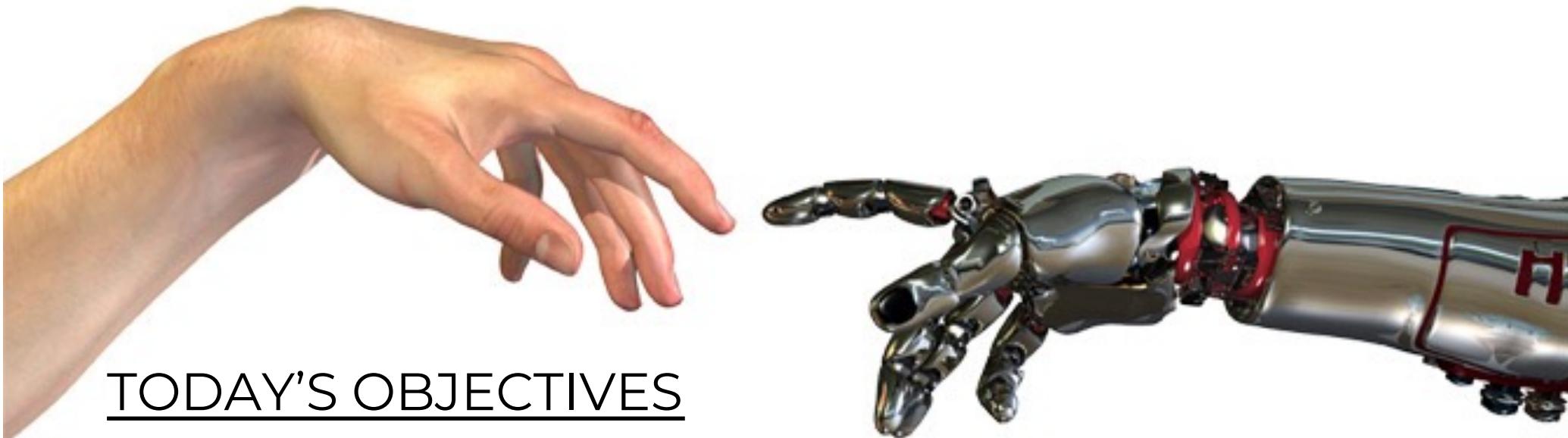


# Human-Computer Interaction

## Virtual Reality Design Guidelines – Part II



### TODAY'S OBJECTIVES

- 1.) Design principles continued

# Immersion

- Often referred to as Presence-perception of being physically present in a non-physical world
- Presence has been frequently defined as a sensation of “being there”
- Greater the immersion, better is user’s information retention
- Popular ways to measure immersion:
  - iGroup Presence Questionnaire (IPQ)
  - Slater-Usoh-Steed (SUS) Questionnaire
  - Witmer and Singer (WS) Questionnaire

Matthew Lombard, Theresa Ditton, At the Heart of It All: The Concept of Presence

E. D. Ragan, "The Effects of Higher Levels of Immersion on Procedure Memorization Performance and Implications for Educational Virtual Environments"

"Igroup Presence Questionnaire (IPQ) Overview." Igroup Presence Questionnaire (IPQ) Overview | Igroup.org – Project Consortium, [www.igroup.org/pq/ipq/index.php](http://www.igroup.org/pq/ipq/index.php)

Usoh, Martin & Catena, Ernest & Arman, Sima & Slater, Mel. (2000). Using Presence Questionnaires in Reality

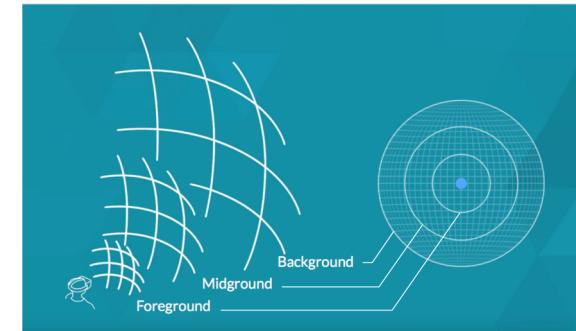
# Types of Immersion

- Sensory-Motoric
  - perform actions with your hands or limbs and get feedback through all of your senses (sight, sound and touch)
- Spatial
  - When the simulated world is perceptually convincing
- Cognitive
  - Perhaps the most common form of immersion
  - Occurs when you're focused on a specific task that requires mental exercise
  - Most people experience it when learning something new
- Emotional
  - Often induced when you watch a film or read an engrossing book
  - Occurs when players become emotionally invested in the experience

Elmsley, Andy. How to Increase User Immersion with (Mostly) Audio. 25 Apr. 2019, medium.com/the-sound-of-ai/how-to-increase-user-immersion-with-mostly-audio-2c7ba6f8777b

