Hi!

Immersion and Memory: how our brains understand virtual worlds

The interaction between immersion, presence, and learning (and why it’s all about perception)

Pathway

How we perceive Reality

How we perceive in Virtual Reality

How perception supports immersion and presence

How immersion and presence (and perception) supports learning

Sophia Batchelor

Neuroscientist, researcher, and
builder of a brighter tomorrow.

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ICON
IMMERSIVE COGNITION

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What I do is try to understand the "why" of "what" we are by looking at the brain and technology

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How I do it is by building the technology that investigates the brain ... that builds the technology ... that investigates the brain ...

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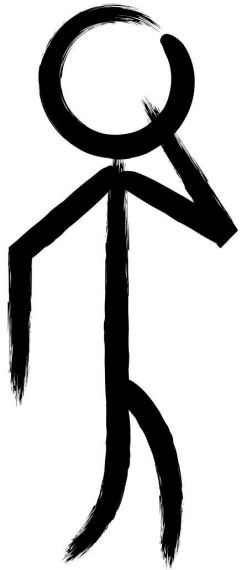
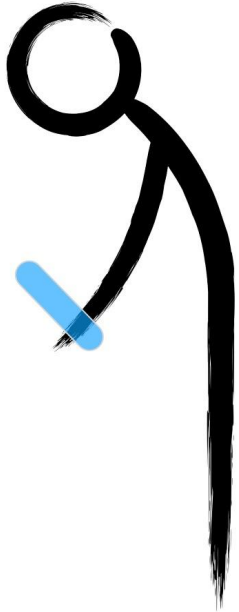
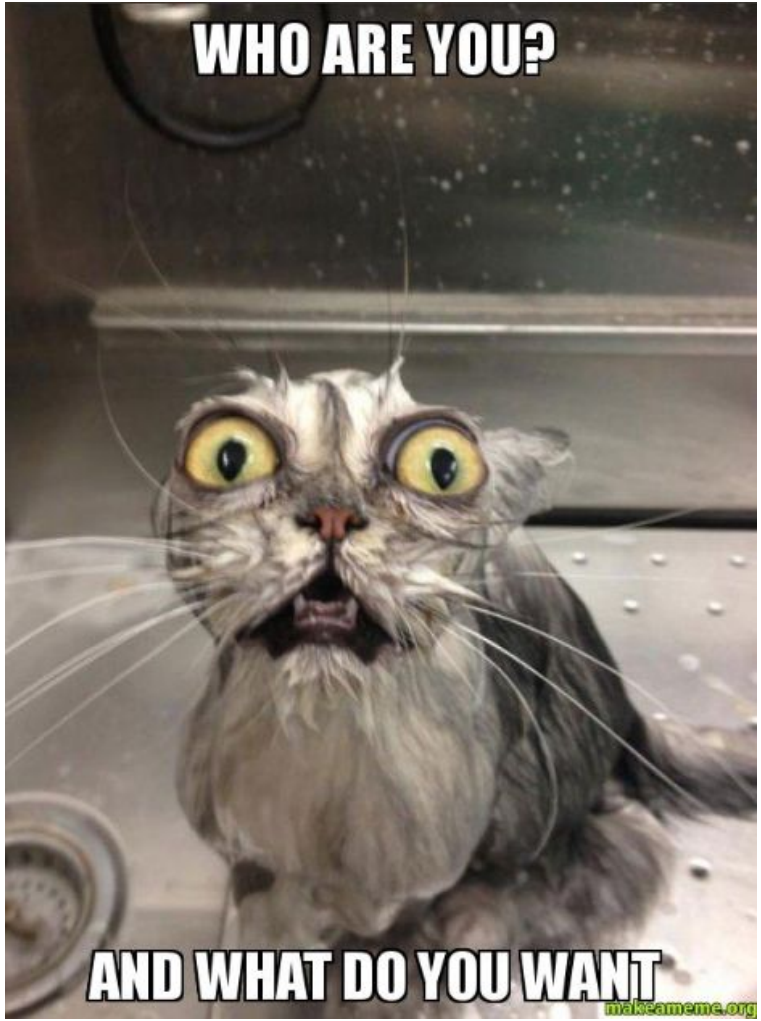


Perception

Interaction



Experience


WHO ARE YOU?
AND WHAT DO YOU WANT
makeameme.org

The Immersion in the Room

“Immersive technologies”

“Psychological sense of being there”

Virtual Reality (VR) is the technology that provides almost real and/or believable experience in a synthetic or virtual way.

The goal of *Immersive VR* is to completely immerse the user inside the computer generated world, giving the impression to the user that he/she has “stepped inside” the synthetic world.

The Immersion in the Room

- **Tactical immersion**: Tactical immersion is experienced when performing tactile operations that involve skill. Players feel "in the zone" while perfecting actions that result in success.

- **Strategic immersion**: Strategic immersion is more cerebral, and is associated with mental challenge. Chess players experience strategic immersion when choosing a correct solution among a broad array of possibilities.

- **Narrative immersion**: Narrative immersion occurs when players become invested in a story, and is similar to what is experienced while reading a book or watching a movie.
    - Ernest Adams (2004). "Postmodernism and the Three Types of Immersion".

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- **Spatial immersion**, which occurs when a player feels the simulated world is perceptually convincing. The player feels that he or she is really "there" and that a simulated world looks and feels "real".
  - Björk, Staffan, & Jussi Holopainen (2004). *Patterns In Game Design* ISBN 978-1-58450-354-5

The Immersion in the Room

- Immersion with VR is also about the technology's capabilities

- **Abrash (and Valve)**
  - A wide field of view (80 degrees or better)
  - Adequate resolution (to avoid screen door effect)
  - Low pixel persistence (3 ms or less)
  - A high enough refresh rate (above perception)
  - Global display where all pixels are illuminated simultaneously.
  - Optical calibration
  - Tracking – translation with millimeter accuracy or better, orientation with quarter degree accuracy or better, and volume of 1.5 meter or more on a side
  - Low latency (20m/s motion to last photon)

The Immersion in the Room

“If immersion is analogous to wavelength distribution in the description of colour then “presence” is analogous to the perception of colour.

Presence is a human reaction to immersion.”

- Slater, et al. 2009

Full citation: Slater, M., Lotto, B., Arnold, M. M., & Sanchez-Vives, M. V. (2009). How we experience immersive virtual environments: the concept of presence and its measurement.

