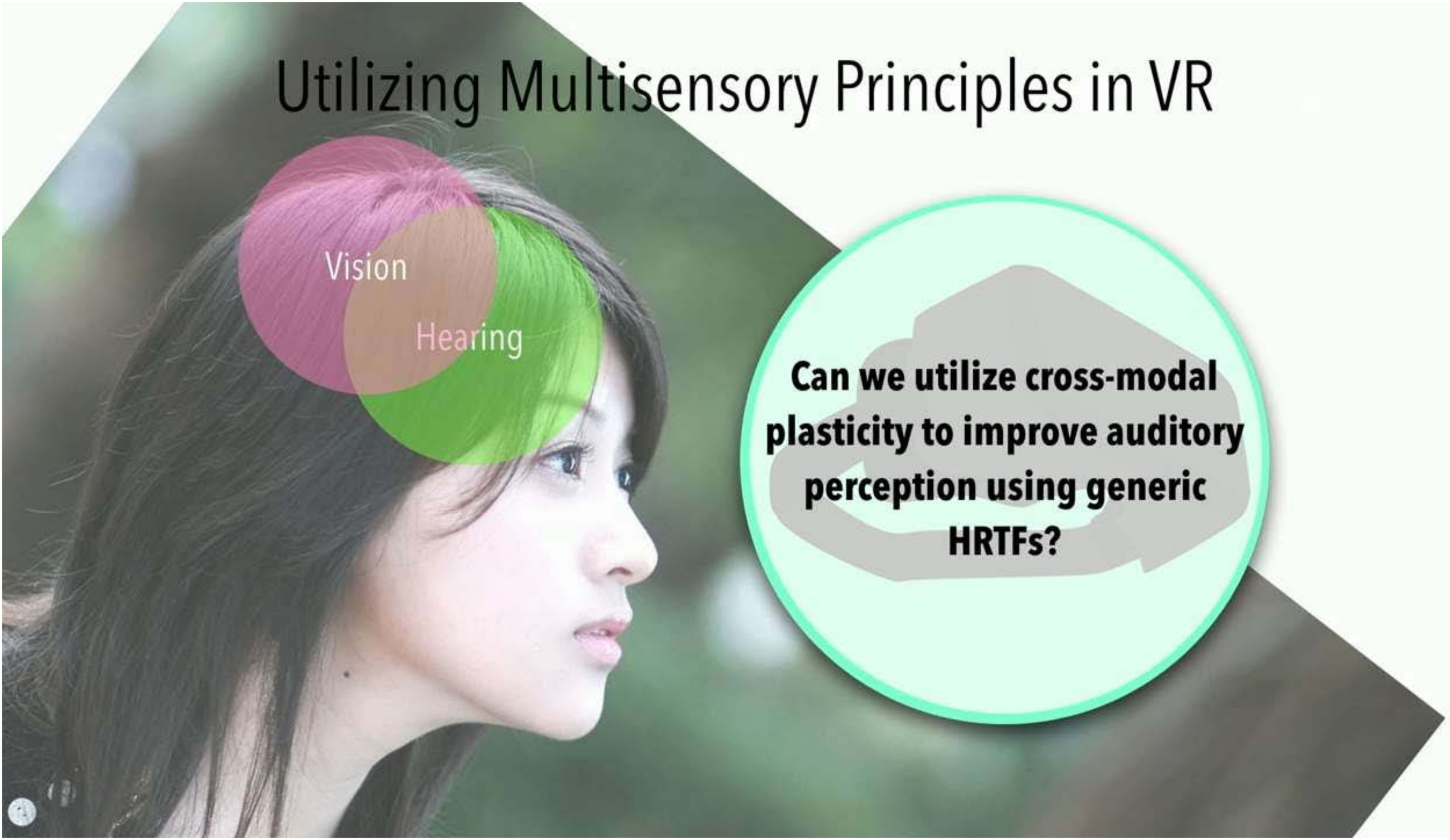


Summary of Multisensory Perception



- The integration of information from our different senses can lead to dramatic changes in how we perceive the world around us.
- Examining each sense in isolation within a multisensory environment will lead to failures to predict the output of perception.
- The influence of one sense over another does not rely on an inherent dominance of one sense over another per se, but rather the quality of the information provided by each sense in a given context.
- Our brains will not only integrate sensory information that is 'bottom-up' but also sensory information that is 'top down' .

Utilizing Multisensory Principles in VR



Can we utilize cross-modal plasticity to improve auditory perception using generic HRTFs?

Generic HRTF might be enough in Virtual Reality.

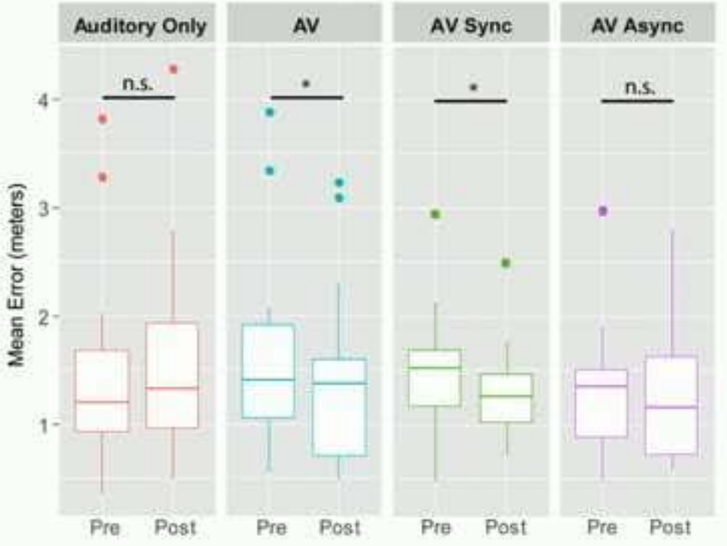
Improving source localization through cross-modal plasticity

C C. Berger, M Gonzalez-Franco*, A Tajadura-Jiménez
D Florencio, Z Zhang

Berger, C. C. , Gonzalez-Franco, M, Tajadura, A., Florencio, D., Zhengyou, Z. (submitted). *Frontiers in Neuroscience*

Why Generic HRTFs Might be Enough

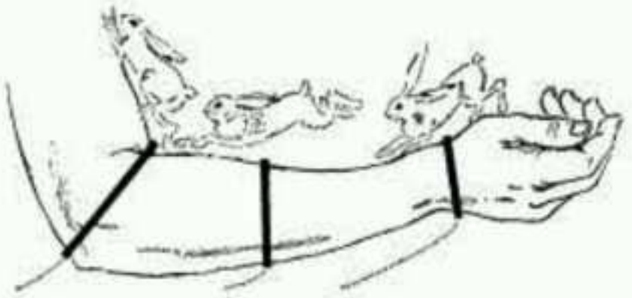
Berger, C. C. , Gonzalez-Franco, M, Tajadura, A., Florencio, D., Zhengyou, Z. (submitted). *Frontiers in Neuroscience*



Utilizing Multisensory Principles in VR

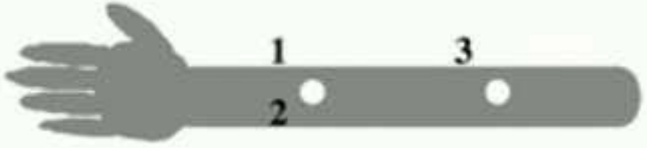
Can we expand haptic perception in VR beyond two independently handheld controllers using only two independently handheld controllers?

The Cutaneous Rabbit Illusion



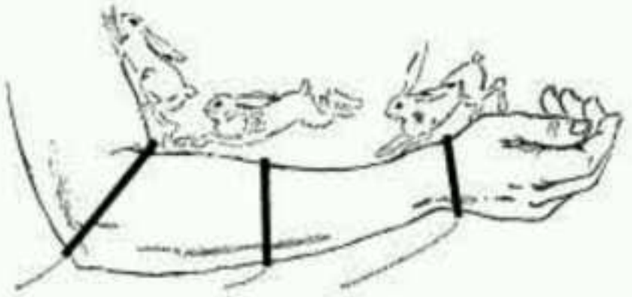
Geldard & Sherrick (1972). *Science*

Cutaneous stimulation
(40-200 ms equal intervals)



Shimojo (2014). *Frontiers in Psychology*

The Cutaneous Rabbit Illusion



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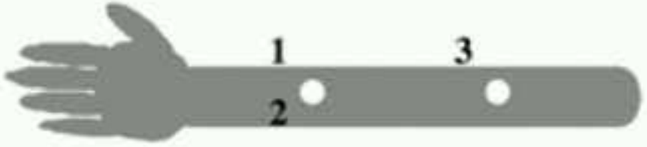
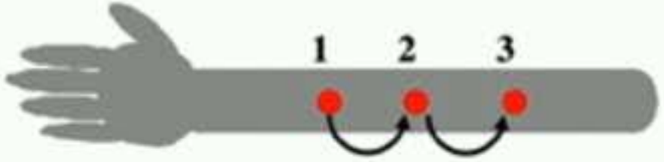
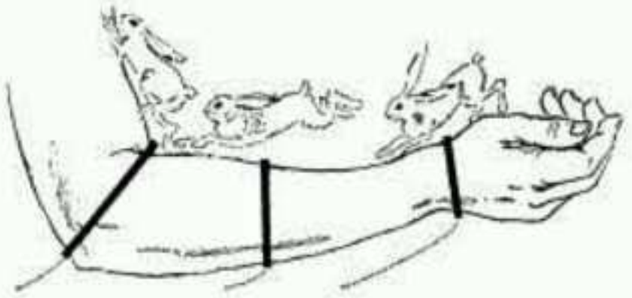


