

Stumbling into Virtual Worlds. How Resolution Affects Users' Immersion in Virtual Reality and Implications for Virtual Reality in Therapeutic Applications

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Abstract

Studies of how users experience Virtual Reality (VR) have thus far failed to address the extent to which rendering resolution and rendering frame rate affect users' sense of immersion in VR, including applications of VR involving simulators, treatments for psychological and mental disorders, explorations of new and nonexistent structures, and ways to better understand the human body in medical applications.

This study investigated if rendering resolution affected users' sense of immersion in VR. This was conducted by comparing the responses of two groups, relative to two measures of participant immersion: (a) participant's sense of presence and (b) participant's sense of embodiment. The treatment levels were (a) low 512 pixels per inch (ppi) and (b) high 2048 ppi rendering resolution. One potential moderating variable, game type, varied over three levels: narrative, objective, and situational. The participants were randomly assigned to a treatment level account for previous VR experience, neither participants nor the research observer knew the treatment level. Measurements were collected after each game via an Immersion tendency Questionnaire after each game. For each dependent measure, sample descriptive statistics—mean (M) and inter-quartile range (IQR) with a conventional significance level of 0.05—were evaluated to conclude the results. Data indicated that the rendering resolution did not affect user immersion, but the game type did affect immersion and the situational game type was determined to be significantly more immersive than the other game types.

Keywords: Virtual Reality, Immersion, Resolution, Therapeutic, Environment, Video Game

Objectives

RESEARCH GOAL: Investigate how rendering resolution impacts VR users' sense of immersion.

RESEARCH QUESTIONS: How does rendering resolution affect users' sense of immersion? Does the treatment effect vary with game type?

Key terms:

Embodiment: The degree to which users feel their bodies are inhabiting a virtual avatar.

Immersion: The degree to which a user regards a virtual environment as a satisfactory simulacrum for reality. This includes the degree to which virtual stimuli, objects, and interactions with the simulation seem real, natural, and intuitive. Indications to this effect include natural, engaging reactions like flinching, dodging, reaching out to grab something, and verbal reactions to stimuli.

Presence: The degree to which users feel they are experiencing a real and reactive environment.

Rendering Resolution: an image's quality, measured in pixels per inch (ppi).

Virtual Reality (VR): A medium that creates virtual realities.

Knowledge gap: Ambiguity in the research over what 'gaming technicalities' are important.

Methods

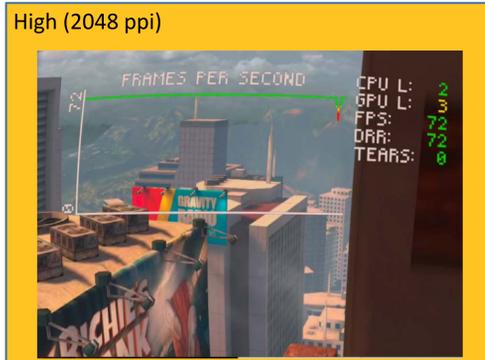
1. Play through Oculus First Contact to get acclimated to VR.
- 2a. Play through the situational game: Richie's Plank Experience, and then filled out an Immersion Tendency Questionnaire about the experience.
- 2b. Play through the objective game: Oculus First Contact, and then filled out an Immersion Tendency Questionnaire about the experience.
- 2c. Play through the narrative Game: Ghost Giant, and then filled out an Immersion Tendency Questionnaire about the experience.
3. Debrief.

Repeated for 31 participants – all games were played at their randomly assigned low or high resolution, and the games' order (2a – 2c) were randomly assigned

For the dependent measure, overall and per-game-type sample descriptive statistics—mean (M) and inter-quartile range (IQR)—were tabulated by treatment level (Table 3).

RQ1 was addressed by analyzing differences between low- and high-resolution VR experiences in summary statistics and distributions of overall presence and embodiment scores.

RQ2 was addressed by analyzing differences between high- and low-resolution VR experiences in summary statistics and distributions of immersion scores across game-type conditions. RQ2 was also addressed by looking for different patterns of means and medians between treatment levels in the interaction plots.



Equipment: Oculus Quest 2 and Oculus Touch Controllers.