The Immersion in the Room

“Presence” is considered by its response - if a person experiences high “presence” then they will respond to the to virtually generated sensory data as if it were real (Sanchez-Vives & Slater, 2005)

The Immersion in the Room

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It’s about the interaction

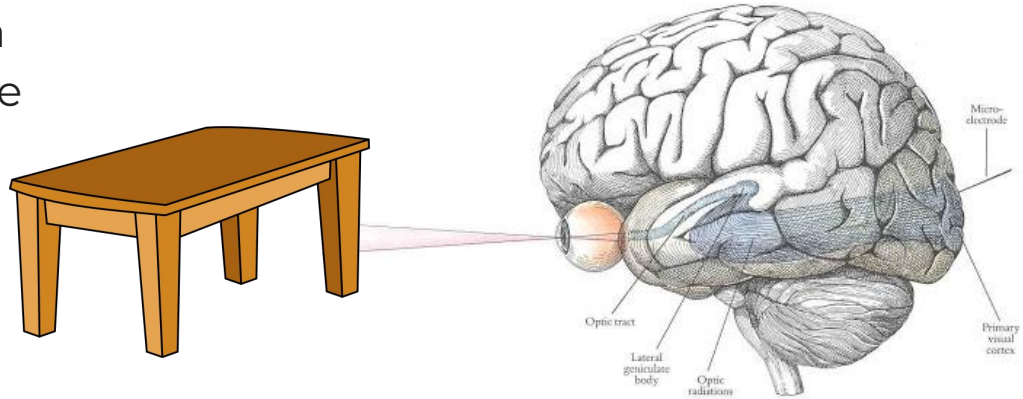
It’s about giving your senses (your brain) sensory input that makes it respond as if the input was “real” (ie. not generated with software).

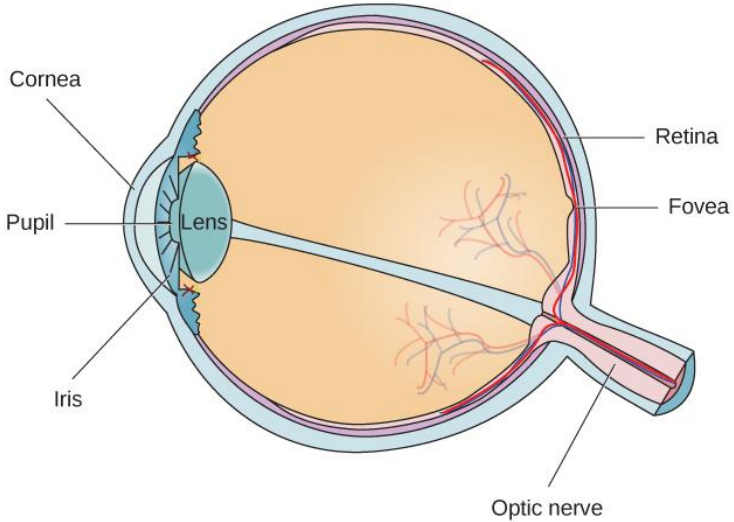
What we experience
=
(memory) + (interaction)

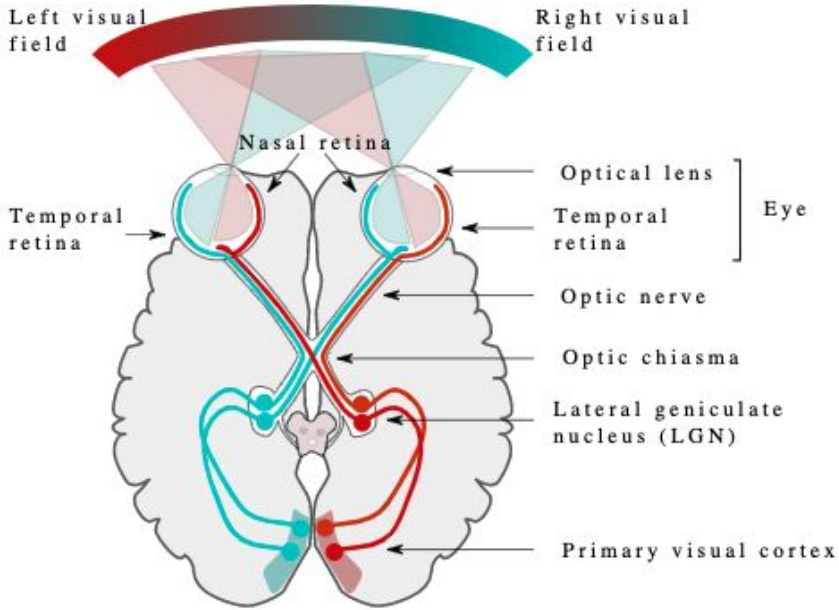
We experience presence, when our interaction and expectation (memory models) match

How does the world exist?

- Photons bouncing off objects
- 26 million neurons in the retina
- 1 million neurons synapse to the optic tract







Images Source: https://courses.lumenlearning.com/wmopen-psychology/chapter/outcome-vision/

Image Source: VectorStock.com/25924023

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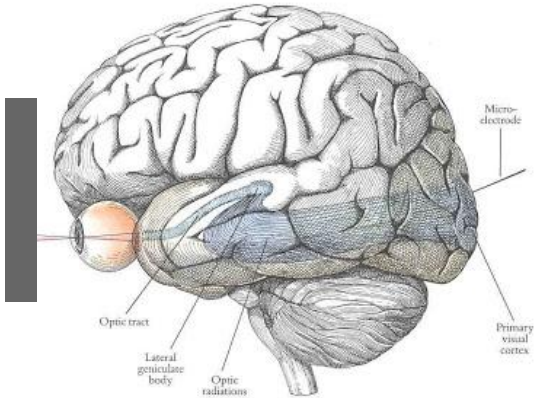
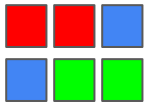
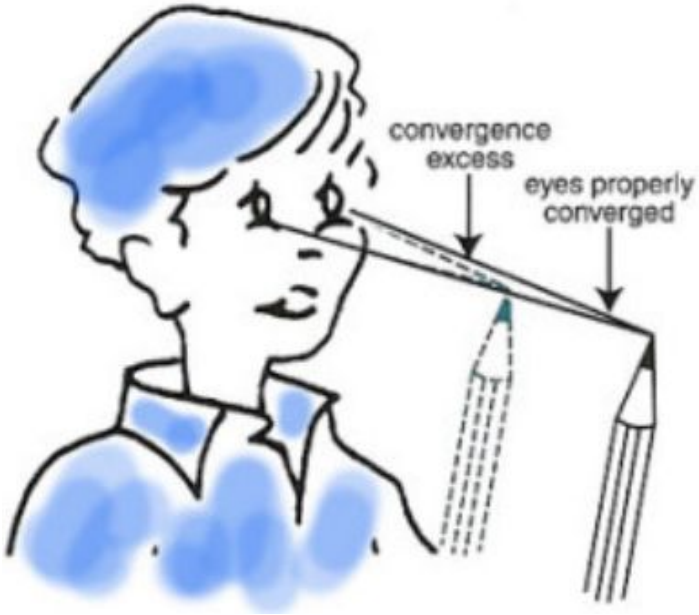