Percept

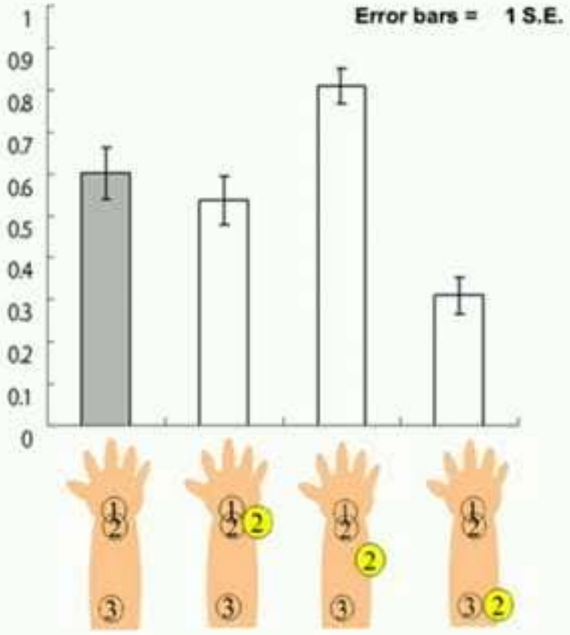


Shimojo (2014). *Frontiers in Psychology*

The Cutaneous Rabbit Illusion



Geldard & Sherrick (1972). *Science*



Asai & Kanayama (2012). *Frontiers in Psychology*

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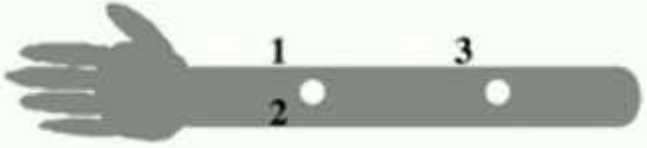

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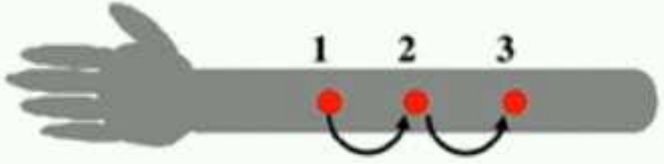
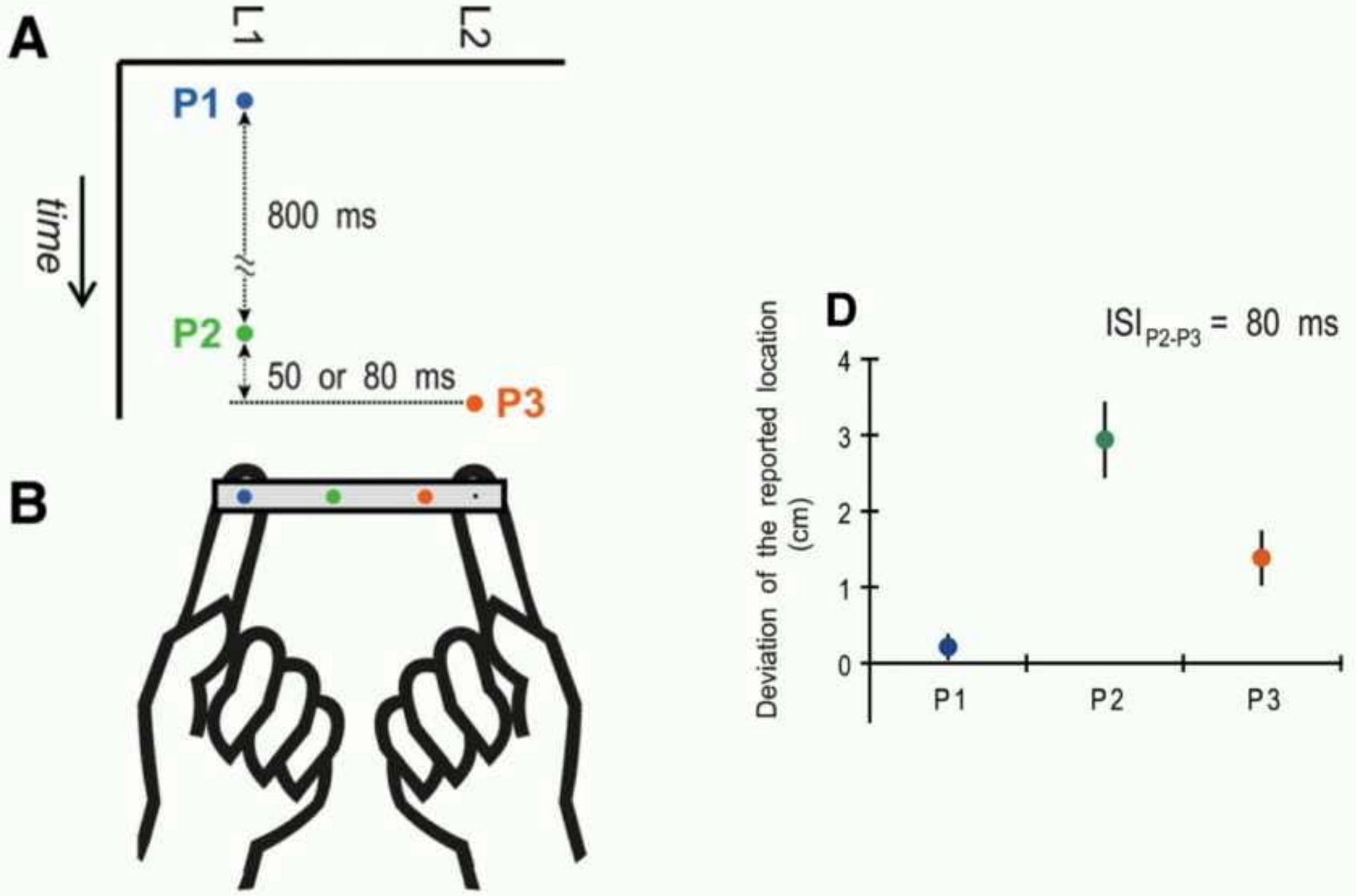
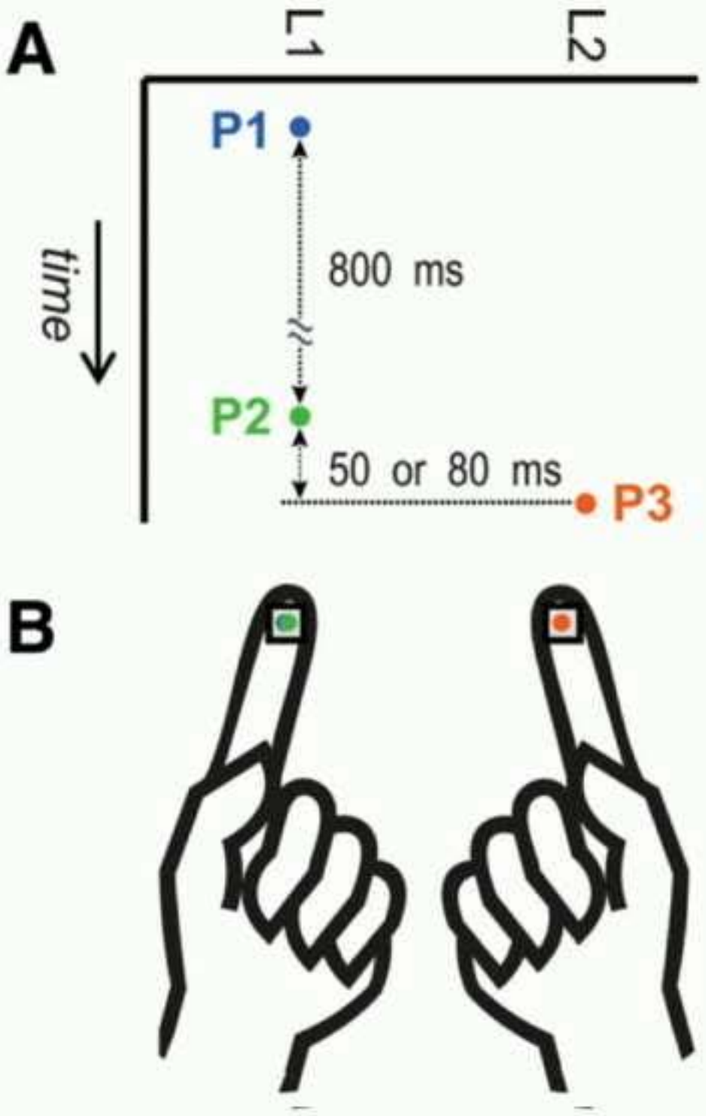
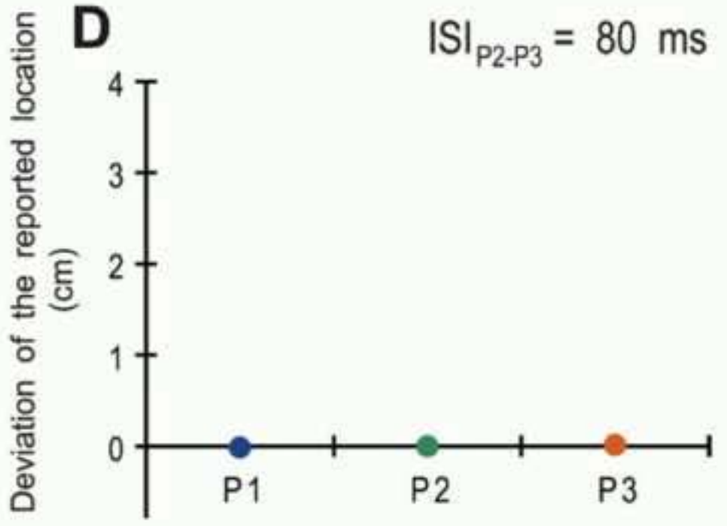


