

**Cybersickness during VR gaming undermines game
enjoyment: A mediation model**

Caglar Yildirim PhD

Arman, Irem, Ryan

Talk Outline

- Introduction and Related Work
 - Problem Statement
- Experiments
 - Between-Subjects Experiment (1)
 - Within-Subjects Experiment (2)
- Discussion and Conclusion
 - Findings
 - Future research



VR has been *the next new thing* for five years and counting.

Here's why virtual reality still hasn't taken off, despite being around for nearly 2 decades

FORTUNE

The fall and rise of VR: The struggle to make virtual reality get real

Virtual reality has been the next new thing for five years and counting. Clunky headsets, a dearth of content, and lack of consumer interest have caused VR to stall. Can this much-hyped technology finally catch on?

Four Reasons VR Gaming Still Isn't Mainstream

By SIMON SPAULL - Jul 24, 2019

Virtual reality will take off, but only when it gets over a host of barriers to the mass-market.

MINUTE-HACK

3 big reasons VR failed to revolutionize PC gaming



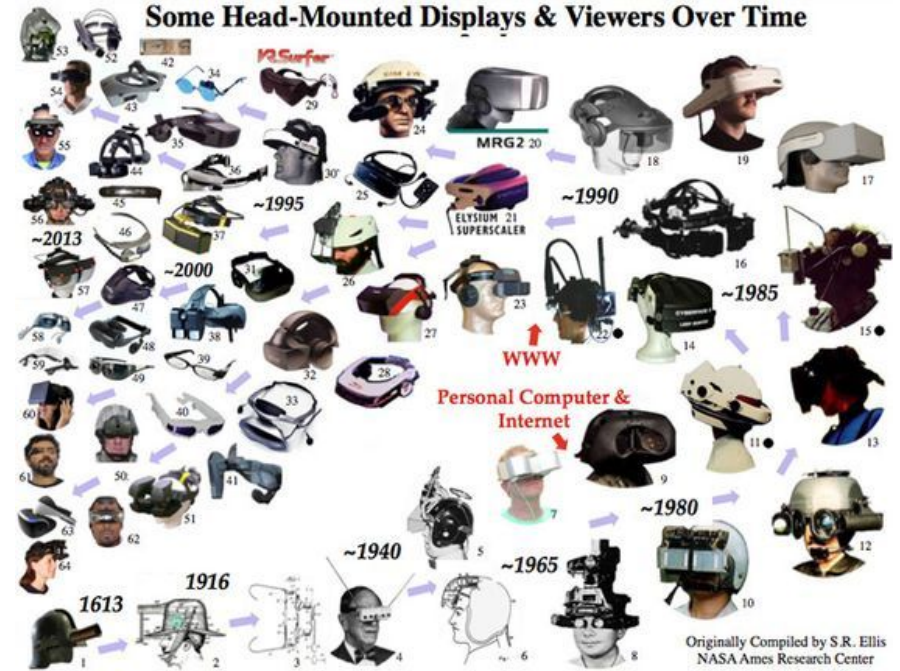
With a lower profile at this year's E3, virtual reality may not be the game-changer some expected.

Introduction & Related Work

Availability and affordability of virtual reality head-mounted displays



- Research
- Military
- Healthcare
- Education
- Entertainment
 - Gaming industry, in particular, witnessed the massive adoption to VR technology



“While the increasing number of video games designed for VR or providing VR support bodes well for the future of VR as a gaming console, **human factors issues** inherent in VR technology represent **a barrier** to its moving closer into the mainstream.”



Cybersickness

- Unwanted side effects that arise from exposure to virtual environments
- Characterized by a combination of symptoms related to:
 - Nausea
 - Neurovegetative changes
 - General discomfort
 - Increased stomach awareness
 - Disorientation
 - Dizziness
 - Vertigo
 - Difficulty in concentrating
 - Oculomotor
 - Eye strain problems
 - Headache
 - Fatigue
 - Disturbances related to eyeball and eyelid movement

Sensory Mismatch Theory

Cybersickness



Conflict between visual and vestibular systems

Related work

Displays and cybersickness

likelihood and intensity of cybersickness depends on ***the display on which the VE is projected.***

HMD (Head Mounted Displays) are worst in comparison to CAVE, desktop, or theater displays.