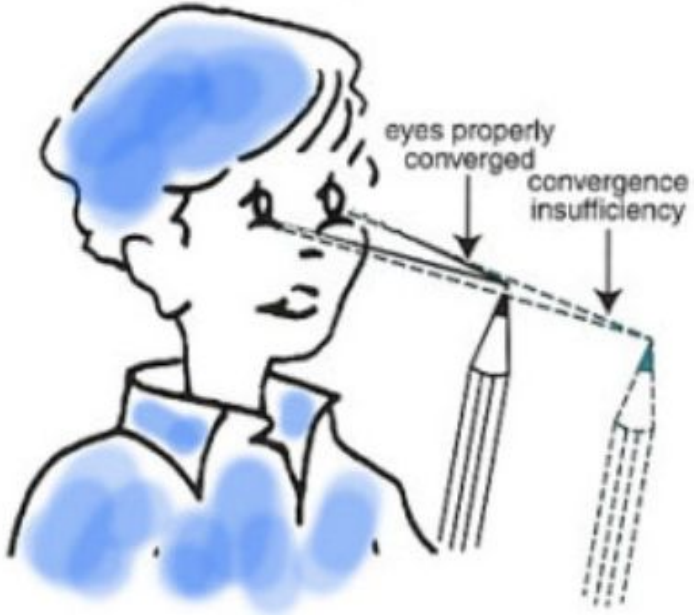
What happens when there's no actual depth, no objects to bounce off



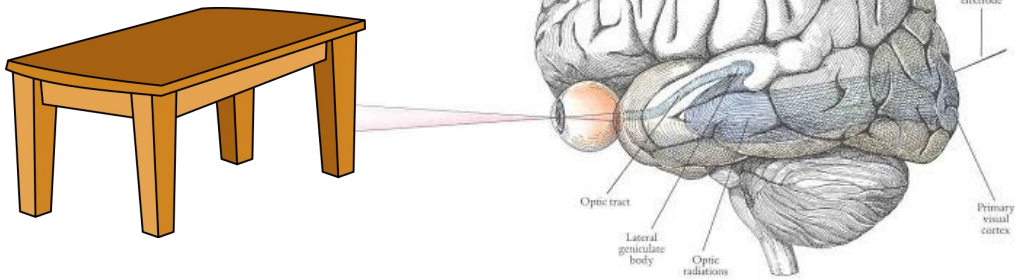
- RGB lights
- Set number of pixels
- Artificial light

