The challenges of VR

This is the fantasy…

Too often, this is the reality….

How do we get this… without that… ?

We need to understand why we get sick

- Our brains are very complex mechanisms for understanding reality
- We have lots of senses that go into understanding motion in particular
  - Vision
  - Acceleration (inner ear)
  - Proprioception (feedback from muscles)
  - Touch (wind in face, etc)

Our brains are trained and evolved to take all these cues and create one coherent understanding

- Signals from CNS to muscles are called *afference*
- Signals from CNS to CNS are called *efference*
- Confirming signals from senses to CNS are called reafference

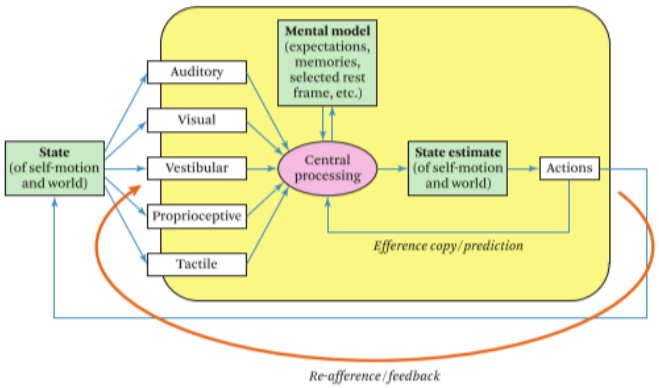


Figure 12.1 A unified model of motion perception and motion sickness. (Adapted from Razzaque [2005])

We are doing afference, efference copy and re-afference all the time without knowing it

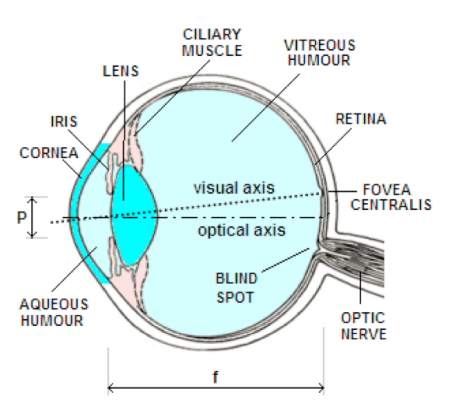
- Lets try a few experiments
  - Efference copy and triggered afference in attention focus
    - Why do you think this happens?
  - Efference copy and re-efference in eye movements
    - Why d o you think this happens?

Why do we move our eyes to focus

- Thoughts?

Human eye is mostly low-res

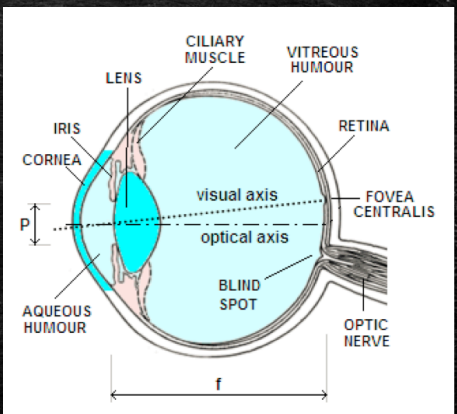
- The high-res part of the eye is the Fovea Centralis
- Its about a 2 degree arc on the retina.
- We move our eyes to scan the environment and build a mental model
- High color response, high resolution, slow response



The rest of the retina

- Gives us peripheral vision
- Much lower resolution
- Mostly black and white
- **MORE** light sensative
- **FASTER** response time

Why might our biology have evolved this way?

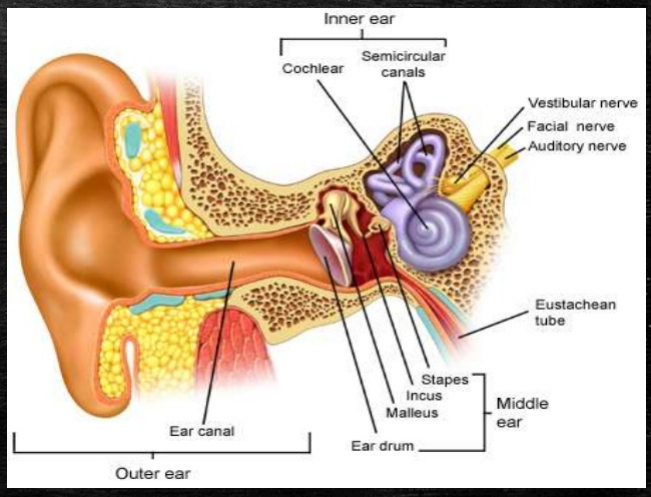


When standing still, tilt is importamnt When moving, acceleration is important

- Keeps us balanced
- How do we measure tilt and acceleration? Anyone know?