Related work

Displays and cybersickness during gameplay

Two experiments -- participants played a video game while sitting or standing and reported cybersickness levels

Used a third-person shooter game (*Whacked*) & a first-person shooter game (*Halo*)

Considerable level of cybersickness, with greater intensity in standing conditions than in seated conditions

Related work

Displays and game enjoyment

The display used to play a video game -- important factor affecting game enjoyment

Comparison in VR gaming on Oculus Rift HMD to desktop gaming

Tower defense game

enjoyment levels were higher for VR

Comparison in VR gaming on (1) desktop, (2) Oculus Rift, (3) HTC Vive

FPS game

no significant different across game enjoyment

Problem Statement

- Despite the rising popularity of VR gaming and prevalence of cybersickness during VR gaming, empirical studies examining the putative effect of cybersickness on VR gaming experience are still scarce so this article aims to provide empirical data on cybersickness and game enjoyment
- Overall previous research has been inconsistent on the relationship of display type and cybersickness as well as cybersickness and game enjoyment. Therefore there is a need for a strong evidence based model of the relationship between displays, cybersickness, and game enjoyment.

Experiments

Hypotheses & Goals

Hypotheses

- VR displays create more cybersickness
- Cybersickness decreases enjoyment
- VR displays increase enjoyment

Goals

- Determine the relationship between display, cybersickness, and enjoyment
- Develop a statistical model for this relationship

Mediation Model

C. Yildirim

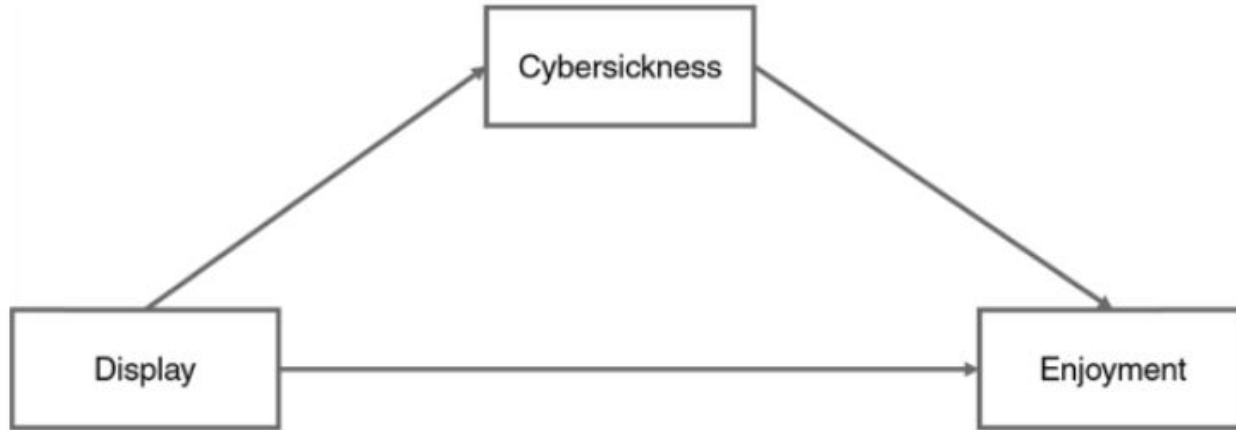


Fig. 1. The proposed mediation model for the effect of display on game enjoyment through cybersickness.