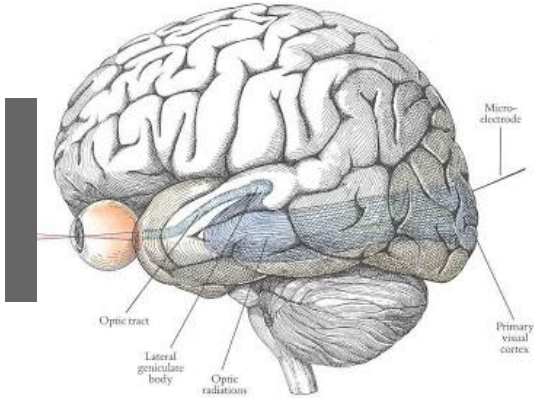
The issue with a screen world

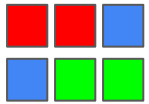


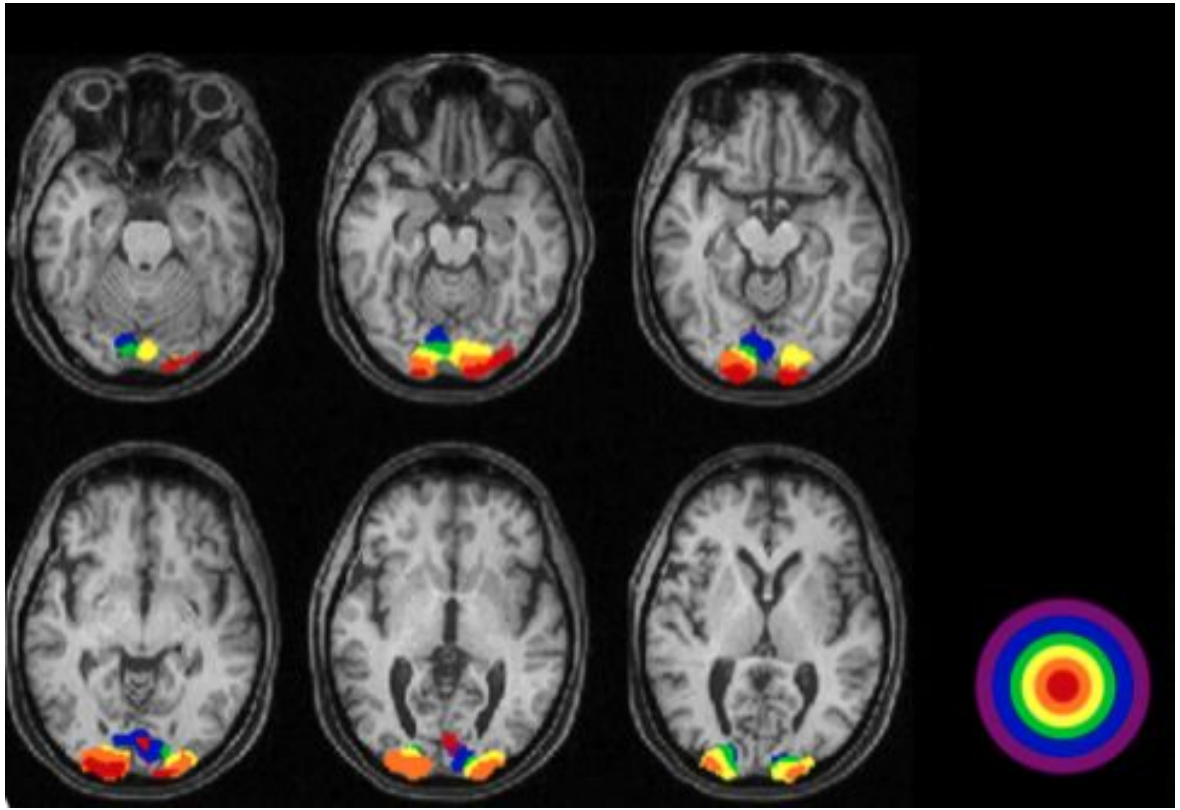


Different visual perceptions









Images provided by Jeffrey Anderson, University of Utah School of Medicine

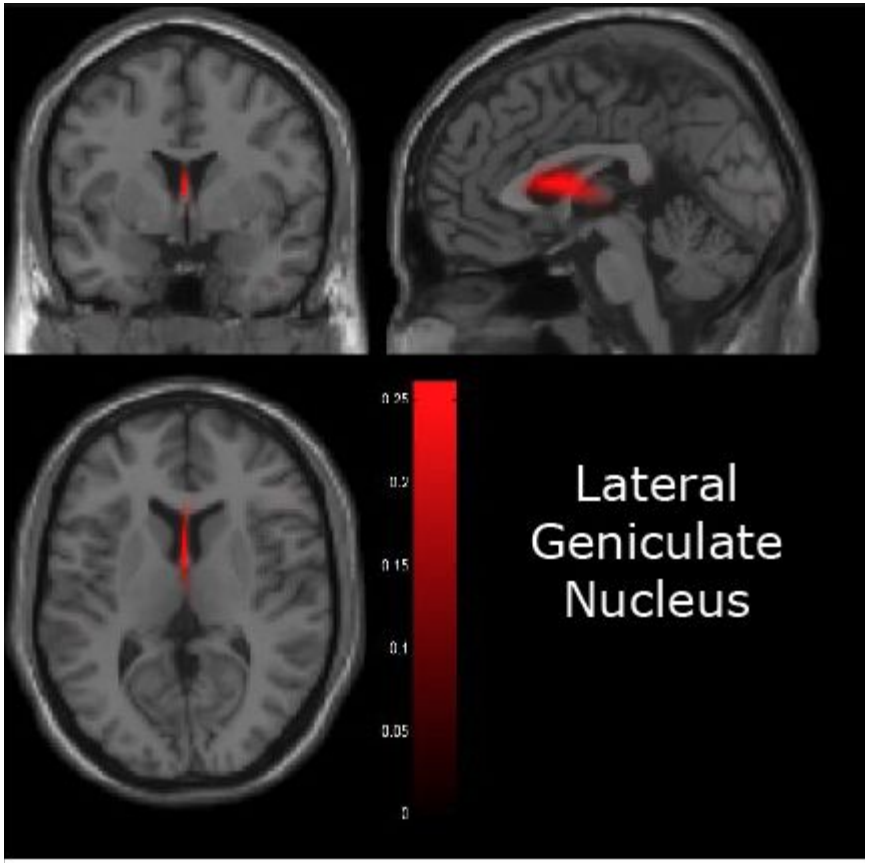


Fig. 3b. Three views of maximum EEG activity in LGN while person views a small reversing checkerbpoard pattern. Courtesy of V. Youssofzadeh, University of Ulster.

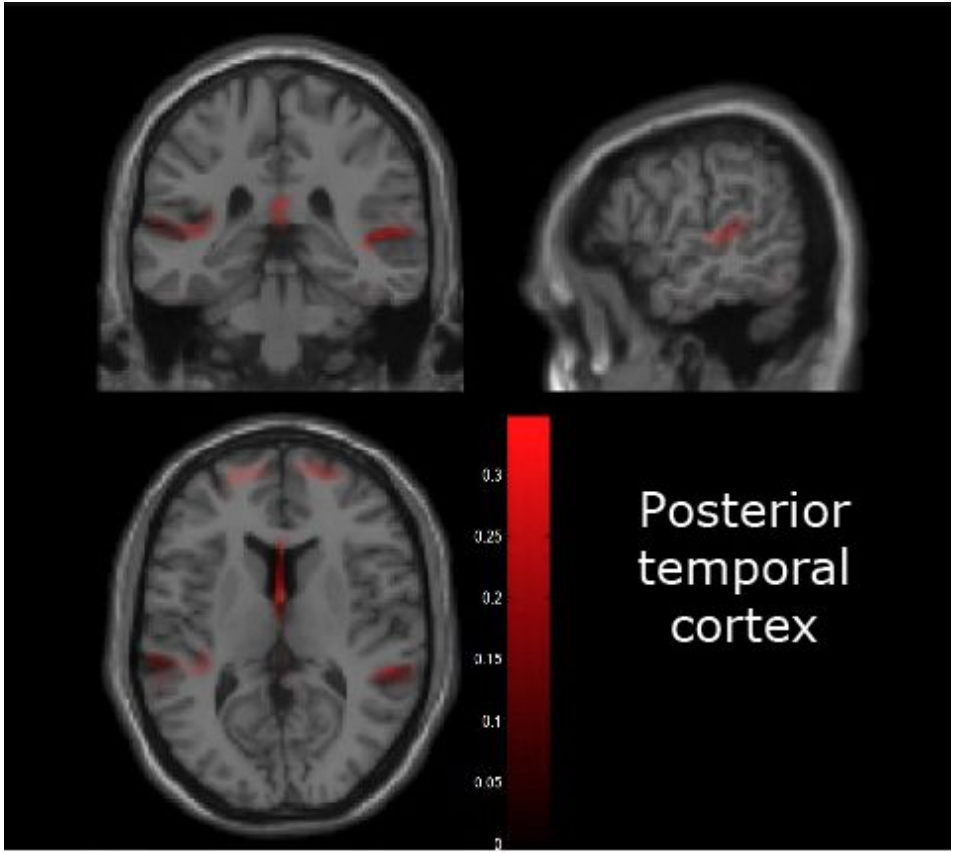
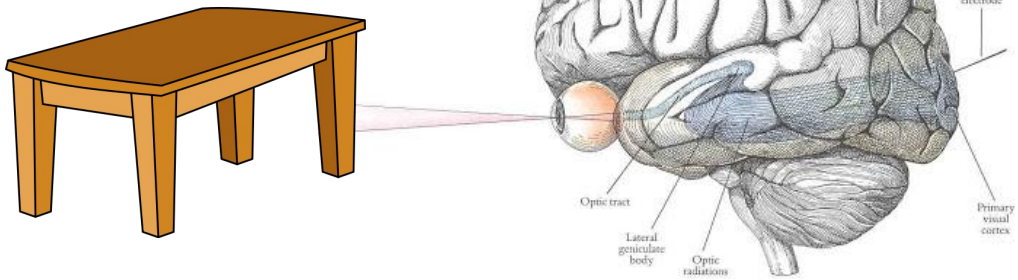
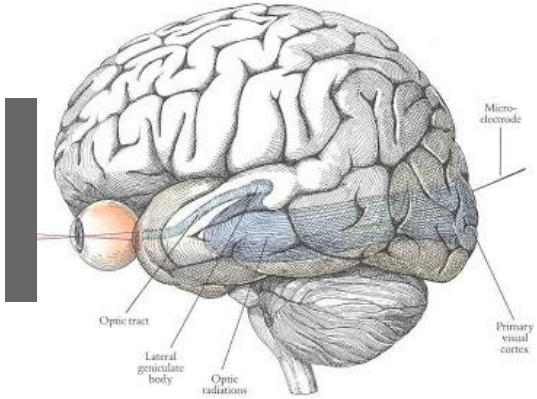
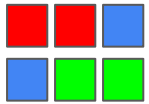


Fig. 3d. Three views of maximum posterior temporal cortex EEG activity while person watches reversing checkerboard. Courtesy of V. Youssofzadeh, University of Ulster.