# Increase Immersion/Presence

- Atmospheric (aerial) Perspective
  - can help users to understand the scale of the virtual environment
  - Make objects that are farther away look less sharp and bluer than close objects
- Occlusion
  - Happens when one object in a 3D space is blocking another object from view
  - Consider different viewpoints and camera positions
- Linear Perspective
  - All shapes get smaller in all directions with increasing distance from the eye
- Relative Sizes
  - Match objects sizes to virtual world



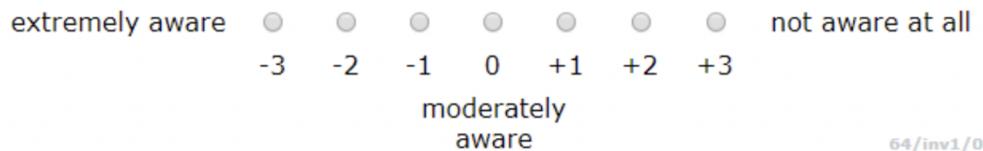
Chung, Tessa M. "Making Sense of Skyboxes in VR Design." *Medium*, Medium, 11 Feb. 2018, medium.com/aol-alpha/making-sense-of-skyboxes-in-vr-design-3e9f8fe254d3.

# Increase Immersion/Presence Contd.

- Shading
  - Since the eyes are separated by a short distance they see the environment from a slightly different perspective
  - Use similarities between the perspective view of each eye to lessen redundant rendering work
- Texture Gradient
  - Objects that are farther away or higher up, should have a lighter shader/color than those that appear closer
- Motion Parallax
  - Objects moving at a constant speed across the frame will appear to move a greater amount if they are closer to an observer (or camera) than they would if they were at a greater distance
  - Consider how to place one object in front of another to create a sense of depth

# Immersion Contd.

**How aware were you of the real world surrounding while navigating in the virtual world? (i.e. sounds, room temperature, other people, etc.)?**



**How real did the virtual world seem to you?**



**I had a sense of acting in the virtual space, rather than operating something from outside.**



## SLATER-USOH-STEED QUESTIONNAIRE (SUS)

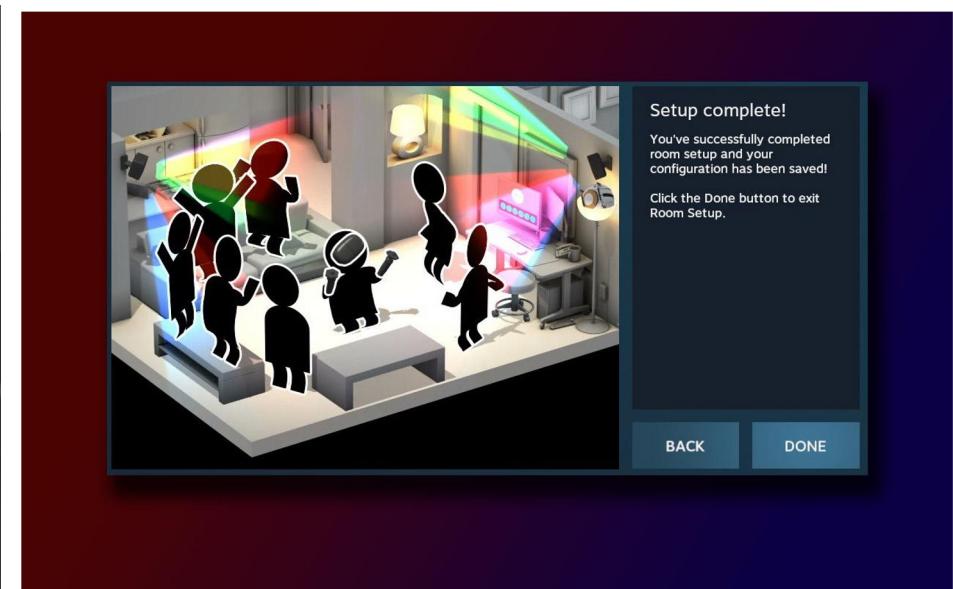
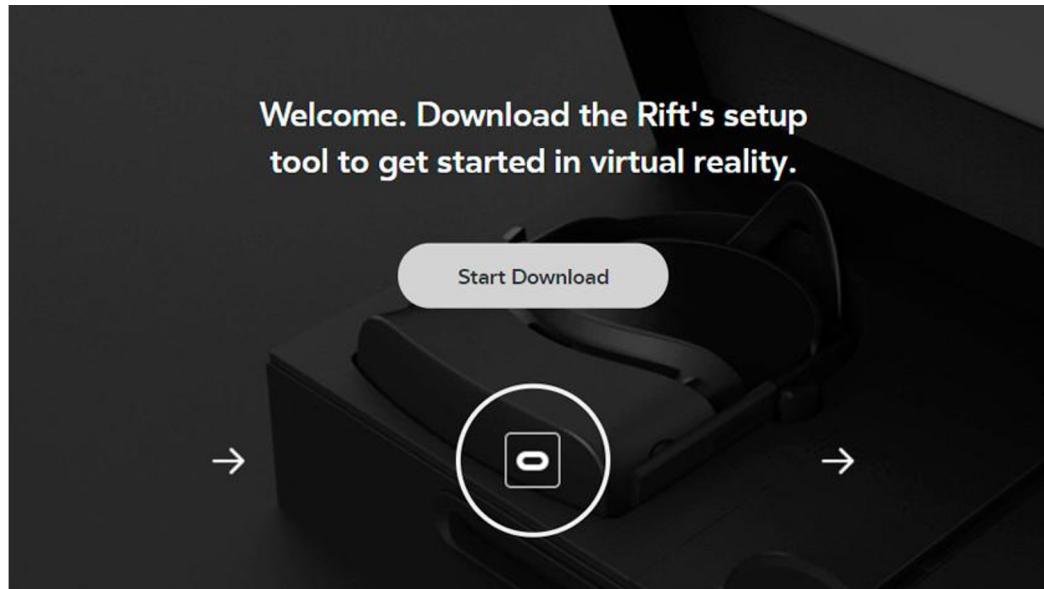
1. Please rate your *sense of being in the virtual environment*, on a scale of 1 to 7, where 7 represents your *normal experience of being in a place*.
2. To what extent were there times during the experience when the virtual environment was the reality for you?
3. When you think back to the experience, do you think of the virtual environment more as *images that you saw* or more as *somewhere that you visited*?
4. During the time of the experience, which was the strongest on the whole, your sense of being in the virtual environment or of being elsewhere?
5. Consider your memory of being in the virtual environment. How similar in terms of the *structure of the memory* is this to the structure of the memory of other *places* you have been today? By ‘structure of the memory’ consider things like the extent to which you have a visual memory of the virtual environment, whether that memory is in colour, the extent to which the memory seems vivid or realistic, its size, location in your imagination, the extent to which it is panoramic in your imagination, and other such *structural elements*.
6. During the time of your experience, did you often think to yourself that you were actually in the virtual environment?