Shimojo (2014). *Frontiers in Psychology*



Miyazaki, Hirashima, & Nozaki (2010). *Journal of Neuroscience*





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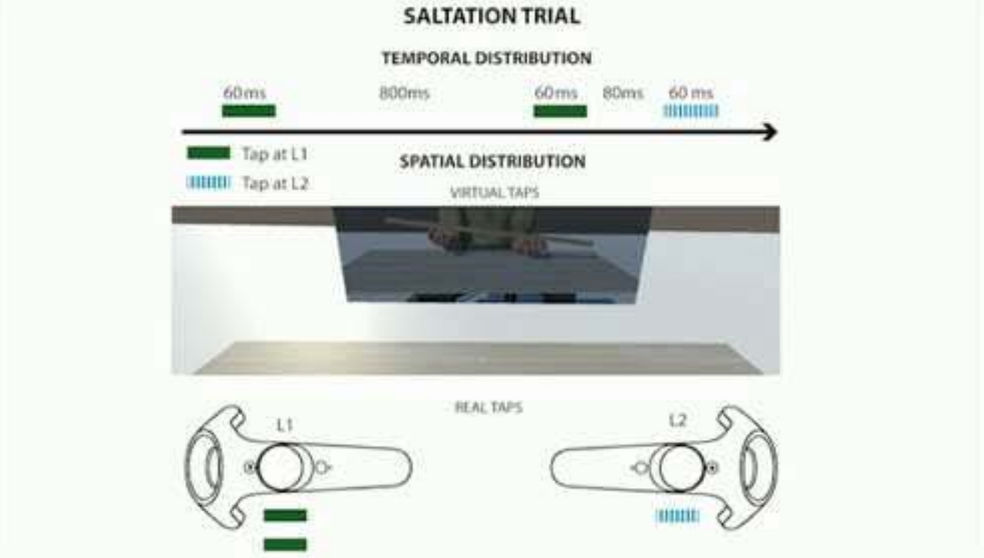
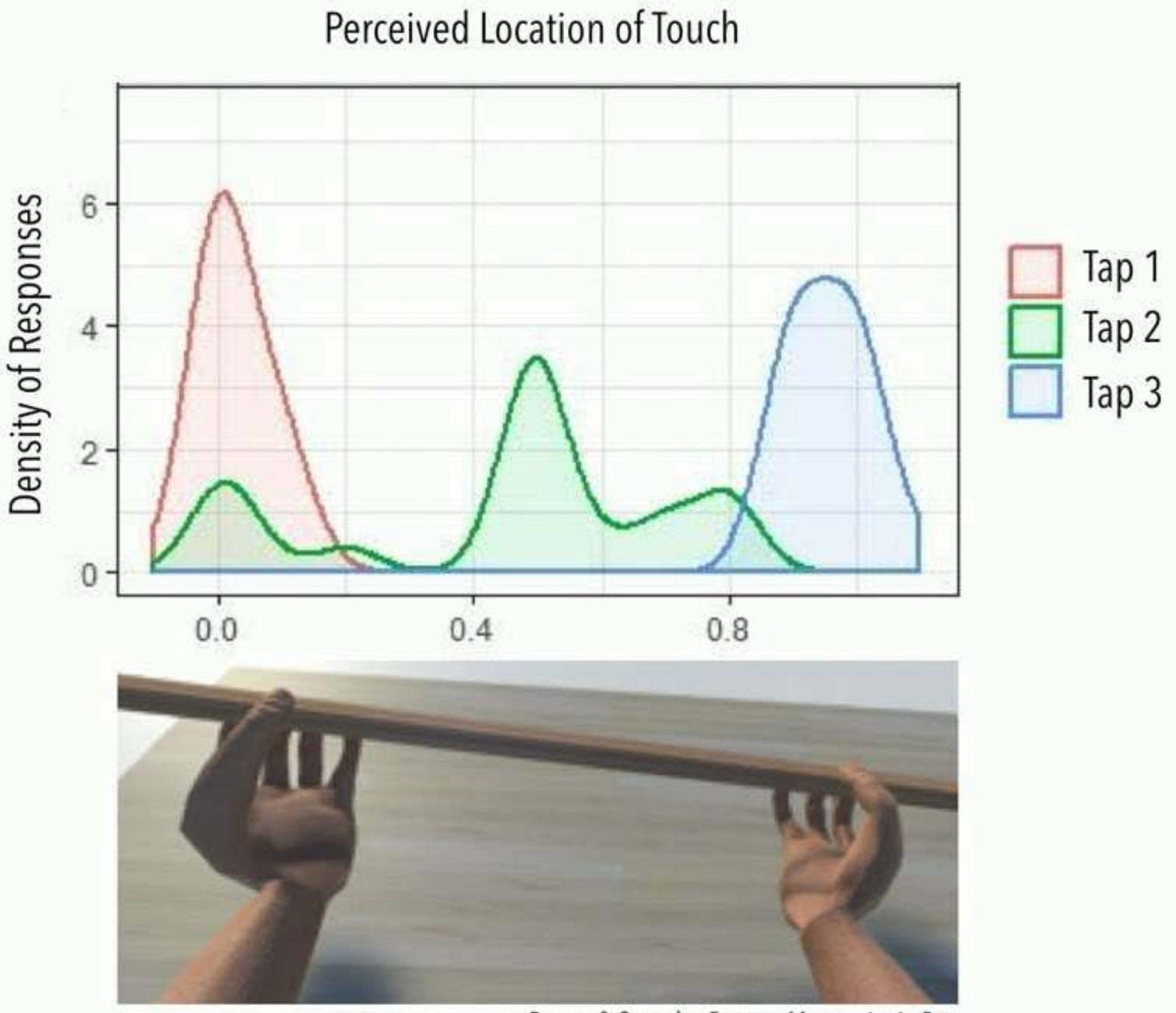
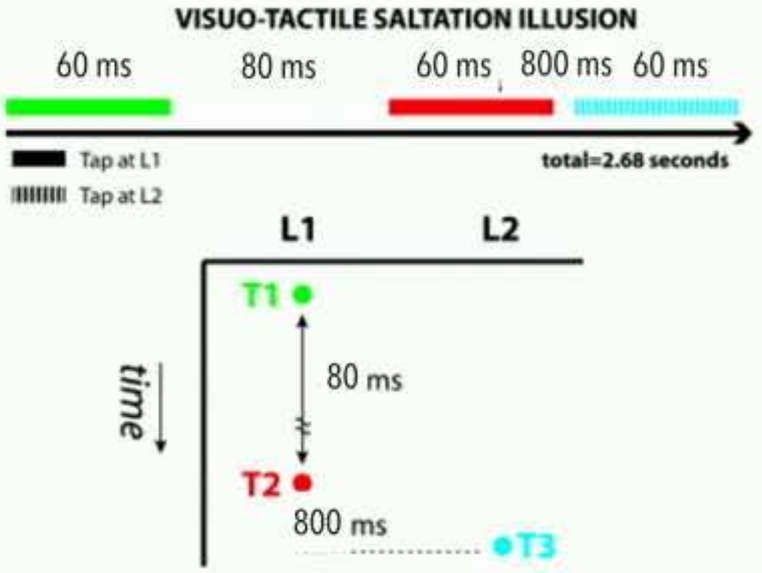
Berger & Gonzalez-Franco, *Manuscript in Prep.*