Different visual perceptions







Depth Perception (visual) relies on 12 cues that get integrated and processed

The cues we rely on

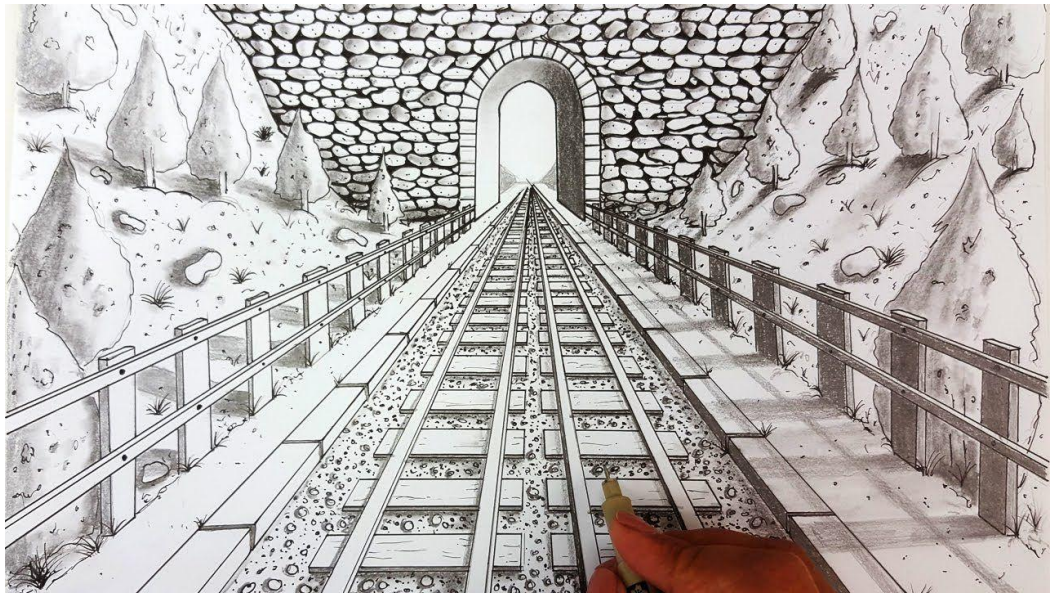
Focus (objects further away are out of focus)

Photo source: https://photographylife.com/understanding-focus-in-photography

The cues we rely on

Focus (objects further away are out of focus)

Perspective



Screenshot Source: https://www.youtube.com/watch?v=iL1N0avBDR8

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Perspective

Occlusion

Image Source: https://nianticlabs.com/blog/nrwp-update-110619/

The cues we rely on

Focus (objects further away are out of focus)

Perspective

Occlusion

Lighting, Shading, Saturation, Contrast

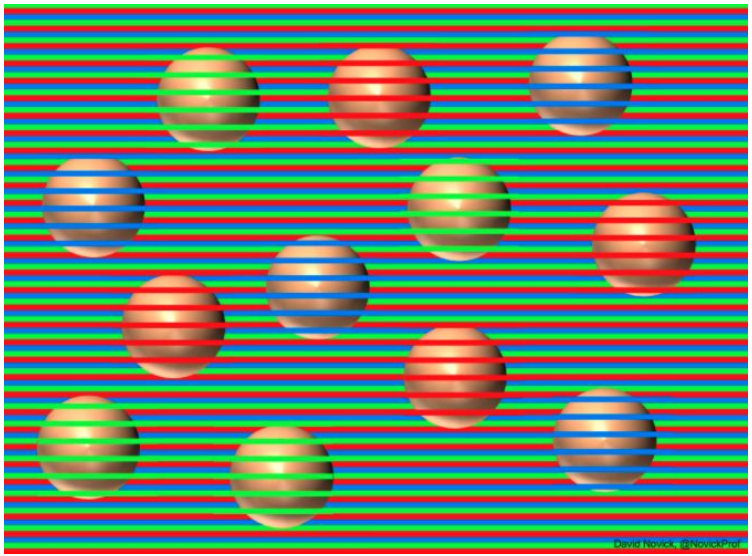

Image Credit: David Novick

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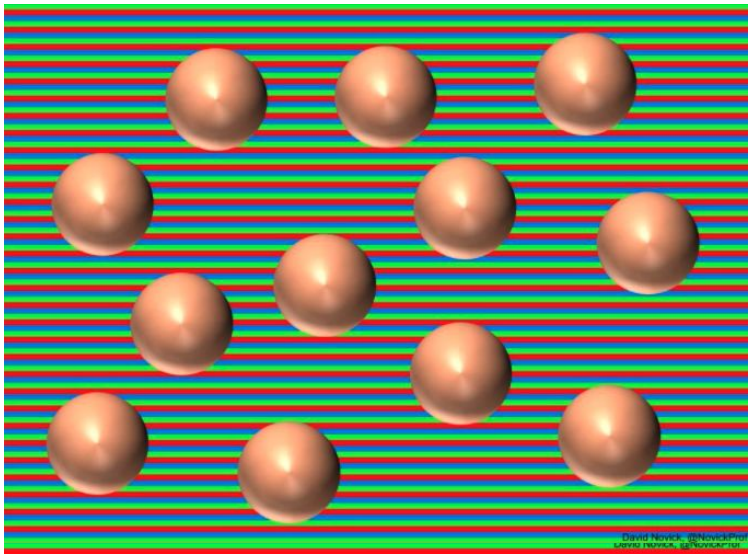

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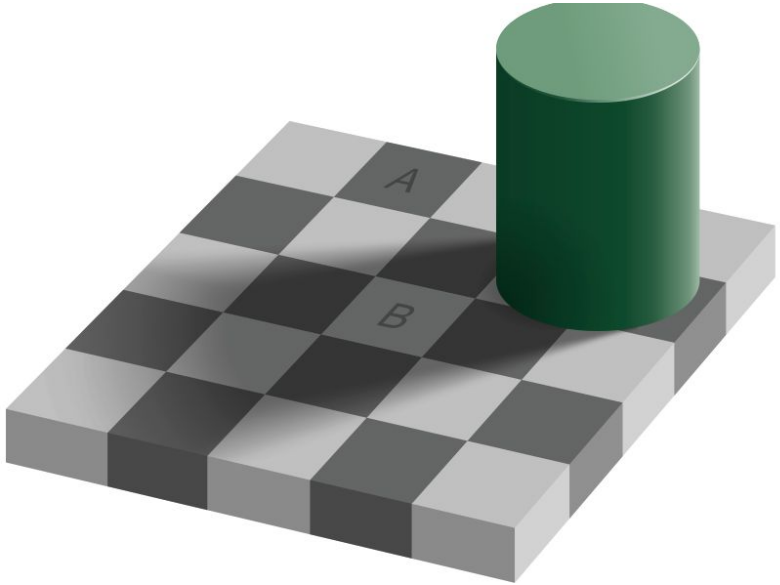

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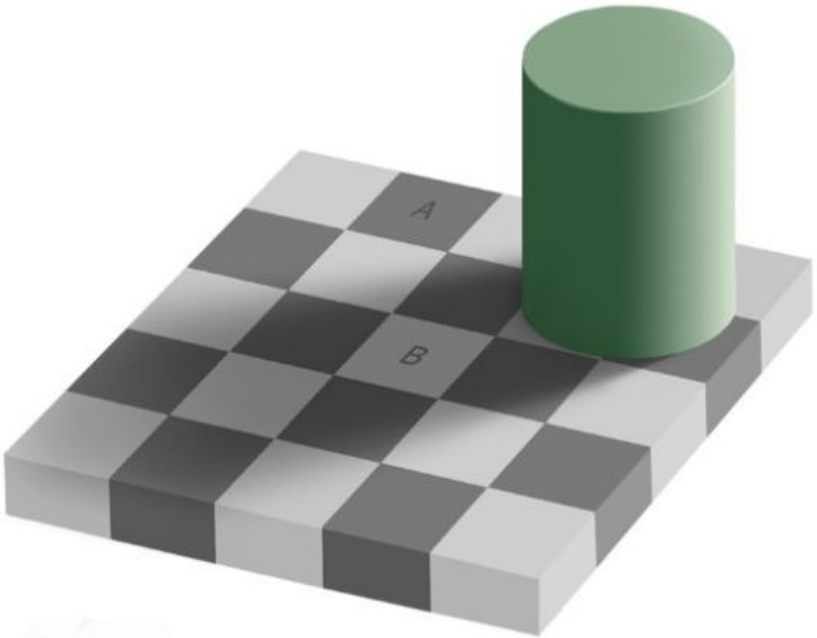