# Increase Immersion/Presence Contd.



Chung, Tessa M. "Making Sense of Skyboxes in VR Design." *Medium*, Medium, 11 Feb. 2018, [medium.com/aol-alpha/making-sense-of-skyboxes-in-vr-design-3e9f8fe254d3](https://medium.com/aol-alpha/making-sense-of-skyboxes-in-vr-design-3e9f8fe254d3).

# Establish Familiarity



- Getting situated in a VR experience may take time
- Experience should only begin when the user is ready
- Do not start the experience automatically
- Wait for user to click on an initial screen to indicate readiness

# Consistency

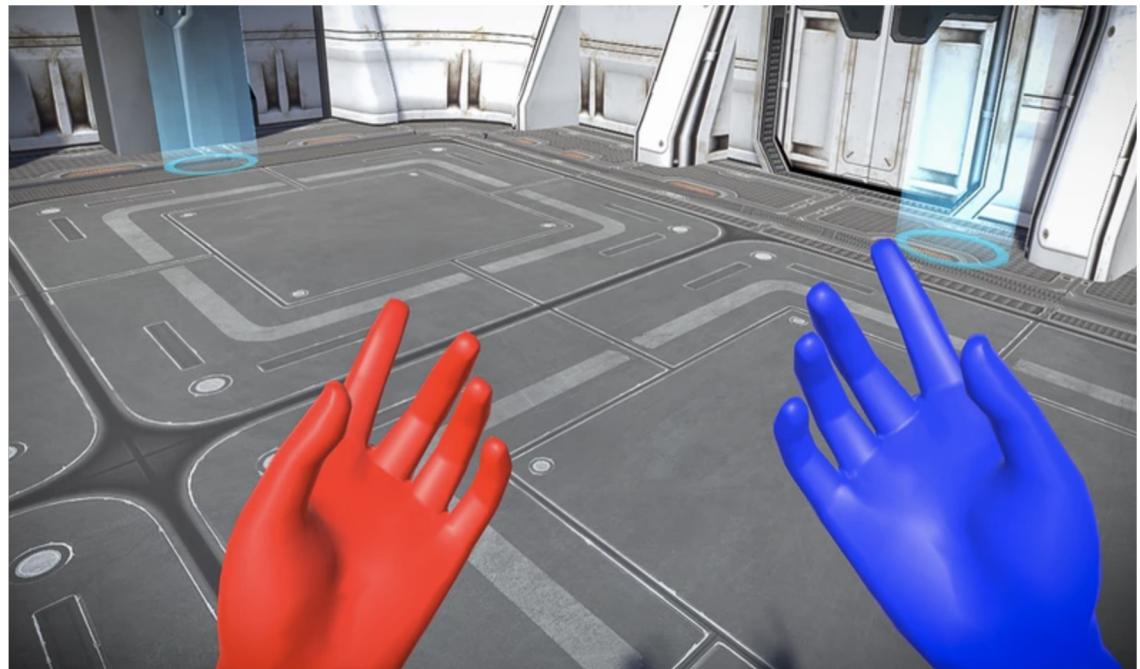
- Have consistency throughout the experience
  - Have similar ways to give instructions (dialog boxes, though phones, etc)
- Use objects similar to real world to maintain consistency
  - Traffic signs
  - Cars