Hypothesized Mediation Model

C. Yildirim

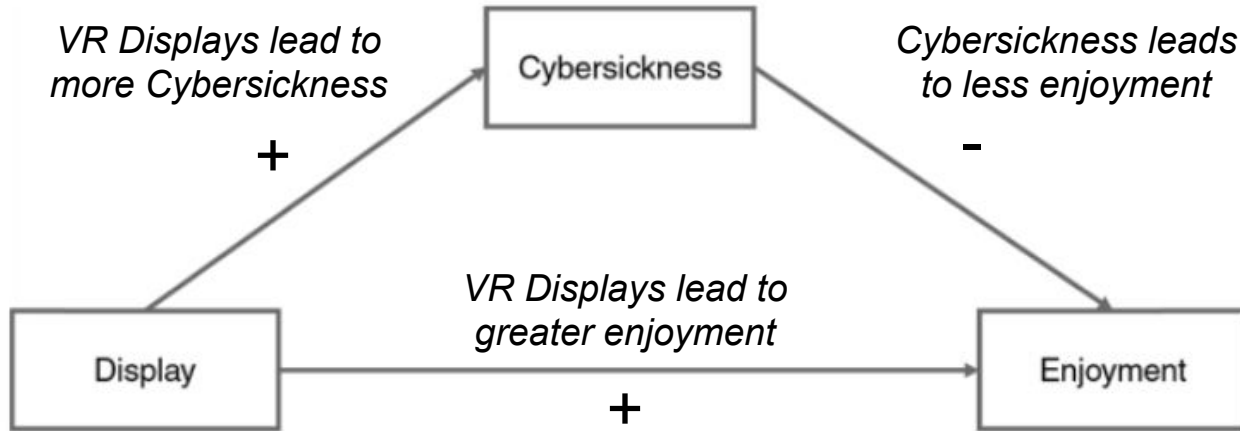


Fig. 1. The proposed mediation model for the effect of display on game enjoyment through cybersickness.

How do you prove a mediation model?

- Show a statistical link! Develop an experiment.
 - Independent variable
 - Type of display: Desktop or VR HMD (Head Mounted Display)
 - Dependent variables
 - Cybersickness
 - Operational Definition: Score on Simulator Sickness Questionnaire
 - Enjoyment
 - Operational Definition: Score on Game Enjoyment Scale
- Goals
 - “Fill in the blanks” of our proposed mediation model.
 - Exactly how much cybersickness is caused by a VR display?
 - How much of the variance in enjoyment is attributed to cybersickness?
 - If cybersickness was not a factor, how much more enjoyment would our model predict?

How do you ensure correctness?

- Run the same experiment with different but equivalent procedures
 - Experiment 1
 - Between-subjects design
 - One Xbox controller
 - Racing game
 - Experiment 2
 - Within-subjects design
 - Xbox controller for Desktop, VR controller for HMD
 - First-Person-Shooter game

Experiment 1

- Participants
 - 16 male 16 female
 - Average age: 22
 - Groups self reported their “gaming” experience to ensure experimental and control groups did not have a significant difference in experience.
- Setup
 - They used a standard 24in desktop and a Oculus headset. Both groups used an Xbox controller.
 - Participants played Asseto Corsa, a racing game

Experiment 1 Results

- Mann Whitney U test was used to determine that in comparison with desktop displays, VR displays led to significantly more cybersickness.
 - In the most significant areas: nausea and disorientation
- Same test also revealed that the display had no significant effect on game enjoyment (shock and horror!)
 - However, this can be explained by the fact the cybersickness accounts for less game enjoyment, and so the benefits of the VR display are cancelled out by the detrimental effects of cybersickness.