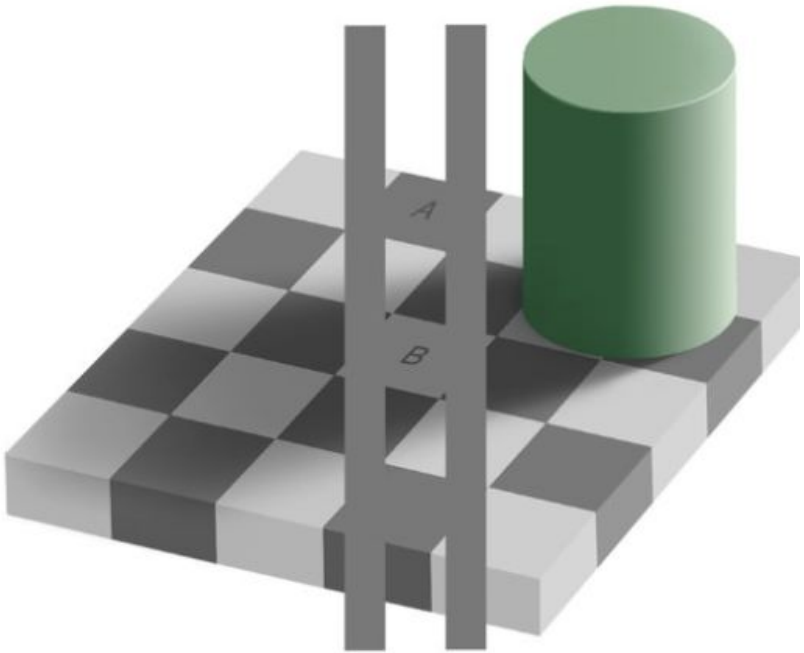

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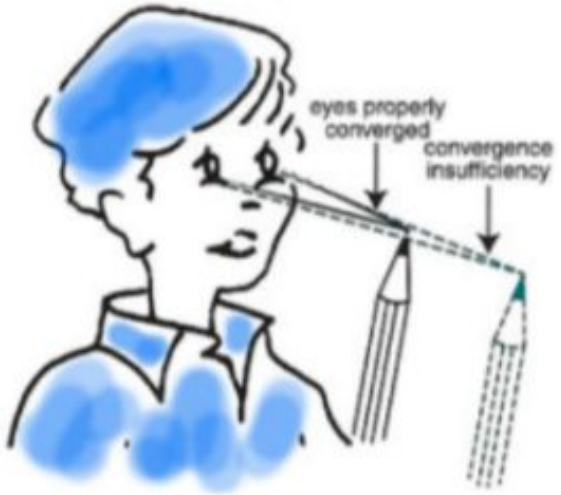
Vergence (VAE)



The cues we rely on

Focus (objects further away are out of focus)

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Vergence (VAE)

Motion cues (internal physics, motion, interceptive timing, parallax)

Stereopsis

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Image Source: VectorStock.com/25924023

Experience = memory + interaction

When our expectation of the world diverges from the information we are getting there is a conflict.

Conflicts are resolved by

- adapting schemas
- flagging this as an important exception
- or by ignoring them completely.

The more discrepancies, the more “wonky” our experience will be because our interactions are not matching up with our memory models.

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Remember something “better”

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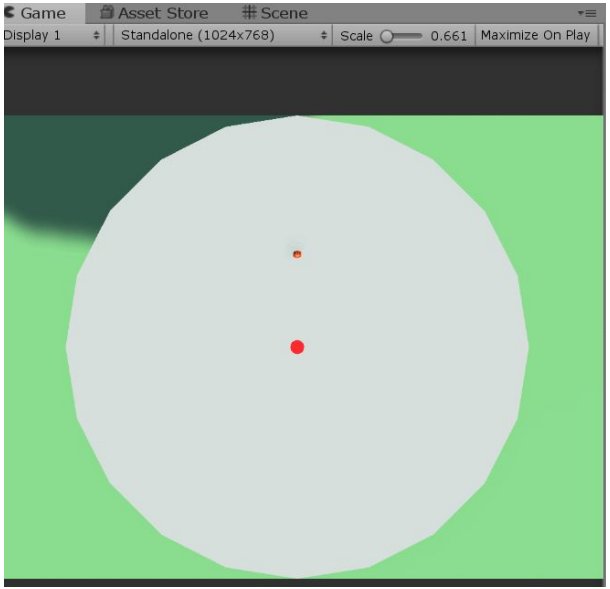
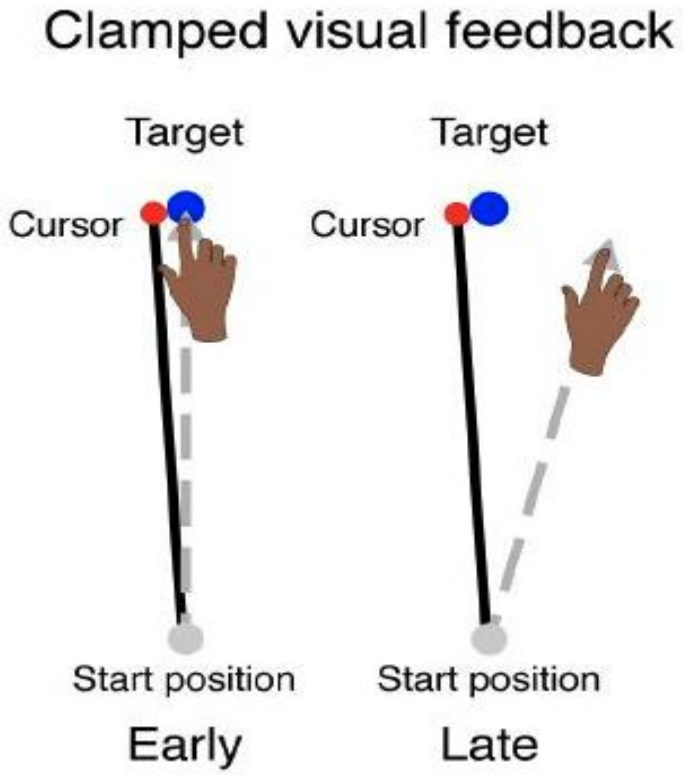
Cue Discrepancy: Visuomotor Adaptation

How does an unexpected interaction affect learning?