"User Interface Components." Oculus Developers, developer.oculus.com/learn/hands-design-ui/?locale=en\_US

# Feedback

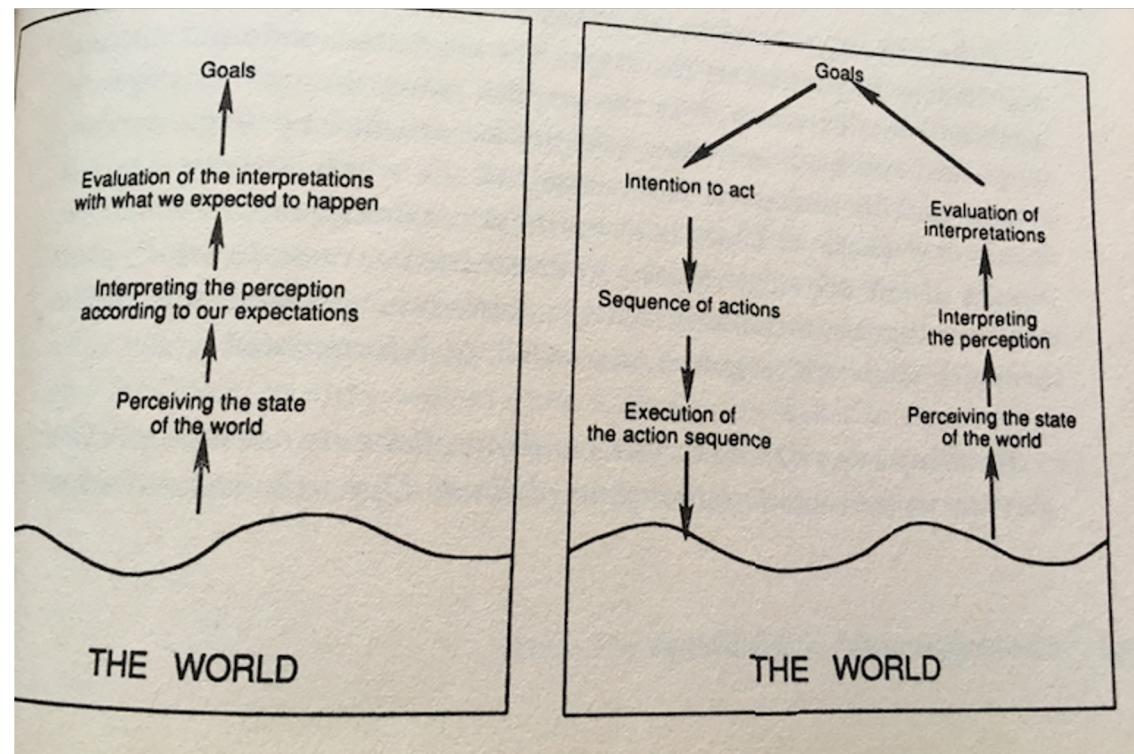
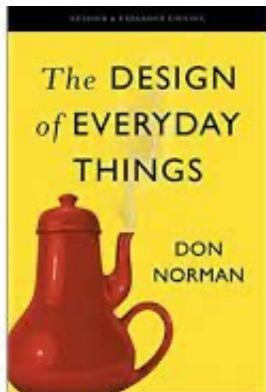
- Provide haptic feedback to the user
  - Highlight areas which user can interact with
  - Provide feedback when a button is pressed by physically vibrating the controllers, audio and visual cues
  - More tangible experience



"Unit 5 - Hand Presence and Interaction." *Unity Learn*, [learn.unity.com/tutorial/unit-5-hand-presence-and-interaction](https://learn.unity.com/tutorial/unit-5-hand-presence-and-interaction).

# Feedback Contd (Interaction).

## Cycle of Interaction



Norman, D. A. (2013). *The design of everyday things*.

