Was I There? Impact of Platform and Headphones on 360 Video Immersion

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Abstract
Virtual reality industries claim that 360 videos are a powerful tool for creating empathy because they are an immersive medium, and wearing headphones is encouraged for the full immersive experience. To investigate these claims, we carried out a 2x2 between subjects lab study (*n*=40) to explore whether 360 viewing platform (magic window / google cardboard) and headphone use (with / without) have an effect on Film-Immersion for the 360 video *Fire Rescue*. Our results reveal a significant interaction effect: headphones increased immersion for google cardboard, but decreased immersion for magic window. However, not all dimensions of the immersive experience were affected. This suggests that head-mounted displays increase presence, but do not necessarily lead to more empathy and greater interest in the 360 video. Thematic analysis of interview data suggests contributing factors such as fear of missing out (FOMO). These findings have implications for film makers and researchers of 360 videos.

Author Keywords
Immersion; Presence; Empathy; 360 Video; User Experience; Headphones; Magic Window; Head-Mounted Display; Google Cardboard; Virtual Reality.

360 video platforms

Figure 1: Magic window on mobile phone. The viewer moves smartphone or taps with finger to navigate.

Figure 2: Head-mounted display using mobile phone. The viewer moves head and/or body to navigate.

ACM Classification Keywords
H.1.2. User/Machine Systems: Human Factors.

Introduction

The development of 360 video is a catalyst for a new form of journalism that aims to engage and immerse viewers in the storytelling [19]. For example, viewers can be transported to refugee camps in Calais to witness Syrians attempt to board lorries en route to Britain [5], or tour Ai Weiwei's landmark exhibition at the Royal Academy of the Arts augmented by curatorial commentaries [1]. However, commercially available 360 video is still relatively new, and there is still much that is unknown about users' experiences and preferences. In this study we explore how the type of viewing platform and the use of headphones can affect users' experiences of immersion. Our results highlight the multifaceted nature of human behaviors and interactions, as the interaction between viewing platform and headphones is more complex than we had first assumed.

Background

360 degree cameras have existed for a number of years but are more prominent now due to lowered costs of production and public interest [15]. 360 video is created with a camera system usually consisting of multiple lenses shaped into a sphere. The camera simultaneously records all 360 degrees of a scene, and footage is stitched to produce a video in which users can pan and rotate the 360 video's perspective to watch it from different angles.

There are two ways that users can experience 360 videos on smartphones: 1) Magic window (MW), where the viewer physically moves the smartphone or taps their finger to pan around (see Figure 1); and 2) Head-mounted display (HMD), such as Google Cardboard (GC) and Samsung Gear VR, which turn 360 mobile videos into virtual reality (VR) experiences (see Figure 2). 360 videos can also be experienced on the desktop, where the viewer uses their mouse or overlaid arrow keys to navigate around the environment.

360 video offers exciting applications as a dynamic news experience. In contrast to the linear narrative formula of traditional journalism, 360 video provides a first-person VR experience within the events or situations usually described by reporters [19]. Aaron Luber at Google VR [14] said: *"This makes VR and 360 video an incredibly powerful tool to create empathy. When a viewer feels like they are there, they have a greater sense of the situation. Messages become more impactful"*. VR storytelling has shown itself as capable of changing individuals' viewpoints. There is immediate anecdotal and visceral evidence, such as viewers experiencing Peña's *Hunger in Los Angeles* at Sundance, bursting into tears afterwards, becoming overwhelmed with emotion, and deciding to take real world action by donating to charities [18]. Yet despite the popularity surge of journalistic 360 videos, there is limited research available on users' experiences.