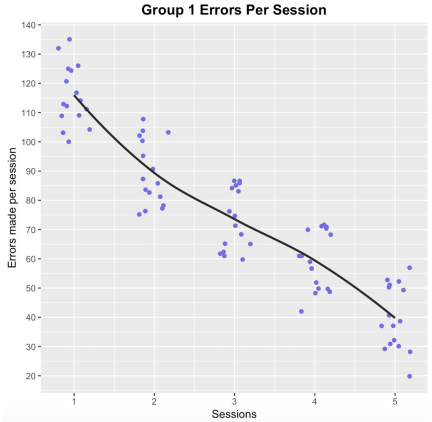


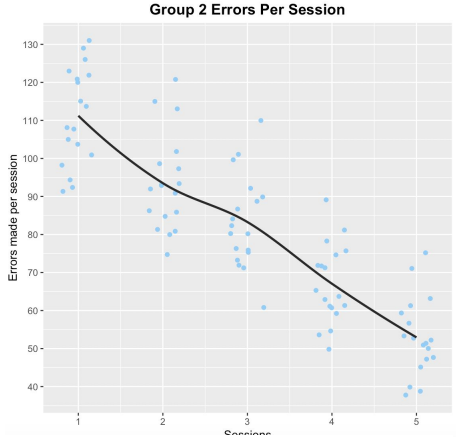


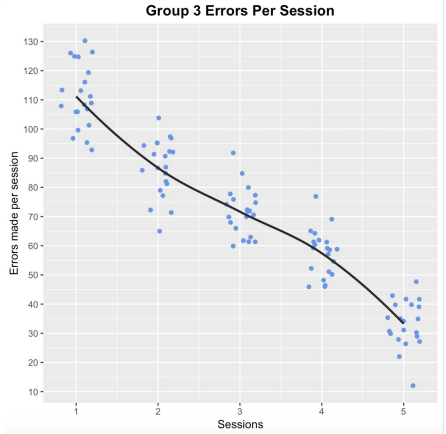
Virtual Reality sessions have resulted in “better” learnings.

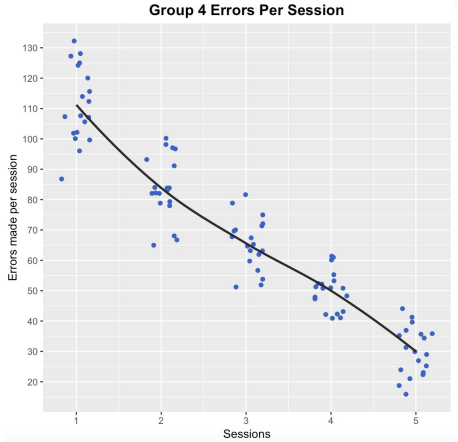
What can we learn?

What can we learn?









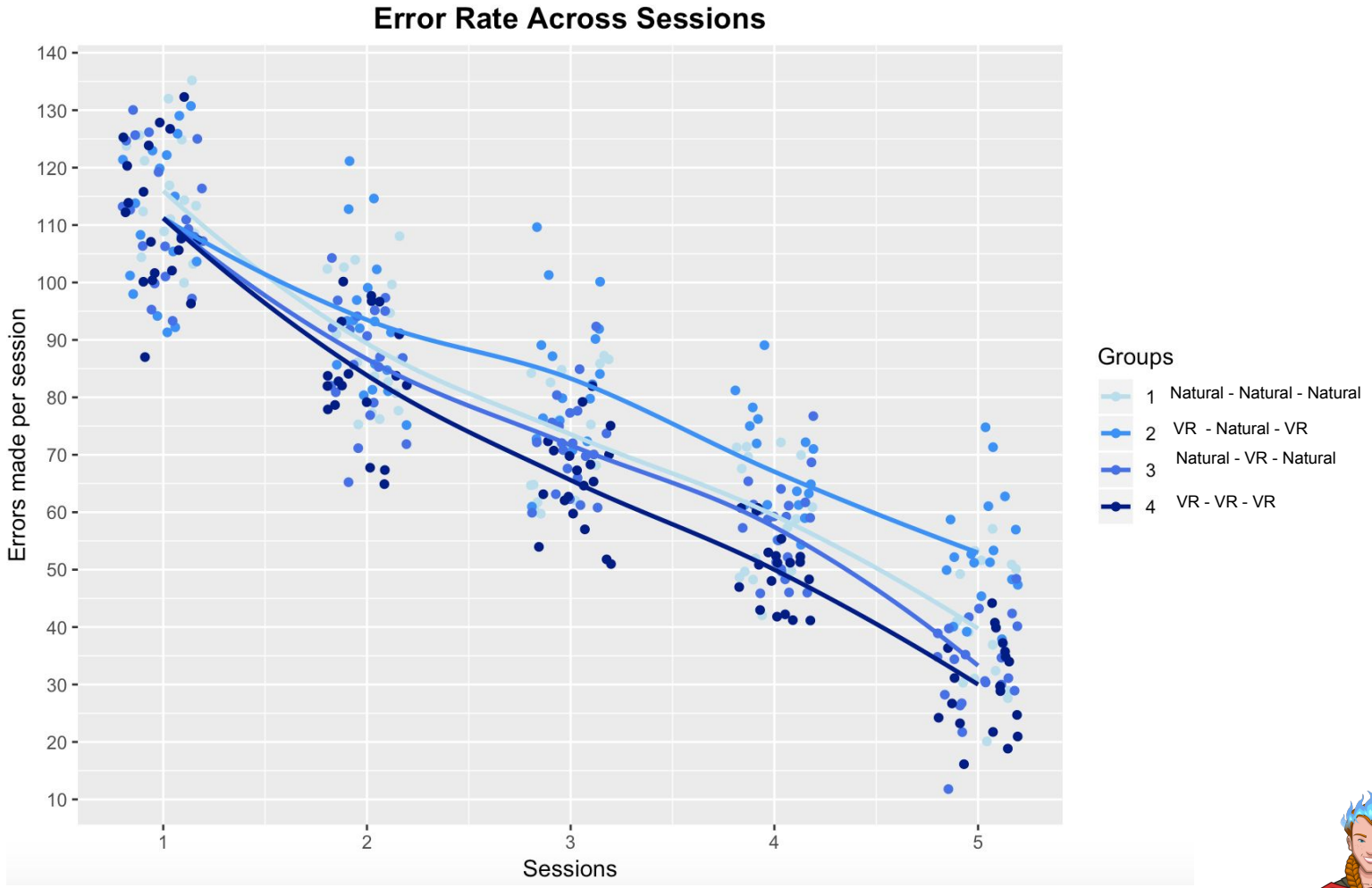
Figures read top left, to bottom right.

Figure 1. Errors made by participants in Group 1 (Natural test and trained) across the 5 sessions.

Figure 2. Errors made by participants in Group 2 (VR test, Natural trained) across the 5 sessions.

Figure 3. Errors made by participants in Group 3 (Natural test, VR trained) across the 5 sessions.

Figure 4. Errors made by participants in Group 4 (VR test and trained) across the 5 sessions.