# Confirmation

- Confirmation is exactly what it sounds like
- It is a design technique used to confirm critical actions, inputs, or commands
- User gaze (eye fixation) is increasingly used to confirm inputs



# Audio

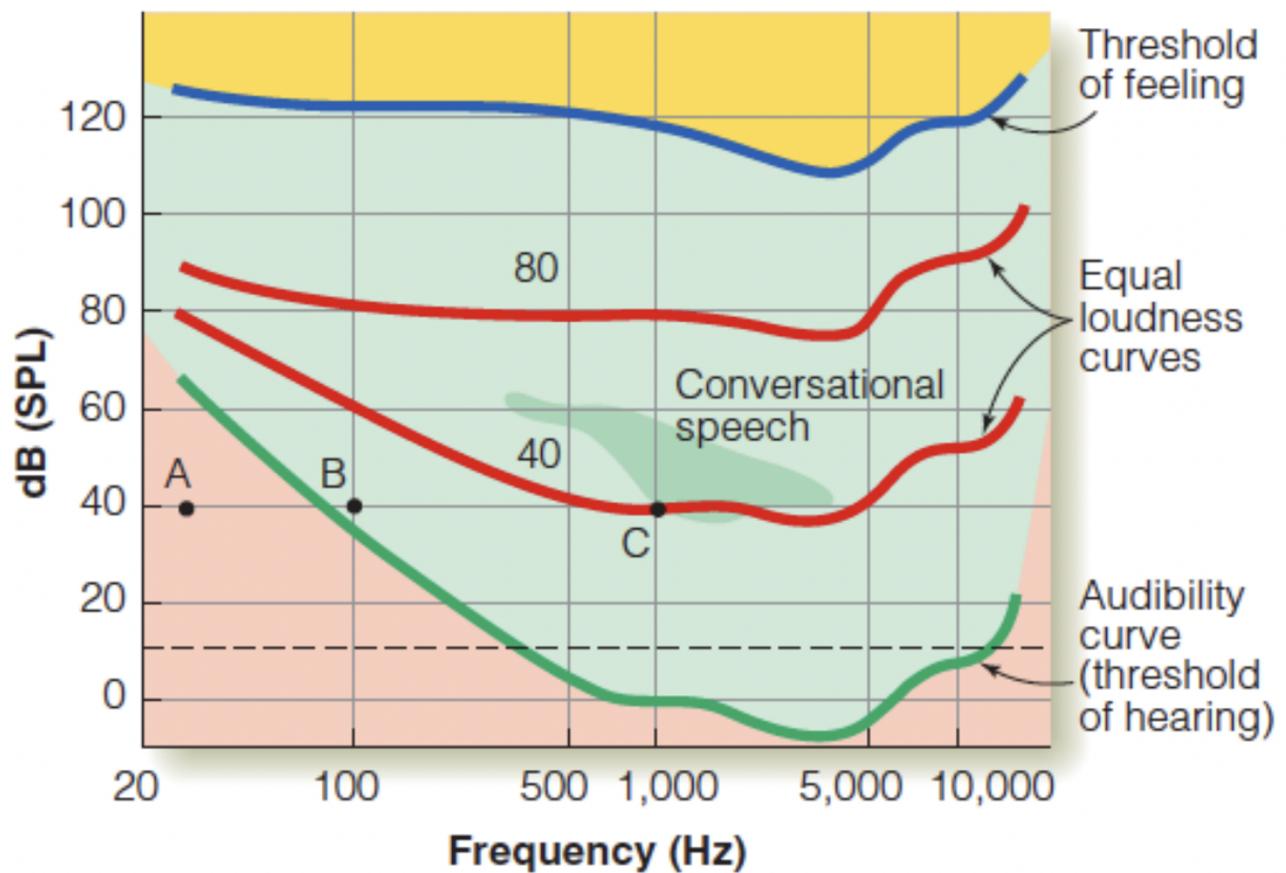
- Auditory perception is quite complex and is affected by
  - Head Pose
  - Physiology
- We can locate an object by using sounds cues
- Humans can hear frequency from 20 - 22,000 Hz
  - More sensitive to 2,000 - 4,000 Hz range (speech)
- Humans can detect a 50 Hz change in sound
  - 30 - 40 ms faster reaction to audio compared to visual cue

Welch, R.B., DuttonHurt, L.D. & Warren, D.H. Contributions of audition and vision to temporal rate perception. *Perception & Psychophysics*

Yost, W. A. (2013). *Fundamentals of hearing: An introduction.*

## Audio Contd.

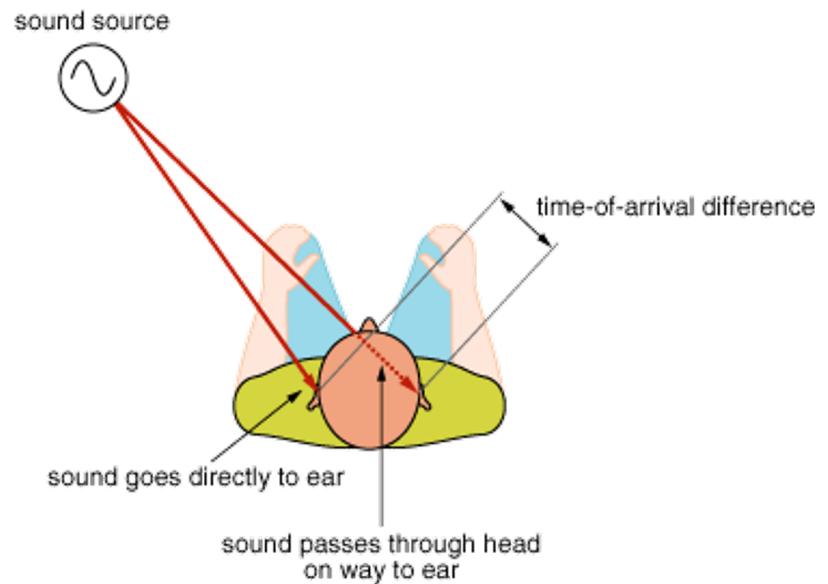
- Area above Audibility curve are frequencies we can hear
- Frequencies over Threshold of feeling can result in pain