Anatomy of the ear

- Semi circular canals are almost orthogonal
- Act as tilt and acceleration sensors across x,y,z

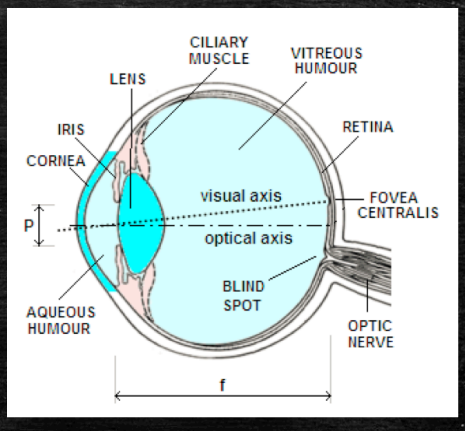


Tilt and acceleration are *reafference* signals

- We predict what they are going to tell us based on afferent movement commands passed through efference
- We test them based on reafferance of all senses
  - Esp. vision
- If they disagree, our body says "something isn't working right!"
  - Classic car sickness
  - Why might this manifest as upset stomache?

Vision and focus reafference

- We don't just use muscles in our eyes to point them
- We use muscles to deform the cornea in order to change focal length
  - Why
  - What info is this giving our brain
  - How might it conflict with other reafference?

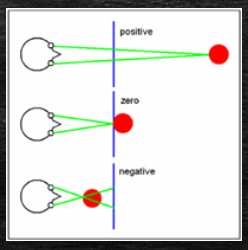


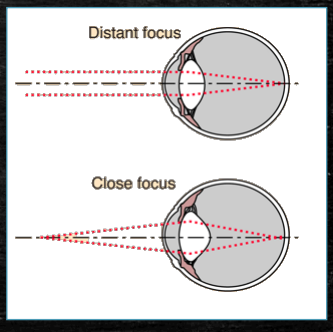
Depth perception mismatch

- Classic GUI frame
  - Flat piece of art lain over the rendered scene
- Very uncomfortable in VR
  - Why is this?
  - How could we fix this?

Stereo vision is parallax based
Focus is cornea based

- The closer something is, the more angled the eyes have to be
- The closer something is the more the cornea has to be distorted by its muscles
- Why might there be a reafference disagreement here?
- How could we fix it?





Vision and frames of reference

- Think back to our focus experiment
- One thing stayed steady in vision and one thing moved
- We call the steady object or objects a "frame of reference"
- Frames of reference are key to our visual understanding of motion
  - Why might this
- Frames of reference are strongly **psychological**
  - Moving the user rapidly through a fixed environment triggers illness
  - Moving an environment rapidly past a fixed user does not
  - Why is this? What is different about the brain's expectations?

Sometimes, however, a fixed frame can help

- A reticle fixed at the center of vision can reduce rapid motion sickness
  - Why might this be?
- An "over-the shoulder" view can also reduce motion sickness
  - Why?

Head-bob and camera shake

- MAJOR sickness inducer
  - Why? What are the afference and efference components?

Disconnects can also just cause discomfort

- In FP POV, camera motion **must** map to head tracker directly
  - Physics constraints not present in real world create discomfort
    - Why?
  - **Lag** causes discomfort and can cause sickness
    - Why is this a direct problem.? Why is it also an indirect problem?
- If hands are in environment, they should map directly to physical hand motions
  - Less likely to cause illness
    - Why?
  - Still uncomfortable if wrong

Brain maintains both external and internal models

- Internal model is called the **Neural Homonculus**
  - Sense of your own body state
- Used to maintain balance, guide motion, etc
- When neural homunculus is confused by conflicting stimuli, it vauses discomfort

Conclusion

- As human beings we are complex inferencing machines
  - We synthesize models of outside world and internal state from many senses
  - This is how we understand reality
- Virtual Reality is an attempt to take over some or all of those senses
  - If we feed them conflicting information we confuse the inferencing machine
  - When we can't understand reality on this instinctive level, we feel sick
- **To make good VR that is convincing and not sickness producing, we have to confuse the inferencing machine as little as possible**
  - Where possible, we eliminate conflicting stimulus
  - Where not possible we can try to "tilt" it to a decision by adding stimulus

Conclusion

- VR, it turns out, is a lot harder then just strapping a monitor to someone's face and tracking their head movement
- The more realistically we simulate input to the human animal, the more care we need to take not to provide confusing signals
- This is just **one** thing that makes VR hard
- There are other problems to solve to, like how to make input comfortable and intuitive.