Error Rate Across Sessions
Errors made per session
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
Sessions
Groups
1 Natural - Natural - Natural
2 VR - Natural - VR
3 Natural - VR - Natural
4 VR - VR - VR

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The more discrepancies, the more “wonky” our experience will be because our interactions are not matching up with our memory models.

Conflicts cause “breaks” in experience (a “break” of immersion, or a “break” in presence)

- **To get better presence, we match cues better.**

What cues help learning?

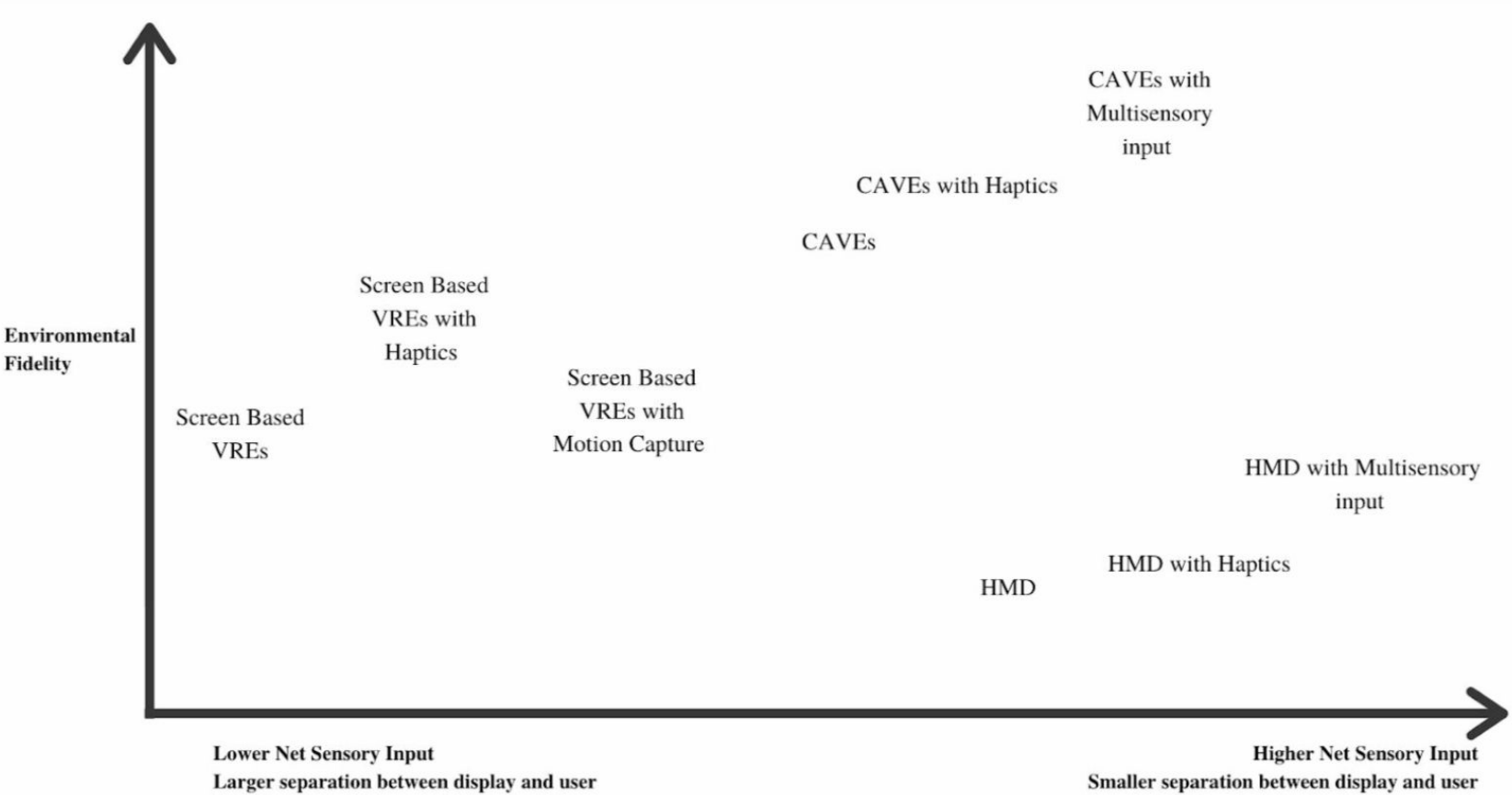
if (Experience = memory + interaction)
Presence = immersion + experience;

Every experience we have involves (and changes) your brain

What are we trying to teach our brains

- Is it math, learning to drive, catching a ball, how to stop a nuclear meltdown?

The VR Spectrum



Immersion and presence depend on matching expected cues with perceived cues.

The cues we rely on

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Perspective

Occlusion

Lighting, Shading, Saturation, Contrast

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Stereopsis

How does immersion and presence affect learning?

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- Hierarchy of motor learning (different structures)

Kording & Wolpert (2004)
- The Bayesian Brain

James Murray and Sean Escola
- eLife 2017;6:e26084

Landy, Maloney, Johnston, Young (1995)
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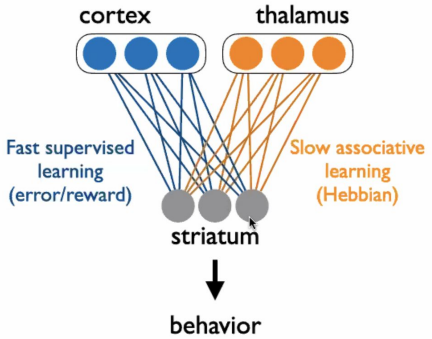

Figure from Murray and Escola (2017)

Citations - UBC Presentation

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- While motor learning paradigms may produce similar results in HMD-VR as in conventional training, they may not be accomplished in the same way.
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- During teleoperation and virtual reality experiences, enhanced haptic feedback incongruent with other sensory cues can reduce subjective realism, producing an uncanny valley of haptics.

Spatialized Audio
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Different tracts for different things

Anglin, Sugiyama, Liew (2017)

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- **flagging this as an important exception**
- or by ignoring them completely.

The **more discrepancies**, the more **“wonky” our experience** will be because our interactions are not matching up with our memory models.

Conflicts cause “breaks” in experience (a “break” of immersion, or a “break” in presence)

- To get better presence, we match cues better.

Strong learning events occur when cues match and/or follow rules.

The Important Bits (so far...)

Depth Cues

- Near, mid, far field

Continuity of cues

- Following a “laws” model

Absence of verdicial orientation (substitution of a simulated one)

- Which human visual perception is highly responsive to

Horizontal and Vertical Lines

The Important Bits (so far...)

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Resolving cue conflicts supports learning (not photorealism)

It’s not about photorealism, it’s about sensorimotor coherence.

Pathway

How we perceive Reality

How we perceive in Virtual Reality

How perception supports immersion and

How immersion and presence supports learning

Thank You!

Questions

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More Information

www.brainonsilicon.com

Call to Action

VResearch - online citizen science platform for virtual reality research

VResearch

- Unity and WebGL XP
- Researcher
- Interested in studying things using VR
- Online Databases XP

☕ I would love to chat

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