In [12], Sarah Jones identified 12 main 360 journalistic stories that had been produced at that time, and categorized three types of storytelling narratives: social 360, reporter-led, and character-led. She also presented the results of a focus group, where participants watched a sample of the 12 videos on various HMDs (GC, Homido, Mattel View-Master). Participants did not have a clear preference for one particular type of storytelling narrative; instead the

Fire Rescue video (1)

Figure 3: In this scene, Paul the firefighter talks about his job. The user can navigate to see more views of the fire station. (CC-BY BBC)

Figure 4: In this scene, Paul talks about a house fire that he tackled. The viewer's perspective is inside the room where the fire starts. They can navigate to see the fire growing and the room filling with smoke. (CC-BY BBC)

issues they discussed were more about the experience in general. Participants talked about how wearing a HMD meant that the story took up their full attention and *"made it all feel more real".* Yet at the same time, participants expressed a fear of missing out (FOMO) as they were unsure of where to look, even when visual cues were used. This highlights a need for some sort of unobtrusive or ambient way of directing the viewers' attention to the action.

Passmore et al. [17] investigated users' experiences across different viewing platforms. Participants were assigned to one of three conditions (desktop, MW, Gear VR) as they viewed *The Resistance of Honey*. This 360 video has a character-led narrative and it is about an urban beekeeper who makes music and honey from his bees. Participants were observed during the video and interviewed afterwards. Key findings include insights on presence, smartphone interactivity, screen size, exploration, and attention. Gear VR participants frequently stated they felt they were *"there"* and one participant even said *"there was the feeling of it not being a film you're watching, but an experience you're having."* Comparably, participants viewing it on desktop or MW felt more removed. In all conditions, participants were interested and excited to explore the 360 surroundings. However, similar to Jones [12], participants also experienced FOMO. This led to them feeling less free to explore the surroundings as they had to focus their attention on the reporter in order to follow the narrative.

Fonseca and Kraus [8] also investigated users' experiences across different viewing platforms (MW, HMD). Participants viewed a 360 video about the effects of meat consumption and how it related to climate change. Afterwards, they filled in a questionnaire about their sense of presence, empathy, attitude and behavior change. The results revealed that participants in the HMD condition reported higher levels of presence and empathy than those in the MW condition. Higher presence and emotional impact also enhanced pro-environmental attitudes and behavior.

Together these studies suggest that 360 videos viewed on HMDs result in users having a stronger sense of presence in the VR environment. However, does the platform type also affect users' experience of immersion? Immersion is a complex experience and it is possible for a person to feel present in an environment, but not immersed in what they are doing there [11]. For instance, a person may find the story uninteresting or confusing. Therefore, in our study we wanted to explore which aspects of the immersive experience were affected by the platform type.

A further issue is that numerous providers of 360 videos, such as *BBC Taster* [2] and *NYT VR* [16], prompt users to wear headphones with their HMDs. There are studies that suggest headphones provide a more immersive experience over speakers in ordinary video viewing [6, 13]; however, to our knowledge, whether or not this benefit translates to 360 video has not been explored yet.

Research Question

Our main research question was: Does the 360 video viewing platform (MW/GC) and the use of headphones (with/without) affect immersion? We chose MW and GC as viewing platforms to test (and not desktop) because this would allow for a control of screen size. We predicted that GC with headphones would have the

Fire Rescue video (2)

Figure 5: In this scene, the video switches to a first person POV of a gloved hand reaching through the smoke. The viewer can navigate as "their" hand attempts to remove debris and reaches to the staircase banister. (CC-BY BBC)

Figure 6: In this scene, the POV switches to another firefighter, Anthony, getting stuck at the debris at the staircase. The viewer can navigate to see Anthony struggling while the flames envelope the area. (CC-BY BBC)

highest immersion score, followed by GC without headphones, MW with headphones, and then MW without headphones. We predicted that GC would be more immersive than MW because it takes up the users' field of vision, allowing the person to concentrate more on the story and not to be distracted by their environment. Similarly, headphones (+) would be better than no headphones (-) because headphones block out distracting sounds from the environment.

Methodology

Design

It was a 2 x 2 between-subjects study. The two independent variables were viewing platform (MW/GC) and headphone use (+/-). Ten participants were assigned to each condition. As GC does not allow for comfortable viewing with spectacles, any participants wearing spectacles were assigned to the MW condition.