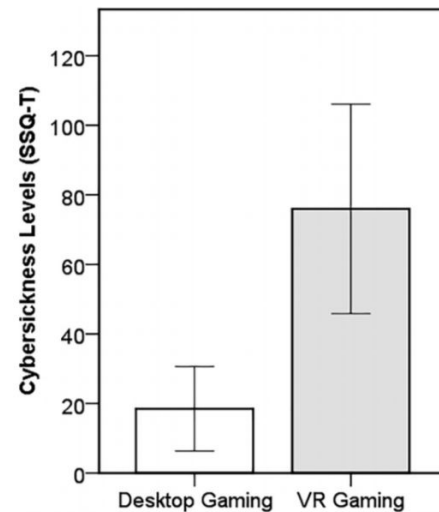
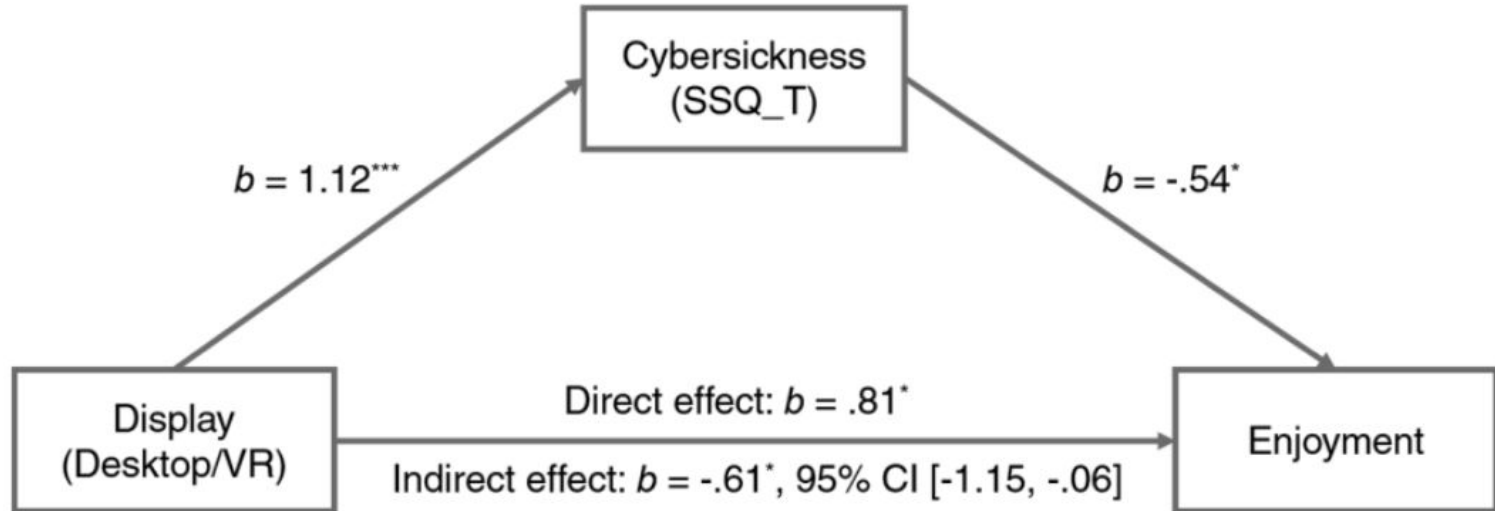


Fig. 2. Bar graphs showing cybersickness levels as a function of display in Experiment 1. Error bars represent 95% confidence intervals.

Experiment 1 Mediation Model



Experiment 1 Takeaways

“The direct effect of display on game enjoyment, after controlling for cybersickness, was significant, indicating that VR gaming was found to be more enjoyable when the effect of cybersickness on game enjoyment was statistically removed.”

