Is there more to cybersickness than simply conflicting information between senses?

Stéphanie Dumoulin, Ph.D. cand., Stéphane Bouchard, Ph.D., Geneviève Robillard, M.A., & Christian Villemaire, B.Sc.

Cyberpsychology Lab of the University of Quebec in Outaouais (Gatineau, Québec, Canada)

Context

- In the context of another study on the impact of distraction on presence in virtual reality, we found unexpected results on cybersickness.
  - Aim of the initial study: to compare the potential of three immersive technologies (low-end HMD, high-end HMD and CAVE-like) to distract from an external and unpleasant stimuli.
- Even if this study was designed with another purpose in mind, it raise important question.

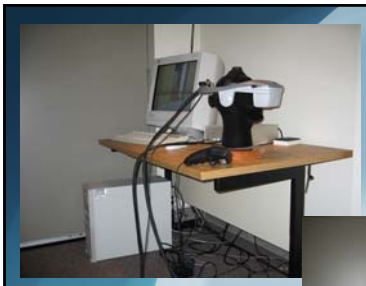
Sample

- **27** participants aged between 20 and 57 years old.
- Each were randomly assigned and performed three repeated immersions with different hardware technologies:
  - Low-end HMD, with an I-Glass **(Low HMD)**
  - High-end HMD, with a nVisor Sx **(High HMD)**
  - Three-wall CAVE-like immersive room **(CAVE)**
- Each immersion lasted four minutes in the same VR environment.

Material

- Head-mounted displays :
  - (a) an HMD of minimum quality (Low HMD)
    - » I-Glass SVGA (resolution of 800 X 600, FoV: 26 degrees)
  - (b) an high quality HMD (High HMD)
    - » nVisor SX (resolution of 1280 X 1024; FoV: 60 degrees)
- Three-wall immersive room (CAVE)
  - Rear projection system (10 feet X 10 feet X 10 feet walls)
  - CRT projectors and NuVision 3D glasses.
- Head tracking in the Low HMD condition is provided by an I-Cube (3 dof) from Intersense and forward motion is controlled with a wireless mouse.
- Motion tracking in High HMD and CAVE conditions are provided by an IS-900 and forward motion is controlled with a Wand from Intersense (6 dof).

Setup



High HMD

Wand

CAVE

Low HMD

Task for each immersion

- The task consisted in visiting a virtual apartment and gather information about the color of different objects.
- After the first minute of immersion an electric sander (disturbing background noise) was heard continuously at 90 db for the rest of the immersion.
- After each immersion, the participant had to physically walk into another room to proceed to the following immersion.

Questionnaires

- The Simulator Sickness Questionnaire was filled prior and after the experiment and brief cybersickness ratings using a 100% Subjective Units of Discomfort Scale were conducted immediately after each immersion.

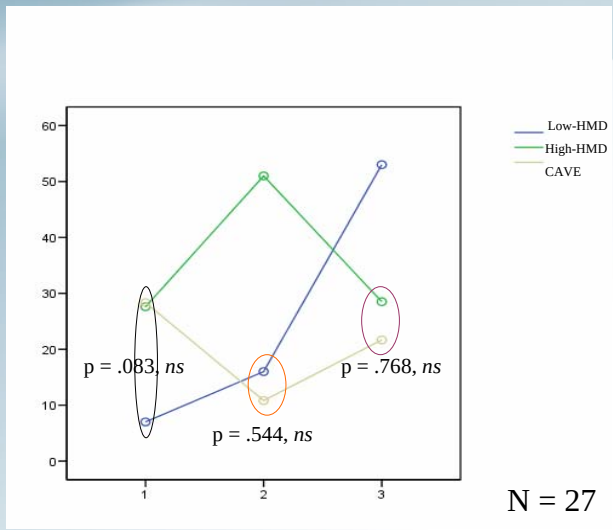
Hypotheses about cybersickness

- Based on the « sensory conflict » theory:
  - Three hypotheses can be predicted :
    - (a) cybersickness would be greater in the HMD with the widest field of view;
    - (b) the CAVE-like system would induce more cybersickness than the HMDs;
    - (c) there should be a progressive increase of cybersickness over the three immersions.

Results

H1. Cybersickness is greater in the HMD with the widest field of view.

As shown, interaction contrasts revealed in the three occasions where the low and high quality HMDs were used, the symptoms were higher (but *ns*), with the HMD with the largest FOV.



N = 27

Results

H2. The CAVE-like system will induce more cybersickness than the HMDs.