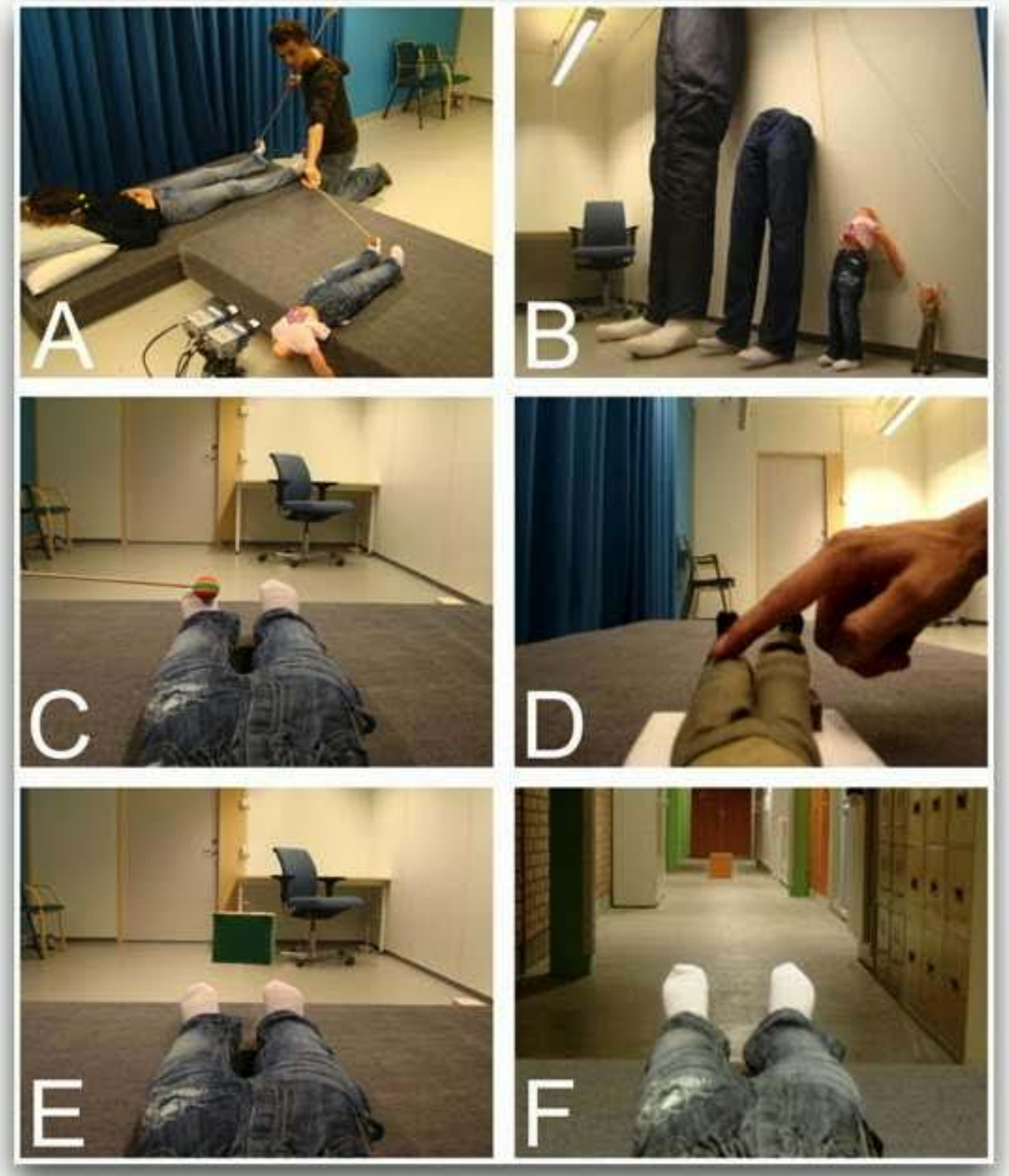
Berger & Gonzalez-Franco , *Manuscript in Prep.*



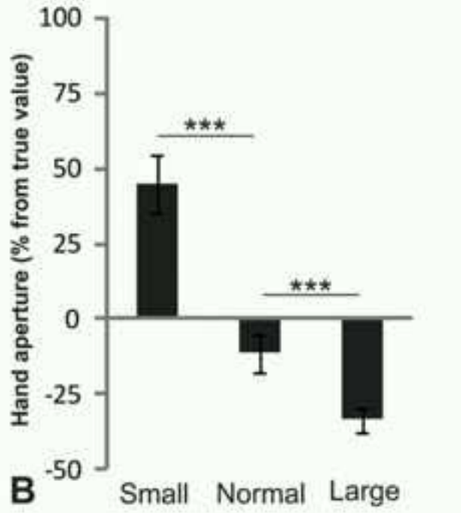
Berger & Gonzalez-Franco, *Manuscript in Prep.*

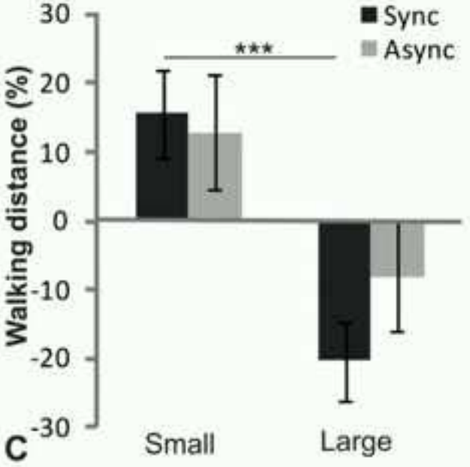
The Multisensory Construction of 'Body Ownership'

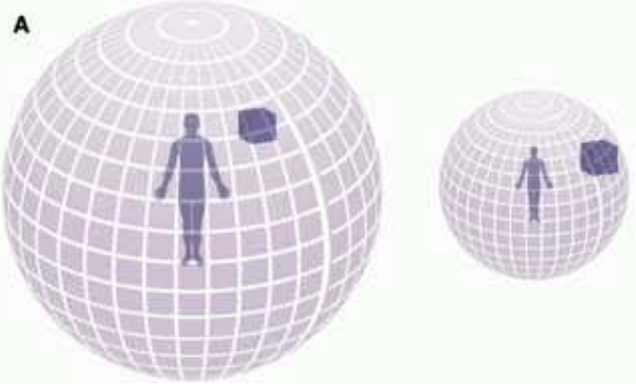
The Body Size Illusion–i.e., "Being Barbie"



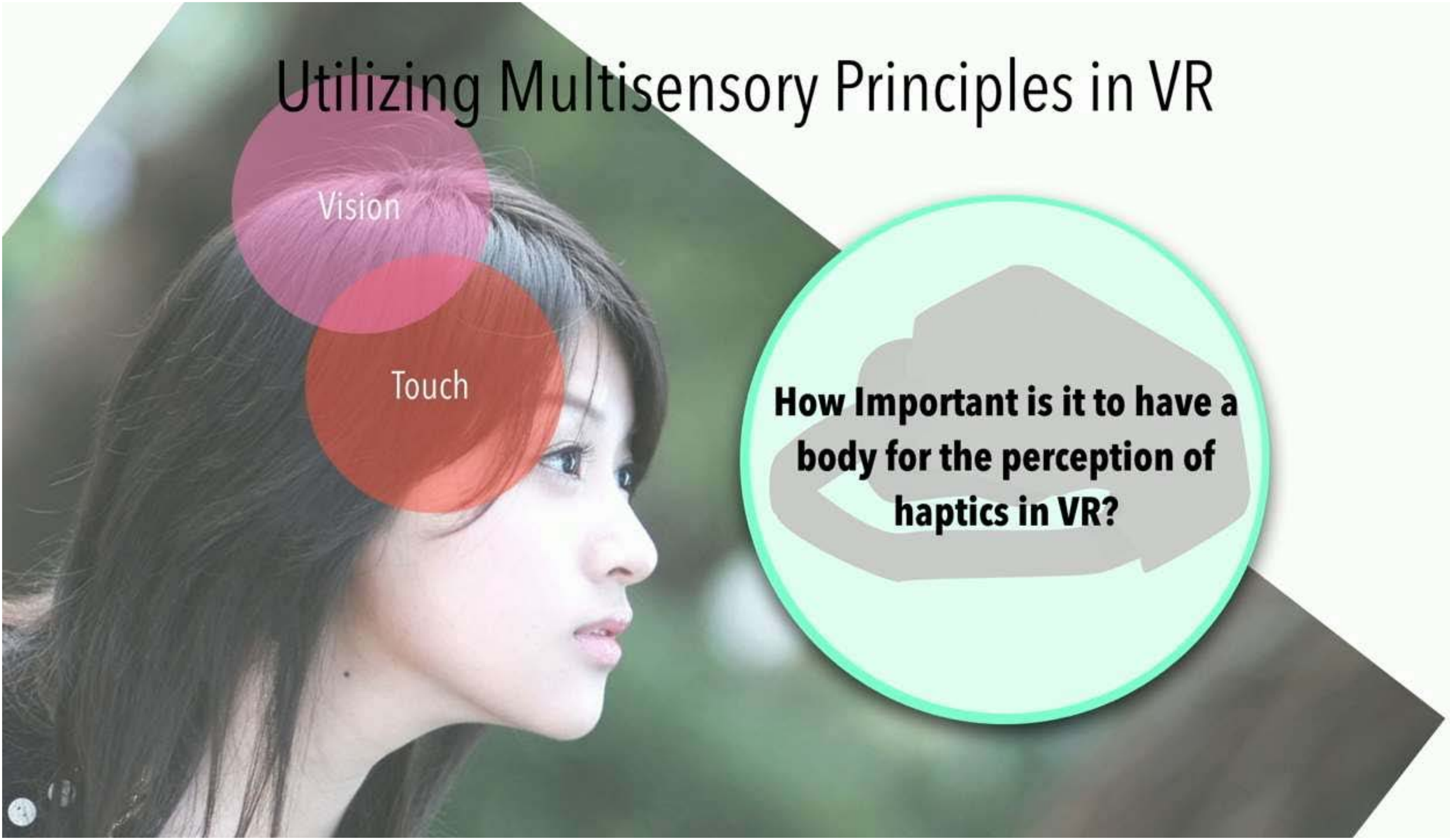
van der Hoort, Guterstam, & Ehrsson (2011) *PloS ONE*