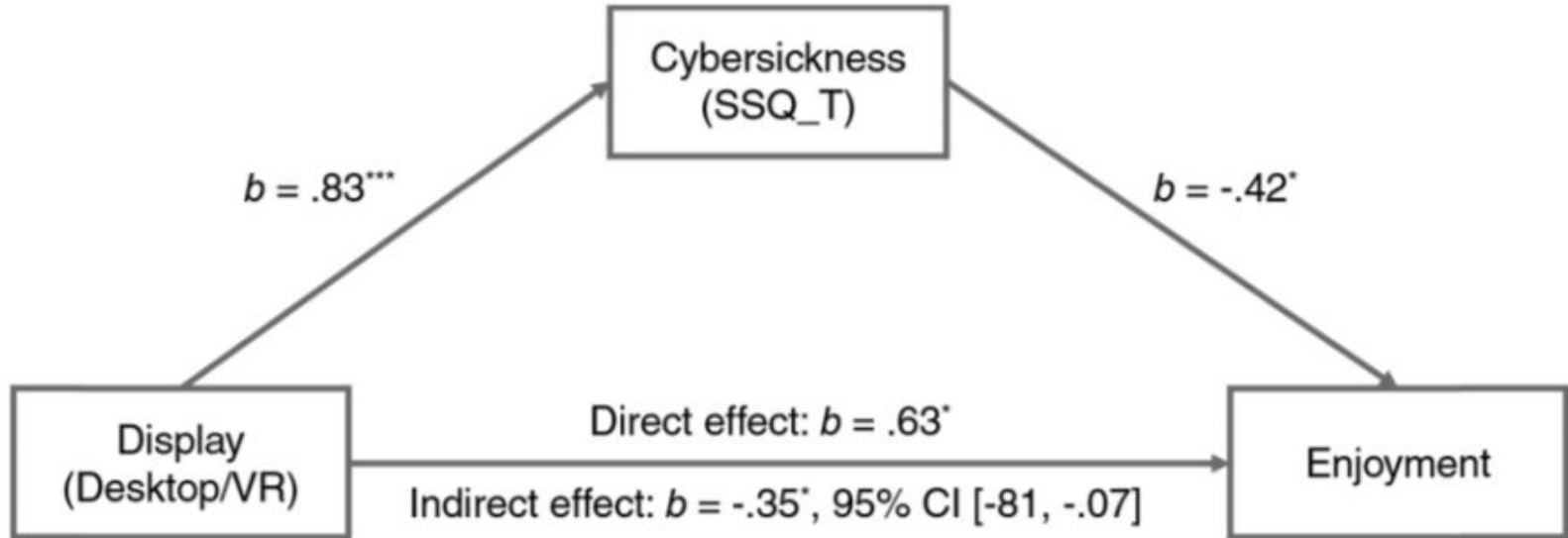
Experiment 2

- Aims to replicate the results in Experiment 1
- Participants
 - 40 participants with an average age of 20 (SD = 1.91).
 - 19 male, 21 female
- Setup
 - They used a standard 24in desktop and a Oculus headset.
 - The desktop display was paired with an Xbox controller, while the HMD had special VR controllers (oculus touch).
 - Participants played War Robots: The Skirmish VR, a first person shooter

Experiment 2 Results

- Similar statistical tests were used; confirming the results from Experiment 1
- Display did not have a significant effect on game enjoyment, but it was found that it did have a significant effect on cybersickness, which in turn had a significant effect on enjoyment (as explained by the mediation model)
- Display alone accounts for 17% of the variance in cybersickness

Experiment 2 Mediation Model



Experiment 2 Takeaways

- Experiment 2 successfully replicated the results from Experiment 1, supporting the mediation model developed from Experiment 1
- Despite changes to variables such as game genre, controller, and experiment design, the conclusions hold:
 - Display accounts for a significant increase in cybersickness
 - Cybersickness levels significantly predicted lower enjoyment levels
 - Display (without the mediator variable) did not significantly affect enjoyment
 - However, through cybersickness, it was shown that display does have a significant indirect effect.
 - “The total effect of display on enjoyment levels (in the absence of the mediator variable) was not statistically significant... On the other hand, there was a statistically significant indirect effect of display on enjoyment levels through cybersickness, $b = -0.35$, $SE = 0.19$, 95% BCa CI $[-0.81, -0.07]$. The indirect effect was considerably large, $\kappa^2 = 0.18$, $E = 0.09$, 95% BCa CI $[0.04, 0.38]$.”

Discussion & Conclusion