Remote and lab-based research of viewing experiences and recollection in cinematic virtual reality

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Introduction

Cinematic virtual reality (VR) affords 360-degree viewing experiences during which a viewer's body position defines the momentary viewing perspective: a moving-image content is presented in 360 degrees, while one only accesses the segment of the narrative space toward which they are facing at any given time (Mateer, 2017). The 360-degree space prompts highly immersive experiences and embodied engagement (Van den Broeck, Kawsar, & Schöning, 2017). However, the arbitrariness and constant changes of viewing perspectives may affect a viewer's comprehension and recollection of narrative elements. The study proposes that such immersive experiences and sensorimotor involvement induce a first-person perspective to observe narrative events (St. Jacques, 2019). As opposed to a camera perspective, first-person perspective is associated with an increased sensation of narrative presence and emotional engagement, as well as more accurate and vivid recollection of information (Serino & Repetto, 2018). To determine these effects, we designed an experiment to compare viewers' reactions to an animated movie, *Pearl* (Osborne, 2016), either watched using a head-mounted display or on a regular screen.

Due to the restrictions related to the Covid-19 pandemic, laboratory testing of the hypothesis was no longer feasible, therefore an online experiment was designed. In this experiment, participants were recruited from internet-based communities and were requested to use their own equipment at a location of their choice.

In the following, we present the methods and findings of the online experiment (Szita, Gander, & Wallstén, 2021) and the methodological challenges and limitations remote data collection holds. Based on these limitations, we outline a follow-up experiment to be conducted in laboratory settings.

Method

To isolate the effects of cinematic virtual reality, we followed a between-subjects design comparing virtual reality and screen viewing of the same six-minute film. *Pearl* has a 360-degree and a screen-based version. In the VR format, the viewer can define the direction of viewing within the six degrees of freedom that allows for a full range of head movements. The screen version uses multiple camera angles.

The study involved 165 participants aged 16–62 (M = 30.44, SD = 9.61). The criterion for taking part was access to the respective screening appliance (tethered VR headset or a stationary screen of minimum 12 inches). Eighty-five participated in the VR condition and 80 in the screen condition. The VR version was advertised in online groups for virtual reality users to target users who have access to headsets and are experienced with VR technology. This was to avoid novelty experiences' biasing effects and to assume that each participant uses the most suitable settings (e.g., interpupillary distance, screen resolution). Participants for the screen version were recruited through online channels targeting communities of cinema enthusiasts and general audiences.

After watching the respective movie sequence, participants were asked to complete an online survey using Psytoolkit (Stoet, 2017). The survey consisted of three sections measuring viewing experience, memory characteristics, and recollection accuracy, and an additional set of questions recorded demographic data, user habits, and technical details of participation (e.g., VR headset type).

The first section (ten items) measured emotional engagement, sense of presence in the fictional space, empathy toward characters, awareness of the physical surroundings, and physiological reactions (e.g., nausea, dizziness) (based on Fonseca & Kraus, 2016; Zhang, 2020). The second section, memory characteristics (ten items), recorded

recollection vividness, emotional and physical reactions when recalling the movie, memory perspective (first- or third-person), and the structural comprehension of the narrative (Berntsen & Rubin, 2006; Qin, Rau, & Salvendy, 2009). The third section measured recollection accuracy (Syrett, Calvi, & van Gisbergen, 2016; Szita & Rooney, 2021): participants were given twelve statements from the movie to determine whether they were true or false.

Results and discussion

The values for each of the dependent variables were not normally distributed, therefore, we used a Mann–Whitney U test to compare the two conditions. The variables that showed significant differences are shown in Table 1.

Table 1. Mann-Whitney U test: mean rank and median values, z-scores, and effect sizes

Variable	Scale (from 1 to 7)	VR		Screen		z-score	r^2
		Mean rank	Median	Mean rank	Median		
Viewing experience							
I felt I was inside the story**	not at all–completely	92.68	5	72.71	5	-2.74	.046
I felt I was at the places in the displayed environment***	not at all–completely	102.93	5	61.83	4	-5.62	.191
When I was watching, time seemed to fly quickly***	not at all–completely	95.96	5	69.23	4	-3.65	.081
This experience was fascinating***	not at all–completely	97.45	6	67.65	4.5	-4.08	.101
I felt nauseous while watching the movie*	not at all–completely	88.74	1	76.91	1	-2.12	.027
Memory characteristics							
When I think of the movie, I can see with my mind's eye what took place*	not at all–as clearly as if I watched it now	89.92	6	75.65	5.5	1.98	.024
The relative spatial arrangement of people and objects in my memory for the movie is***	vague–clear	96.64	6	68.51	5	3.93	.094
At parts, the movie made me feel happy. This feeling was*	weak–strong	90.54	6	74.99	5	2.13	.027
When I now recall the movie, I primarily see what happened from a perspective as seen from**	inside the story world–as an outside observer	72.43	5	84.23	6	-3.00	.055
Recollection accuracy							
Percentage of correct answers**	–	72.06	66.7	94.63	75	-3.07	.057

Note: * $p < .05$, ** $p < .01$, *** $p < .001$

Ratings for feeling like being inside the story and in the displayed environment were significantly higher in the VR condition than the screen condition (U = 2577, U = 1706). Measuring detachment from the physical environment, ratings showed significantly higher values in the case of VR (U = 2298.5). Additionally, participants felt more fascinated by the VR experience than screen viewing experience (U = 2172) but also felt more nauseous in VR than during screen viewing (U = 2912.5). Thus, although VR viewers were found to be more immersed—which may have been facilitated by the fact that participants were recruited from communities gathering active VR users—they were also more likely to experience cybersickness. Discomfort, such as cybersickness, may draw attention to one's physical body, thereby hindering immersion. This might be the reason for the lack of significant differences between screen and VR viewers' emotional engagement and empathy with characters.

VR participants were more likely to recall narrative events as clearly as if they watched the movie at the moment of answering than screen viewers (U = 3988). Correspondingly, the relative spatial arrangement of people and objects in participants' memory was rated clearer in the VR condition (U = 4559). VR viewers reported a stronger feeling of happiness when recalling the movie (U = 4040.5). To measure first- versus third-person recollection perspectives, participants rated their experience on a scale stretching from "inside the story world" to "as an outside observer looking into the story world." Supporting our hypothesis, VR viewers reported recollection more from inside the story world through a first-person perspective than screen viewers (U = 2501.5). In terms of recollection accuracy, screen participants recalled the movie more accurately than VR participants (U = 2470).

We found that VR viewing would more likely induce a first-person point of view while screen viewing leads to a third-person perspective. Although participants rated their memories of the movie clearer in the VR condition, the accuracy of recollection was poorer signaling that the attributes of VR help engagement but hinder access to all visual details. In other words, our results suggest a causal relationship between the 360-degree field of simulation

and attention: VR viewers need to turn their bodies to access information in the different parts of the visual field which may cause them to miss details that are momentarily obscured.

Limitations and future work

This study was conducted in natural settings; each participant watched the movie on their own device and in an environment of their choice. Such a natural experiment leads to results with high ecological validity as participants followed their general routines and our detailed instructions allow for replicability. But while online data collection omits geographic constraints, we were unable to control eventual extraneous variables, such as viewing environments and distractions. Additionally, although using one's personal device and settings would likely lead to a comfortable viewing experience, we cannot rule out the bias of individual devices (e.g., differences in field of view or resolution). Therefore, a laboratory study to confirm our results is an informative next step to make conclusions of the causality of viewing conditions. It would also allow for using a participant pool of both experienced and inexperienced users irrespective of access to virtual reality headsets.

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