Goldstein, E. B. (2014). *Sensation and perception*

# Audio Contd.

- Use Binaural Cues
  - Different audio cues, one for each ear
- Experiment with Head position and audio cue to create better VR environment



*Chapter 5: The Transformation of Sound by Computer.* sites.music.columbia.edu/cmc/MusicAndComputers/chapter5/05\_03.php

Jerald, J. (2016). *The VR Book: Human-Centered Design for Virtual Reality* (Vol. 8). San Rafael, CA: Morgan & Claypool. ISBN: 978-1-97000-115-0

Bible, Thomas. "Binaural Audio for Narrative VR." *Oculus*, www.oculus.com/story-studio/blog/binaural-audio-for-narrative-vr/.

# Avatars and Design Guide

- Avatars are representation of user's body
- Avatars should correspond to user's position, gesture and movement
- Avatars that help user's to anticipate motion reduces discomfort
- Use Avatars only when necessary
  - Imperfections can lead to distraction and decrease presence

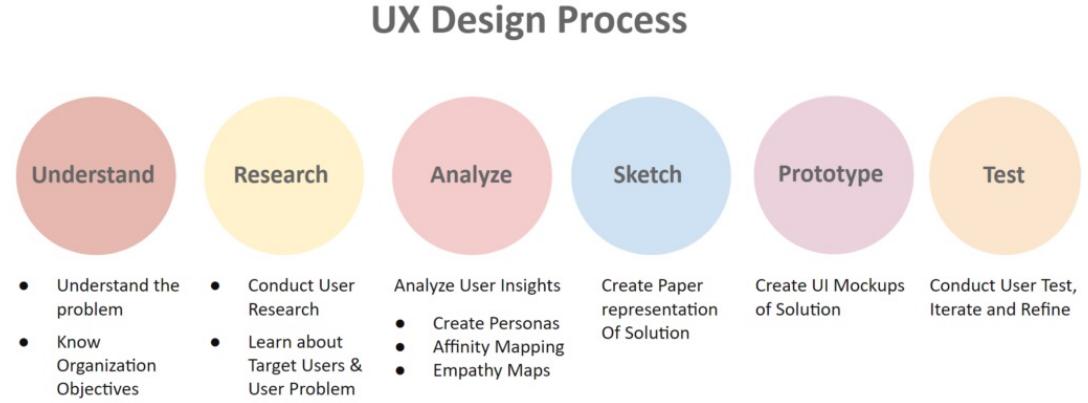


"Avatars." Oculus Developers, [developer.oculus.com/learn/bp-avatars/](https://developer.oculus.com/learn/bp-avatars/).

# Inclusive & UX (User Experience)

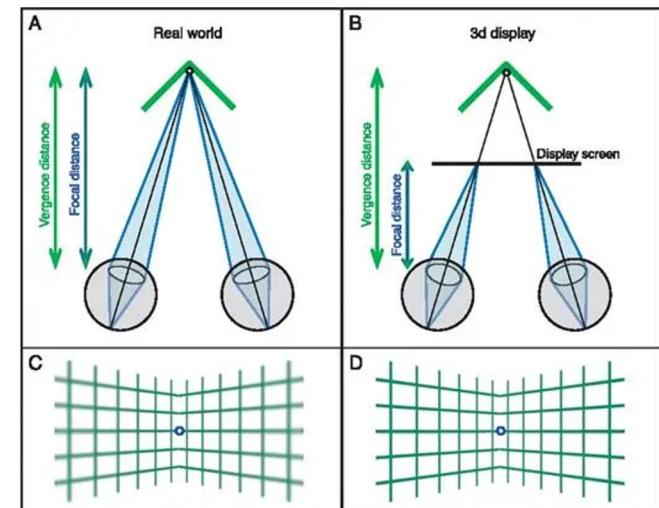
(User Interface Design/UX CSCI Course offered fall semesters)

- Design and test with a variety of users
- Allow customizations
  - Design Iteratively
    - Continuous Discovery leads to better user engagement
    - Helps discover users need
    - UX/UI (User Experience/Human-Centered) Design Framework
  - Refer to earlier HCI course slides on inclusive design/accessibility