Utilizing Multisensory Principles in VR

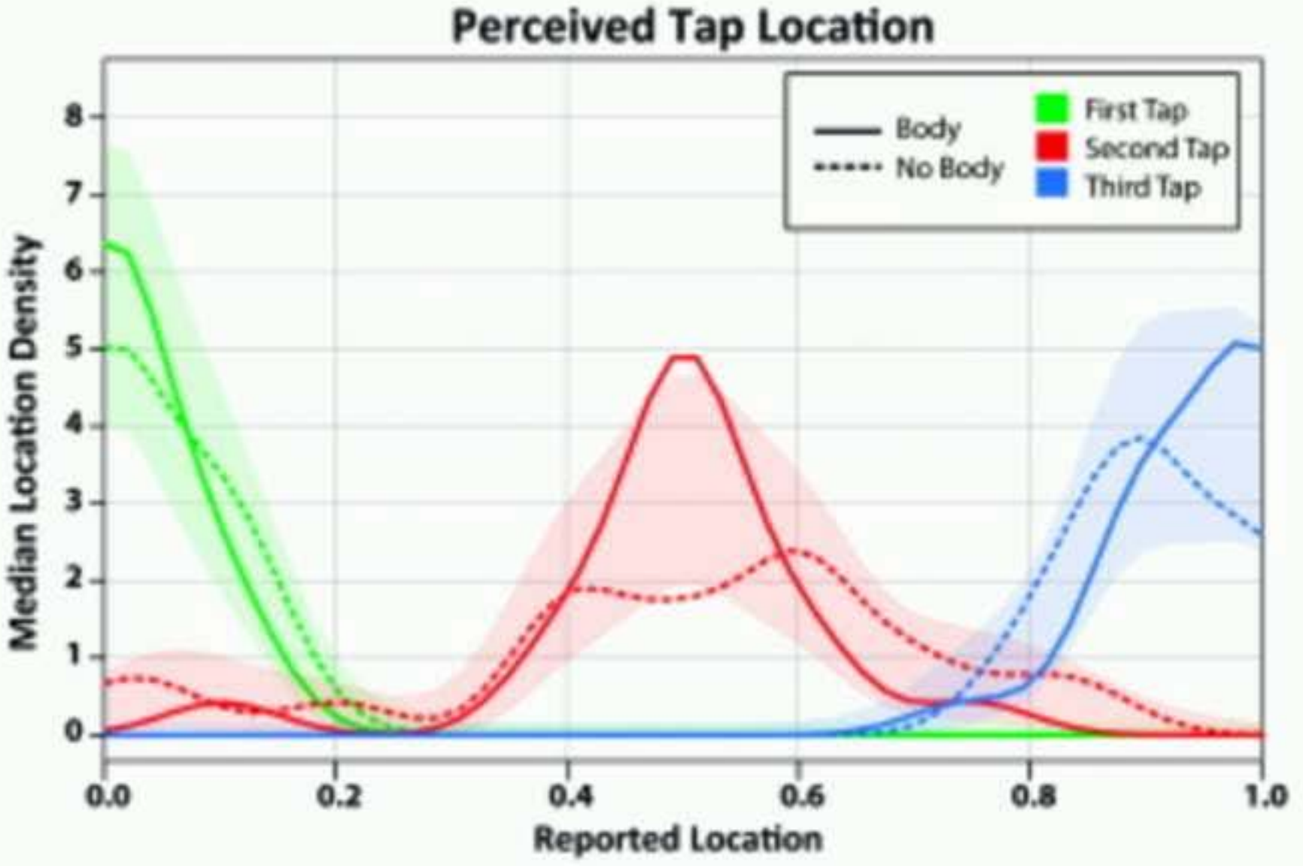


The importance of avatar embodiment for virtual haptic perception

IEEE VR 2018

At the beginning of the experiment, participants get familiarized with the virtual stick.

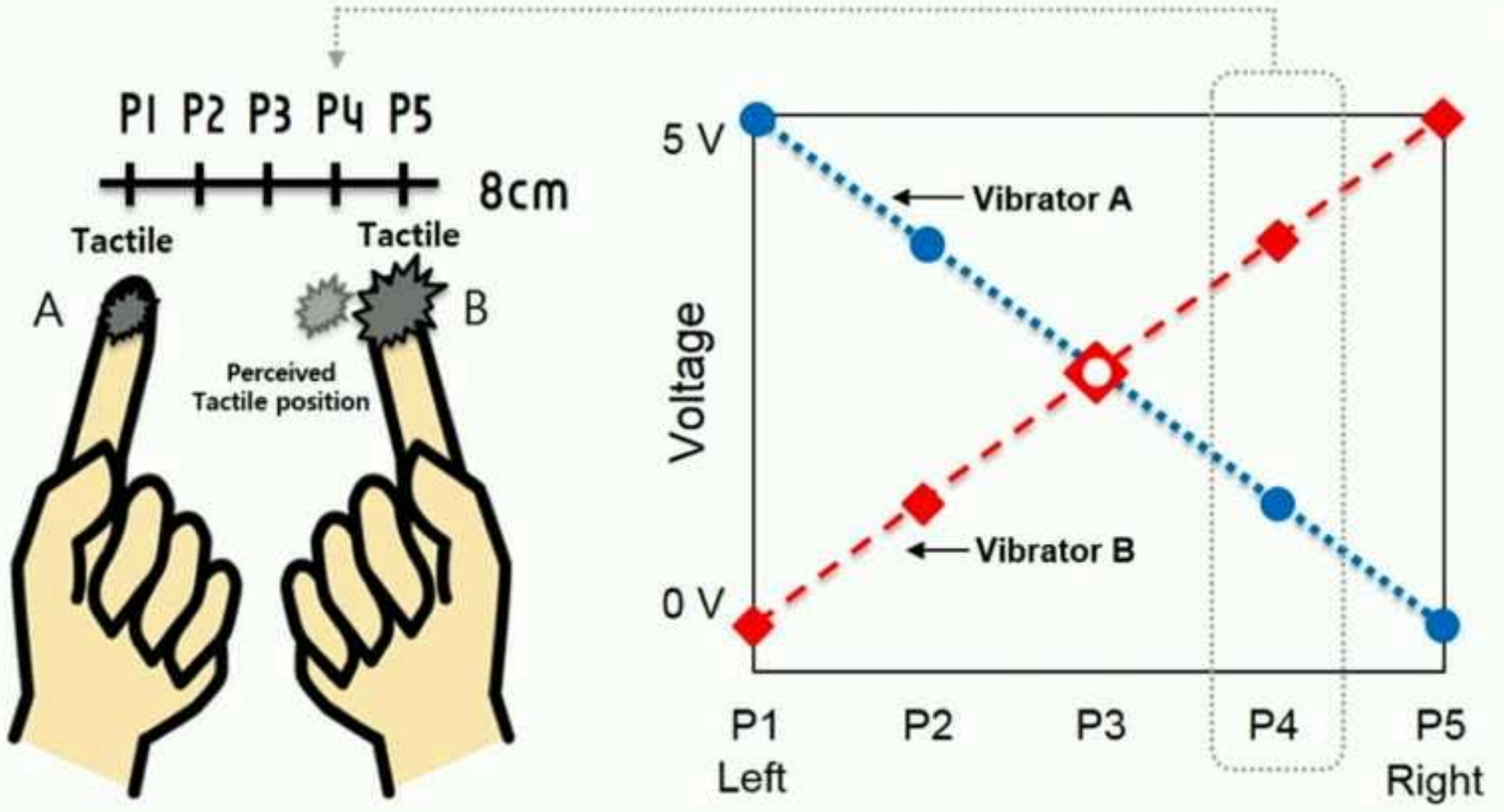
In the body condition, participants are embodied in a matching avatar.