Participants

The study was advertised on Facebook, and a total of 40 participants were recruited via opportunity sampling: 20 females, 19 males, and 1 gender neutral individual. The majority of participants were university graduate students and in the *"25-34 years"* age category. Participants had little previous experience with 360 video (mostly once or twice). They were attracted to sign up for the study because of the novelty of the experience. They were provided with refreshments for taking part.

Apparatus

An iPhone 6, GC, and Sony MDR-ZX300 Sound Monitoring Headphones, were used for the study. Participants were seated on a swivel chair, so that participants in the GC conditions could easily swerve around to explore the video's scenery while seated.

Fire Rescue

The 360 video was *Fire Rescue*, a 5:50 minute dramatic re-construction of a real life rescue of six children on Christmas Day 2012 developed by BBC R&D [7]. It finished production July 2016. This 360 video was chosen because the subject of a house fire is familiar, but the video provides a new point of view (POV), as the majority of people have not seen a fire so close-up nor from a firefighter's POV. The decision was also the result of practical considerations when working with a commercial industry partner. BBC R&D had a range of 360 videos, however many of them had third party copyrights, or could only be viewed on less accessible devices such as Oculus Rift that require high power graphic cards. *Fire Rescue* could be easily viewed on GC with any smartphone, plays with scene switches, injects some first person perspectives, and has a compelling storyline to invoke empathetic feelings. See Figures 3-6 for screenshots of the video.

Film-IEQ

The Film Immersive Experience Questionnaire [20] is an adapted version of the well-cited IEQ that has been used in numerous video game experiments [11]. There are 31 questions with Likert scale answers ranging from 1-7. Examples of questions include *"To what extent were you interested in seeing how the events in the film would progress?"* and *"How much would you say you enjoyed watching the film?"* The Film-IEQ has been validated in a large survey study, which revealed 4 factors of film-immersion: involvement, captivation, comprehension and real world dissociation [20].

Film-IEQ results

Condition	Mean	SD
MW – H	147.60	13.07
MW + H	133.50	12.69
GC – H	145.70	23.68
GC + H	155.00	17.13

Table 1: Film-IEQ means and standard deviations for magic window (MW) and google cardboard (GC) with (+) and without (-) headphones (H).

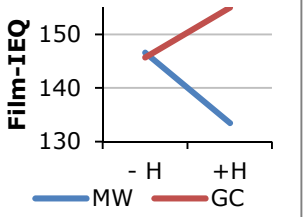

Figure 7: Line graph of Film-IEQ scores showing a significant interaction effect. Wearing headphones (+H) increases immersion for GC, but decreases immersion for MW.

Procedure

The study had ethical approval and was conducted in a lab cubicle. Upon arrival, participants were welcomed and asked to fill in a consent form and a demographics questionnaire. Then they were provided with the appropriate viewing platform and briefly instructed how to interact with the 360 video. They were told the video was called Fire Rescue and was about firefighters in action. All participants were informed that they could withdraw from the study or stop the video at any time. For the GC condition, participants were additionally instructed that if they felt motion sickness at any time, they could stop the experience. Once they felt ready to start, the researcher left the cubicle so that the participant could watch in private. After watching the video, the participant filled in the Film-IEQ and took part in a short semi-structured interview about their experience which was audio recorded (and later transcribed). All participants were debriefed at the end and thanked for taking part. Each participant session took approximately 30 minutes. Film-IEQ data were analyzed using SPSS. Interview transcripts were analyzed using *thematic analysis* - a qualitative research method for identifying, analyzing, and reporting patterns (themes) within data [4].

Results

Between-groups ANOVAs were conducted to explore differences between the conditions. For the total immersion score, no significant main effects were found for viewing platform (p = .080) or headphone use (p = .662) (see Table 1 for means). However, there was a significant interaction effect (p = .039) (see Figure 7). The addition of headphones significantly increased immersion scores for GC viewing, but significantly decreased immersion scores for MW viewing.

Out of the four immersion factors, only two showed significant effects. For involvement, there was a significant main effect for viewing platform (p = .005). For real world dissociation, there was a significant main effect for viewing platform (p = .009) and a significant interaction effect (p = .027).