# Tips for Natural Interaction/Natural Mapping

- Elements placed too close can cause eye strain
  - Vergence-Accommodation Conflict
- Place text and images on a slightly curved concave surface feels more natural as the user looks around
- Text is currently difficult to read in VR, and should be displayed big enough to be legible
  - At least 20px for UI elements and another 2.32 cm height
  - Test with different users



Zhang, Sarah. "The Obscure Neuroscience Problem That's Plaguing VR." *Wired*, Conde Nast, 29 June 2017, [www.wired.com/2015/08/obscure-neuroscience-problem-thats-plaguing-vr/](http://www.wired.com/2015/08/obscure-neuroscience-problem-thats-plaguing-vr/)

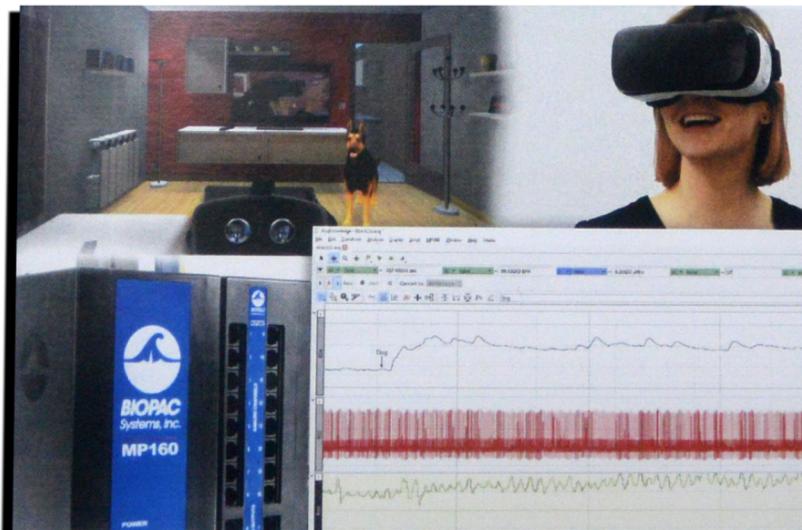
# Physiological Measures

- Designing an experience that is comfortable for people
- Headsets available in market are capable of:
  - Head tracking
  - Eye tracking (Gaze tracking)
  - Hand tracking
- This helps in reducing Cybersickness as well



# Physiological Measures Contd.

- Heart Rate and Respiration Rate is being used to design better VR UI
- EEG (brain) data is also gaining popularity for VR development



"Unity VR Interface for AcqKnowledge: UNITY-INTERFACE: Research: BIOPAC." *BIOPAC Systems, Inc.*, [www.biopac.com/product/vr-unity-interface/](http://www.biopac.com/product/vr-unity-interface/)  
"Looxid Link Meets Media Art." Looxid Link, 29 Apr. 2020, [looxidlabs.com/looqidlink/](http://looxidlabs.com/looqidlink/)

# Eye Tracking

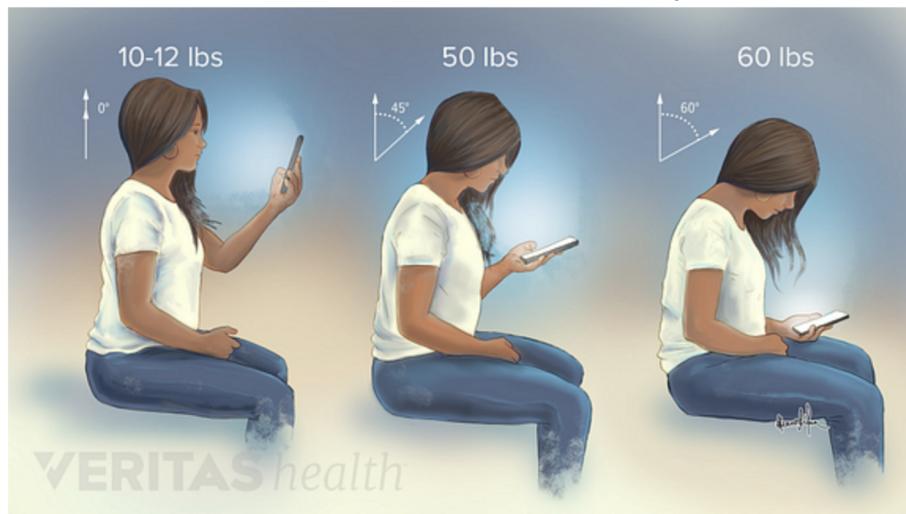


- Reduce GPU load through foveated rendering
  - Only rendering the specific part of the screen where the user is currently looking in full resolution
- Enhanced/More Natural Interaction
  - Reflect eye movements and blinks in virtual avatars
- Increased Comfort
  - Using inter-pupillary distance (IPD) devices can automatically adapt to the user
- Deeper Insights
  - Valuable insights into user attention which aids developers in understanding how their application is being used