Results

Comparison of High and Low Resolution Participant Immersion

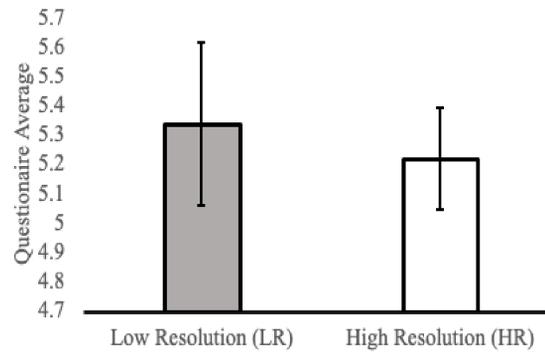


Figure 1. Reflects Table 1, illustrating the distribution.

	Low Resolution (LR)	High Resolution (HR)
Mean	5.341543514	5.22044335
Variance	1.092815199	0.474704638
Observations	14	16
Pooled Variance	0.761684542	
Hypothesized Mean Difference	0	
df	28	
t Stat	0.379158279	
P(T<=t) one-tail	0.353715279	
t Critical one-tail	1.701130934	
P(T<=t) two-tail	0.707430559	
t Critical two-tail	2.048407142	

Table 1. T-Test: Two-Sample Assuming Equal Variances. Gives the results of T-Tests that compare the high- and low-resolution groups. An overall p-value of 0.71 was computed from the T-test.

Situational and Narrative Game Type

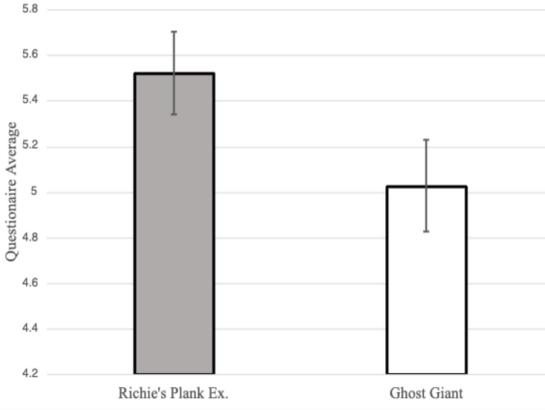


Figure 2. Reflects Table 2, illustrating the distribution.

	Richie's Plank Ex.	Ghost Giant
Mean	5.521851852	5.027222222
Variance	0.97995303	1.233380907
Observations	30	30
Pearson Correlation	0.567031937	
Hypothesized Mean Difference	0	
df	29	
t Stat	2.755668793	
P(T<=t) one-tail	0.005008655	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	0.01001731	
t Critical two-tail	2.045229642	

Table 2. T-Test: Paired Two Sample for Means. Compares the situational game, Richie's Plank Experience, and the narrative game, Ghost Giant. A p-value of 0.01 was computed from the comparison.

Treatment Level	Game Type	M(Average)	IQR(Q3 – Q1)
Low	Overall	5.39	3.00
	Situation	5.51	1.65
	Objective	5.18	1.45
	Narrative	5.33	1.80
High	Overall	5.16	3.00
	Situation	5.40	1.35
	Objective	5.35	1.43
	Narrative	4.73	1.40

Table 3. Descriptive sample statistics for response variables; summarizes the participants' data.

Discussion

- The calculated p-value of 0.71 shows no statistical significance, so we cannot reject the null hypothesis. The difference between the average immersion values for low- and high-resolution experiences was insignificant. (Figure 1 & Table 1)
- The calculated p-value of 0.01 shows statistical significance, so we can reject the null hypothesis. The impact of game type on people's sense of immersion proved significant. (Figure 2 & Table 2)

Limitations

- Rendering resolution vs frame rate.
- Oculus Quest 2 recalibration and guardian issues.
- Small sample size.
- Limited demographic data.
- Measure immersion and related properties.

Modifications /Future Work

- Further investigate if resolution affects users' sense of immersion in virtual reality.
- Use live brain activity feed measurements.

Conclusions

- Investigated potential effect of rendering resolution on the immersive nature of VR.
- Rendering resolution did not affect user immersion.
- Game type did affect immersion. Situational game type
- Future: What ALL factors affect users' sense of immersion in VR?

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