Interaction contrasts:

Immersion 1 :

MIN vs MAX vs CAVE :

MIN vs CAVE = *ns*

MAX vs CAVE = *ns*

Immersion 2 :

MIN vs MAX vs CAVE :

MIN vs CAVE = $p < .001$

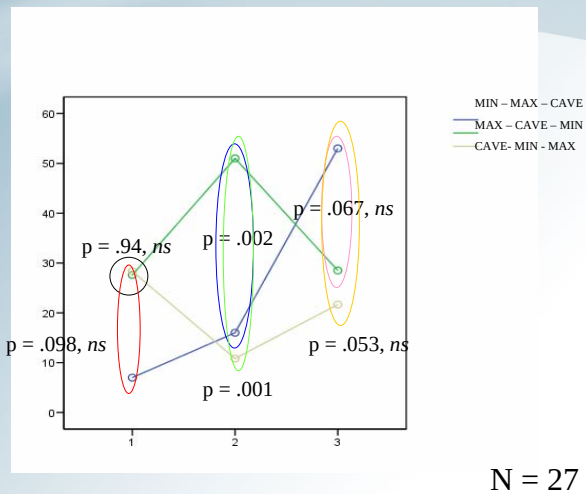
MAX vs CAVE = $p < .01$

Immersion 3:

MIN vs MAX vs CAVE :

MIN vs CAVE = *ns*

MAX vs CAVE = *ns*



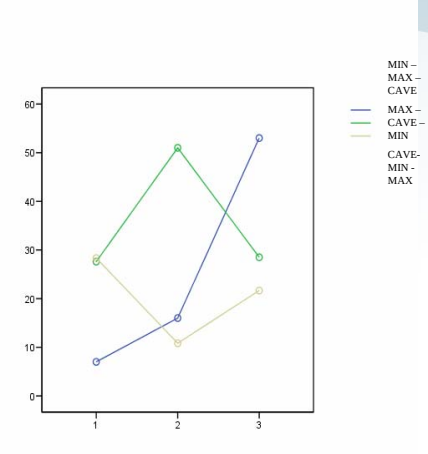
N = 27

Results

H3. There is no progressive increase of cybersickness over the immersion

Repeated mesures ANOVA:

- Time effect : F(2,48) = 4.89, *p < .05*
- Group effect : F (2,24) = 1.12, *ns*
- Interaction effect : F(4,48) = 11.64, *p < .001*



N = 27

Results

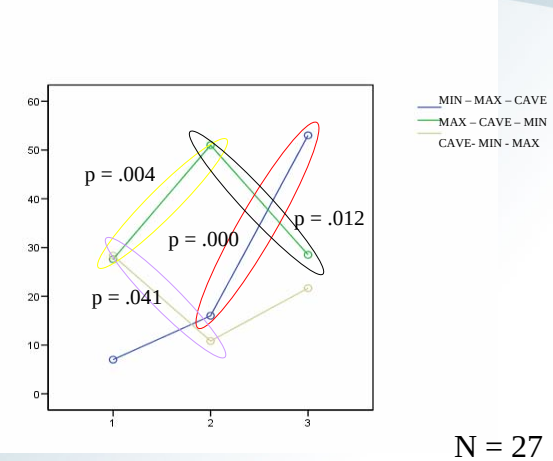
H3. There is no progressive increase of cybersickness over the immersion.

Interaction contrasts :

MIN vs MAX vs CAVE :
MIN vs MAX = *ns*
MAX vs CAVE = *p < .001*

MAX vs CAVE vs MIN :
MAX vs CAVE = *p < .01*
CAVE vs MIN = *p < .05*

CAVE vs MIN vs MAX :
CAVE vs MIN = *p < .05*
MIN vs MAX = *ns*



N = 27

Discussion

- Based on the sensory conflict theory, a steady increase in symptoms is to be expected since each immersion causes conflicts between senses, each return to *in vivo* doesn't allow to readapt to normal functioning and further immersions and return to *in vivo* are imposed to the participant.
- This was not the case. The CAVE-like system always caused more symptoms, even when is was followed by additional immersions.
- Can the Postural Stability theory (Riccio & Stoffregen) offers an better explanation?
  - Being immersed in a CAVE-like system is in itself more challenging for maintaining postural stability than HMD technology. Our results would therefore not be related to an incremental build-up of conflicts between the senses but to challenges in maintaining balance that are imposed by each specific technologies.

Conclusion

- Even if this study was designed with another purpose in mind, it questions the simple relationship between the intensity of virtual reality induced side effects and having to adapt to conflicts among sensory systems.
- Results are more consistent with factors specific to each VR systems.
- Given the methodological limitations, alternative explications cannot be ruled out, such as the lack of a completely random assignment or differences in the equipment used.