Rogers, Sol. "Seven Reasons Why Eye-Tracking Will Fundamentally Change VR." *Forbes*, Forbes Magazine, 5 Feb. 2019, [www.forbes.com/sites/solrogers/2019/02/05/seven-reasons-why-eye-tracking-will-fundamentally-change-vr/?sh=4d3ced353459](http://www.forbes.com/sites/solrogers/2019/02/05/seven-reasons-why-eye-tracking-will-fundamentally-change-vr/?sh=4d3ced353459)  
"VIVE Pro Eye Office: VIVE Enterprise." *VIVE Pro Eye Office | VIVE Enterprise*, [enterprise.vive.com/us/product/vive-pro-eye-office/](http://enterprise.vive.com/us/product/vive-pro-eye-office/)

# Ergonomics

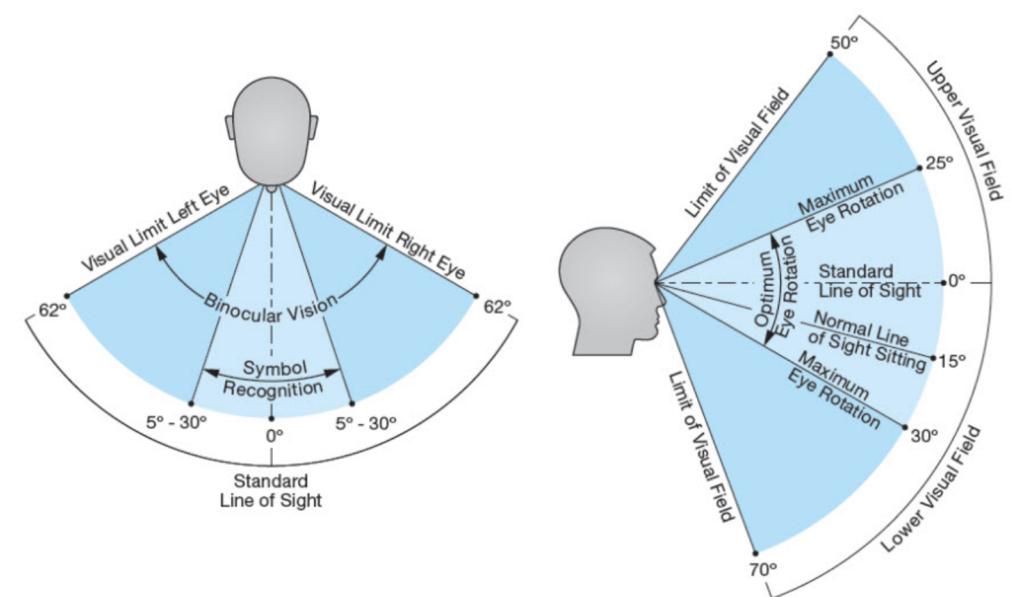
- Human-centered design approach to avoid fatigue and improve body postures
  - Improper postures causes additional strain on spinal column



David DeWitt, MD. "How Does Text Neck Cause Pain?" *Spine*, [www.spine-health.com/conditions/neck-pain/how-does-text-neck-cause-pain](http://www.spine-health.com/conditions/neck-pain/how-does-text-neck-cause-pain)

# Ergonomics Contd.

- Head movement should be minimized and human-eye field of view should be considered during development
- Wide varieties of anthropometric measures should be considered during all phases of development
- Using hand controllers for navigation functionality is proven to be less cognitive taxing for the user



Nathan Navarro Griffin, James Liu, and Eelke Folmer. 2018. Evaluation of Handsbusy vs Handsfree Virtual Locomotion

Bar, Anton. "The Ultimate Immersive Experience." *The Vuze VR Blog*, The Vuze VR Blog, 24 Aug. 2017, [blog.vuze.camera/the-ultimate-immersive-experience/](http://blog.vuze.camera/the-ultimate-immersive-experience/)

# Test Frequently

- Iterate UI designs frequently
  - Avoid making major design frequently
- Don't assume that "one size fits all approach"

**"If a picture is  
worth 1000  
words, a  
prototype is  
worth 1000  
meetings."**

TOM & DAVID KELLEY

[WWW.UXDWORLD.COM](http://WWW.UXDWORLD.COM)

# Developer Resources

- Best Practices
  - <https://medium.com/google-design/from-product-design-to-virtual-reality-be46fa793e9b>
- Unity
  - <https://unity3d.com/unity/features/multiplatform/vr-ar>
  - <https://docs.unity3d.com/Manual/VROverview.html>
  - <https://learn.unity.com/>
- HTC Vive
  - <https://www.raywenderlich.com/9189-htc-vive-tutorial-for-unity>
- Oculus
  - <https://developer.oculus.com/documentation/unity/unity-tutorial/>
  - <https://learn.unity.com/course/oculus-vr>
- VR Development Book
  - Jerald, J. (2016). *The VR Book: Human-Centered Design for Virtual Reality*