Berger & Gonzalez-Franco , *Submitted Manuscript , IEEE VR*

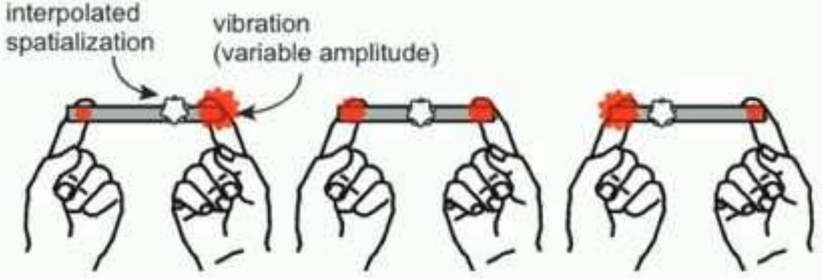
Utilizing Multisensory Principles in VR

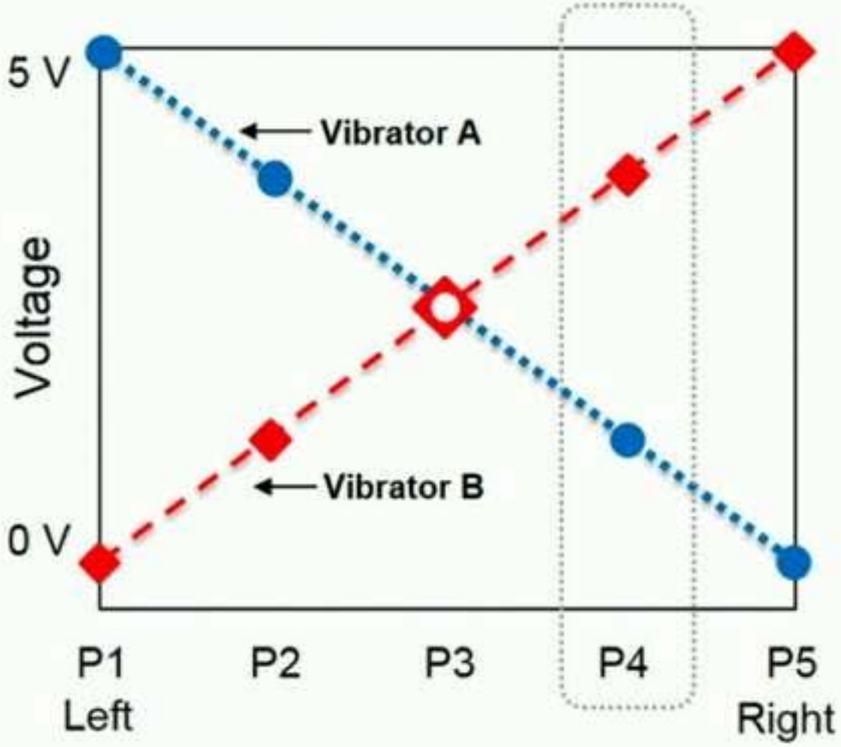
Can we expand haptic perception in VR beyond two independently handheld controllers using only two independently handheld controllers?



Lee, Kim & Kim (2012), *CHI*

Spatialized Touch Illusion





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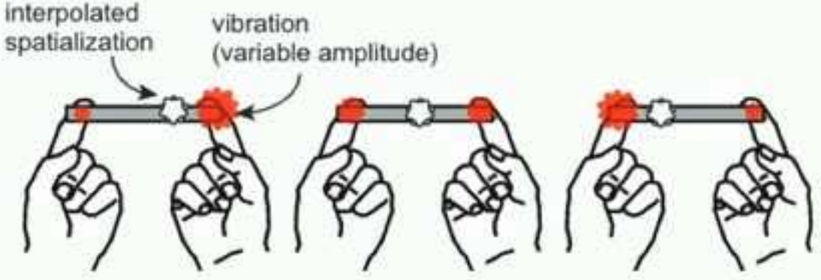
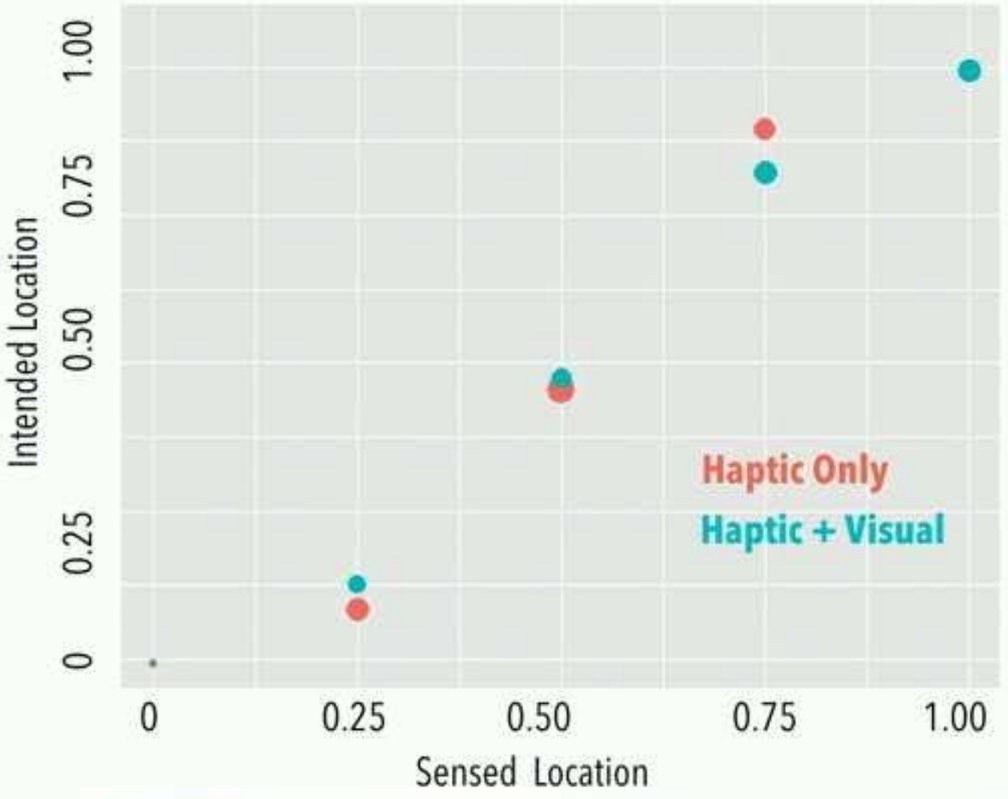
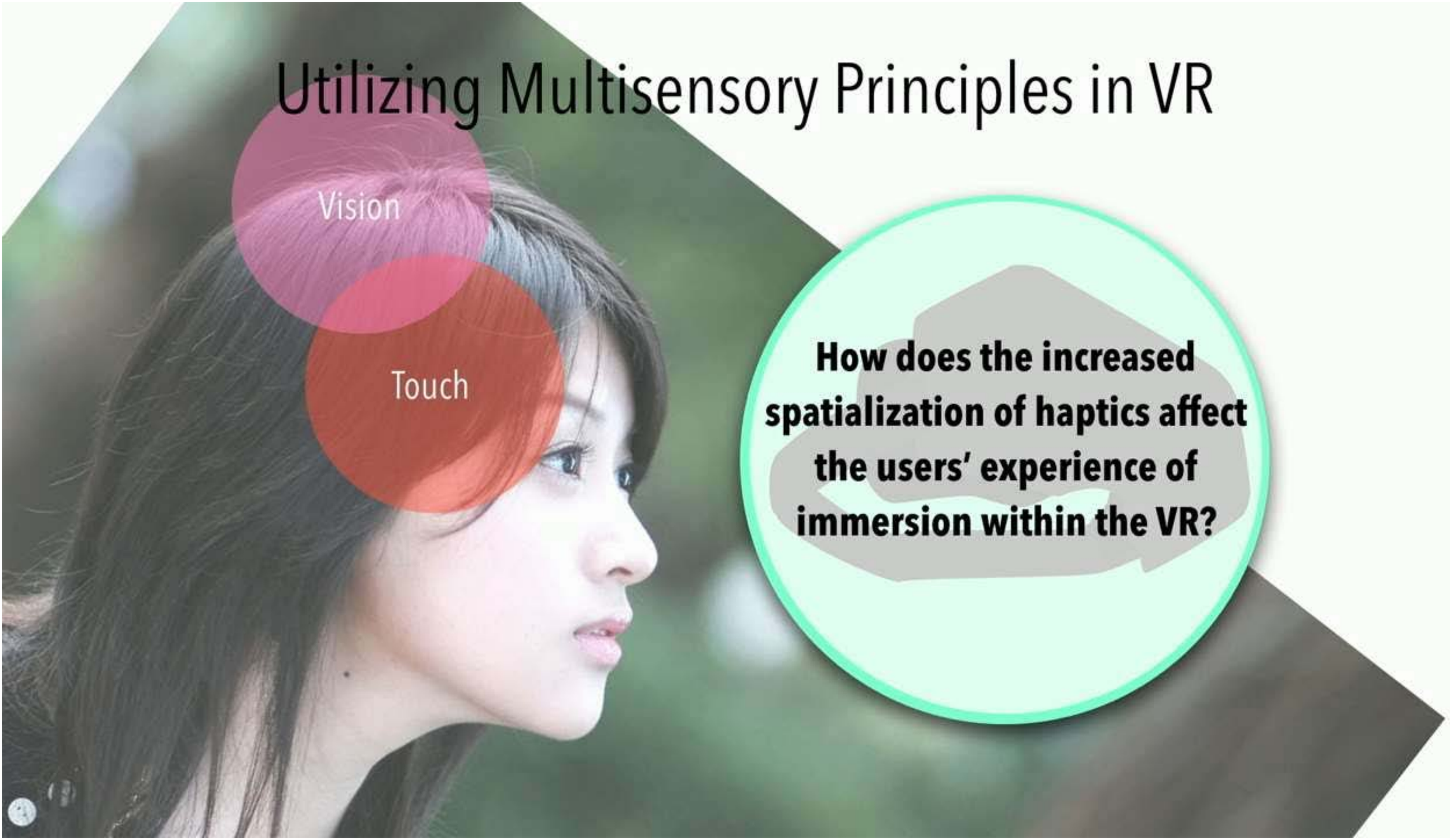