During the interviews, participants were asked which genres they would most like to see 360 videos in. The most popular genres were nature and documentaries, suggesting that exploratory, visually stunning, and beautiful imagery is most desired in this new medium. Some participants highlighted their apprehension towards viewing violent content on 360 video, such as war, and preferred more light-hearted subject matters.

Discussion

As predicted, the viewing platform had a significant impact on the immersive experience. Participants in the GC conditions were more likely to feel as if they were experiencing events for themselves and feel as if they were located in the virtual environment (*involvement*). They were also less aware of their surroundings (*real world dissociation*). This suggests that HMDs lead to a stronger sense of presence in the virtual environment, supporting previous research [8, 12, 17].

The use of headphones also had a significant impact on immersion; however, the results were not as we expected. The addition of headphones improved immersion for GC, but decreased immersion for MW. We suggest that wearing headphones improves immersion for GC because as well as being visually cut off from distractions, the viewer is cut off from distracting sounds too (*real world dissociation*). This was supported by our interview data. For example, P11

Design suggestions

Figure 8: Some participants did not notice the other firefighters sliding down the pole. A hotspot (top right of figure) could help to direct the viewer's attention so that they turn to the right in time to see it.

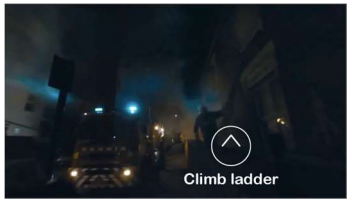

Figure 9: In this overlay the user can click when they are ready to climb the ladder to enter the bedroom, moving them to the next scene. This allows them to explore and then move on at their own pace, rather than trying to keep on top of a narrative that is continuously moving.

said *"I totally forgot I was wearing a physical headset"*, and P12 said *"headphones made it more immersive, because the sound is more scary and stressful on headphones"*. But why isn't this also the case for MW? Some participants said that they were used to viewing videos on their smartphone without headphones, so the experience of wearing headphones was unusual to them. Another possible explanation is that if a person is able to see things in their peripheral vision, but unable to hear the sound, that this is more distracting than if they heard that sound and chose to block it out to focus on the video. These possibilities will need to be explored more in future research.

Another notable finding is that the platform type and the use of headphones did not significantly impact all aspects of the immersive experience. *Captivation* was unaffected - this factor refers to how much the viewer enjoyed watching the video, how interested they were, and their motivation to watch. *Comprehension* was also unaffected - this factor refers to how well the concepts and themes of the video were understood. In contrast to [8, 14], this suggests that HMDs do not necessarily lead to more emotional involvement and empathy with the characters' story. This was supported by our interview data. 35% of participants mentioned experiencing FOMO, similar to [12, 17]. 33% of participants also talked about the medium distracting them from the story content. For example, P15 said *"I was much more focused on the environment than the story."* Recently, researchers have started to explore ways to help viewers focus their attention and alleviate FOMO [9, 15, 21]. Hotspots and mini-maps could help viewers to navigate around the video, directing their attention to the action (see Figure 8). Overlays could be used to give viewers more agency, allowing them to pause, explore, and move on at their own pace (see Figure 9). It would be interesting to explore how these techniques impact immersion in future research.

A final discussion point is that perhaps some genres are more suitable for 360 storytelling than others. In our study, the most popular genres that participants wanted to see in 360 were nature and documentaries. This supports previous research [3], suggesting that 360 videos featuring unfamiliar environments and touristic locations are preferred by users and more likely to trigger the desire to explore and look around.

Overall this study provides initial insights into some of the factors that affect immersive experiences of 360 video. To gain a greater understanding of how 360 storytelling can be best utilized to engage viewers, it will be important to compare different genres of 360 videos across platforms and also to explore how contextual factors affect users' experiences and preferences. For example, it could be that users prefer to see shorter 360 content on MW (similar to typical smartphone video experiences) and longer content on HMD (more of a novel experience, like cinema viewing). Different platforms for 360 videos may be preferred in different locations (on the train, at home, at work, etc.). Situated studies similar to [10] could also explore 360 video retention rate and whether viewers look at video content for longer depending on the platform.

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