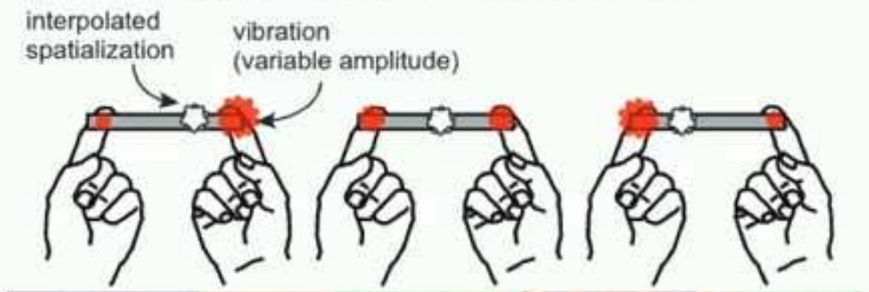
Berger & Gonzalez-Franco , *Manuscript in Prep.*

Utilizing Multisensory Principles in VR

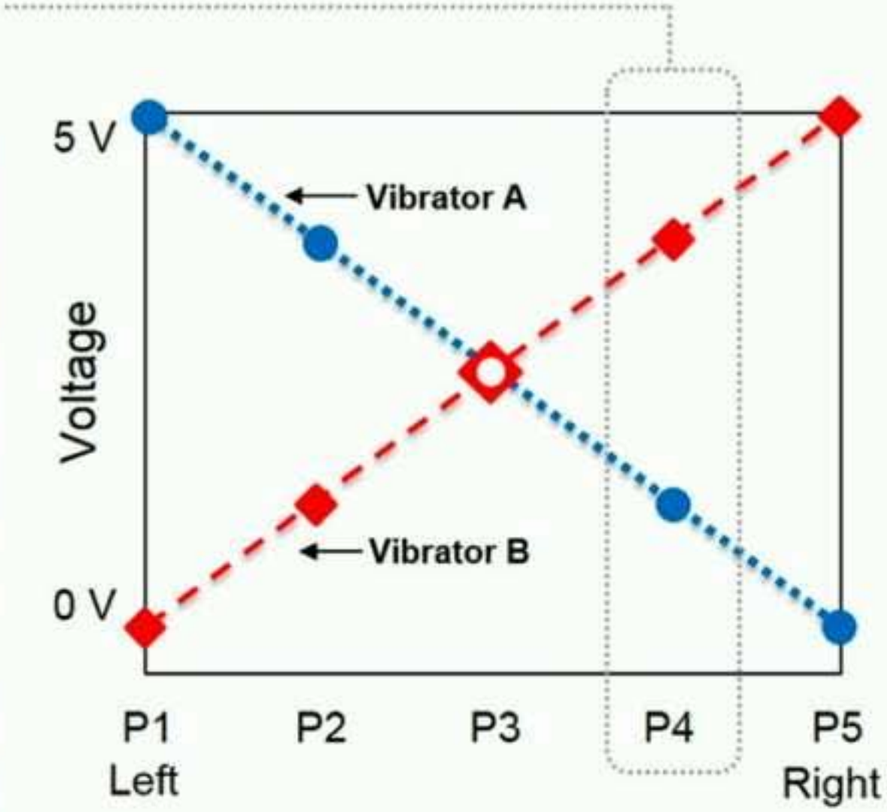


How does the increased spatialization of haptics affect the users' experience of immersion within the VR?

Spatialized Touch Illusion



Berger, Gonzalez-Franco, Ofek, Hinckley (submitted-2018), *CHI*



Lee, Kim & Kim (2012), *CHI*

Immersion

Q1: How aware were you of the real world surrounding while interacting in the virtual world? (i.e. sounds, room temperature, other people etc).
Q2: How real did the virtual stick seem to you?
Q3: I had a sense of acting in the virtual space, rather than operating something from outside.
Q4: I did not feel present in the virtual space.
Q5: I was not aware of my real environment.
Q6: In the Virtual reality world, I had a sense of "being there".
Q7: I felt present in the virtual space.
Q8: I still paid attention to the real environment.

Spatialization of Touch

Q9: I felt as if the vibrations came from the virtual stick.
Q10: I felt as if the vibrations came from multiple locations between the virtual hands.
Q11: The vibrations seemed to originate from a single location at a time.
Q12: I could locate where the vibration originated on the stick.

Berger, Gonzalez-Franco, Ofek, Hinckley (submitted-2018), *CHI*

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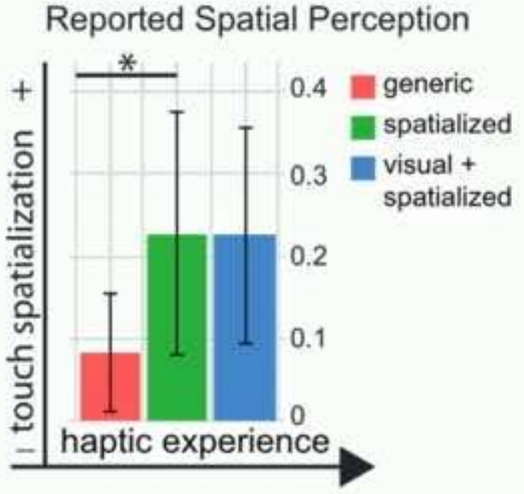

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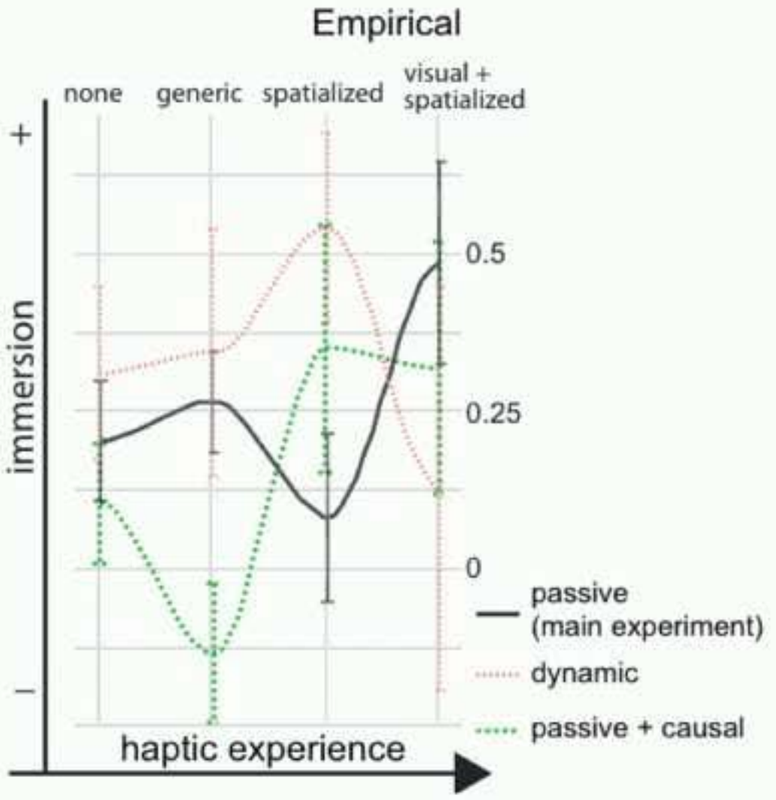
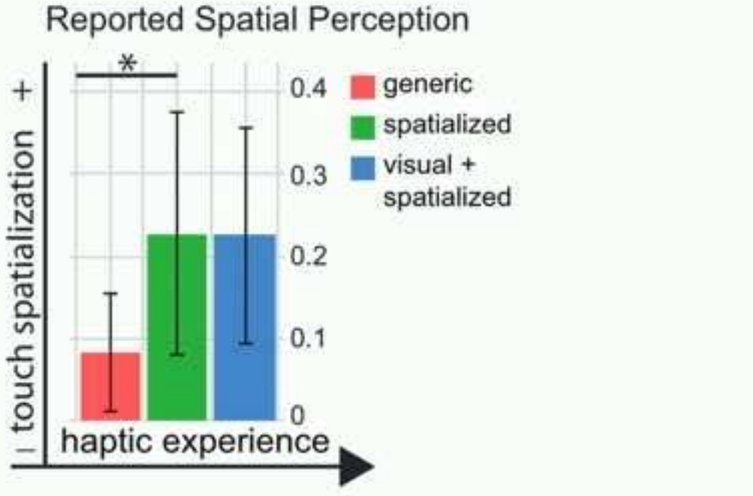
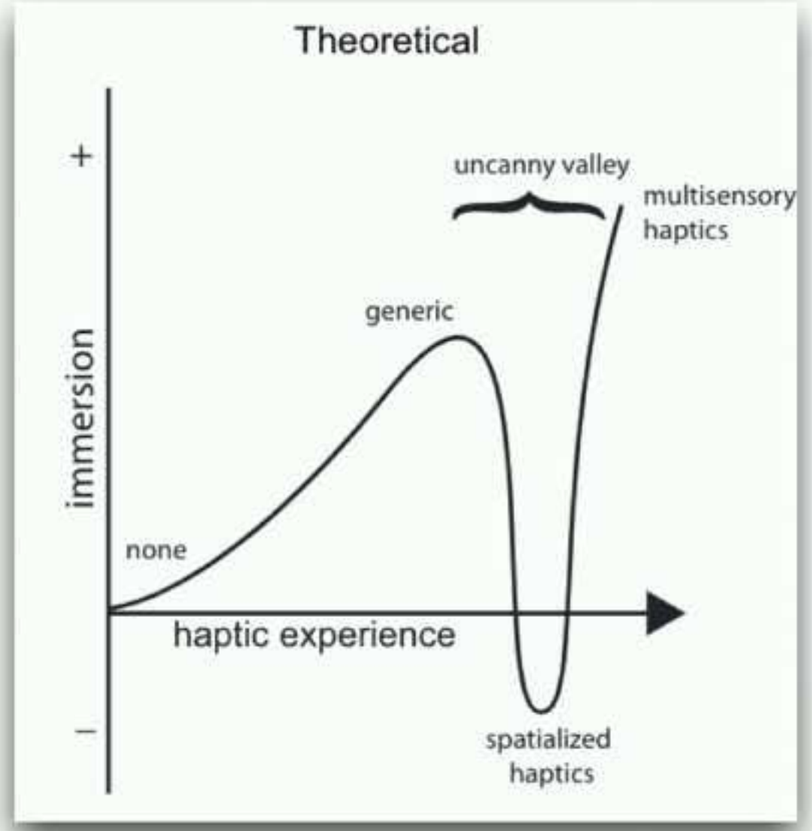


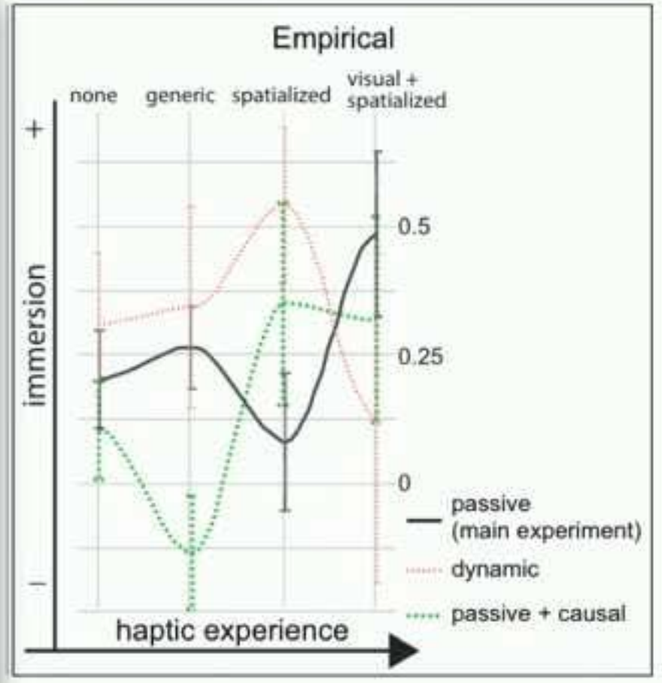


Berger, Gonzalez-Franco, Ofek, Hinckley (submitted-2018), *CHI*

The Uncanny Valley of Haptics

Berger, Gonzalez-Franco, Ofek, Hinckley (submitted-2018), *CHI*





The Uncanny Valley of Haptics

CHI 2018 Papers
Submission # 3570

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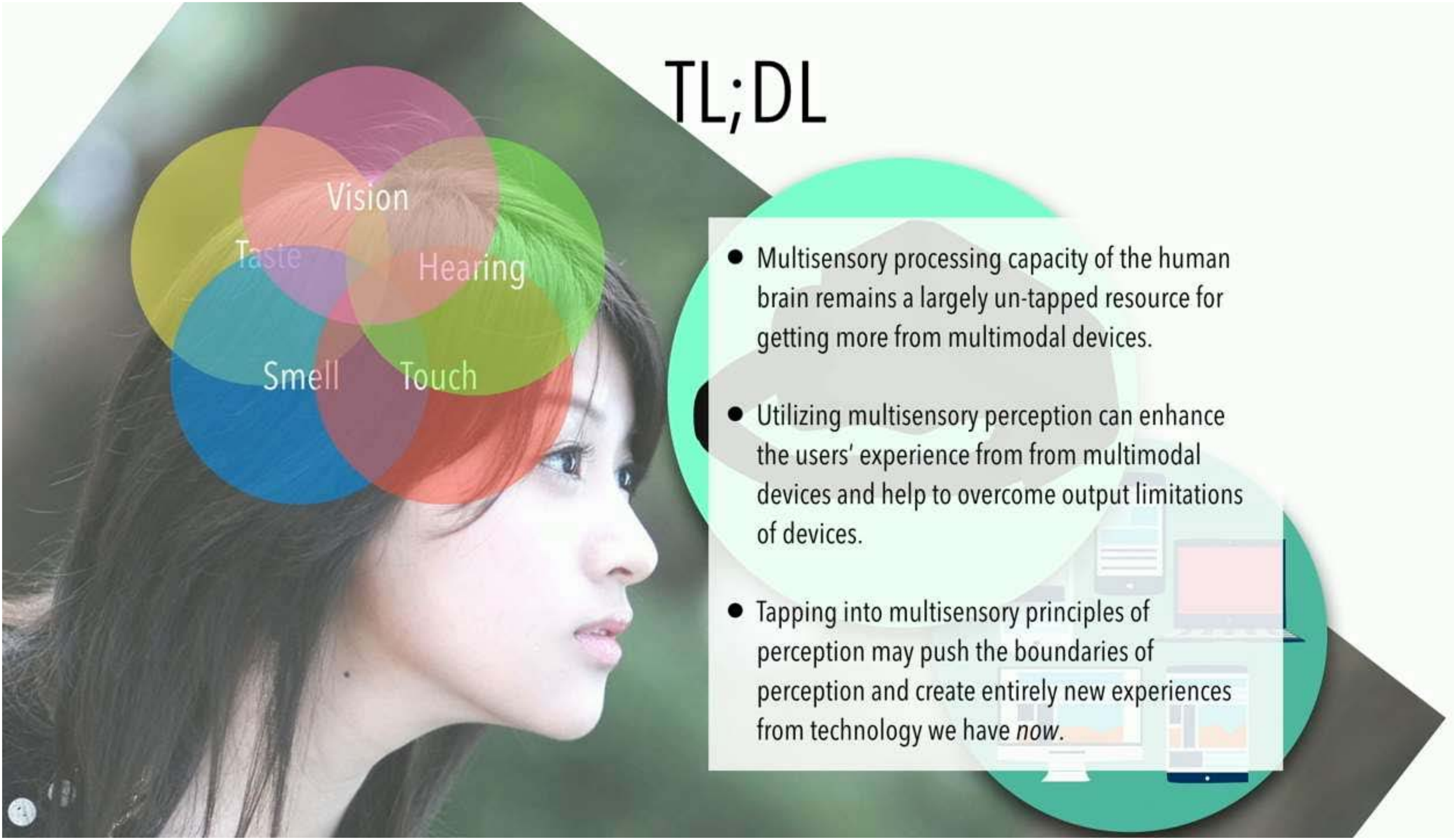

- Multisensory processing capacity of the human brain remains a largely un-tapped resource for getting more from multimodal devices.
- Utilizing multisensory perception can enhance the users' experience from from multimodal devices and help to overcome output limitations of devices.
- Tapping into multisensory principles of perception may push the boundaries of perception and create entirely new experiences from technology we have *now*.

What do you hear?

Thank you.

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