Winter is Coming... To Your Commute: Adapting Passenger ARTV Ornamentations to Match On-screen Visuals For Enhanced Immersion in Fantasy Drama TV Content

Iain Christie
School of Computing Science
University of Glasgow
Glasgow, United Kingdom
i.christie.2@research.gla.ac.uk

Graham Wilson
School of Computing Science
University of Glasgow
Glasgow, United Kingdom
graham.wilson@glasgow.ac.uk

Mark McGill
School of Computing Science
University of Glasgow
Glasgow, United Kingdom
mark.mcgill@glasgow.ac.uk

Stephen Anthony Brewster
School of Computing Science
University of Glasgow
Glasgow, United Kingdom
stephen.brewster@glasgow.ac.uk

Abstract

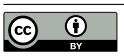
Augmented Reality Television (ARTV) affords new ways to experience media – from displaying auxiliary information to increasing immersion with additional 3D models. Many people consume video content when travelling or commuting; accordingly, the benefits of ARTV in this context merit investigation. We conducted a study (N=20) exploring the effects of using ARTV Ornamentations when watching *Game of Thrones* on a train. We used Virtual Reality to simulate use of AR in a train carriage and evaluated four different levels of ARTV Ornamentation, from a simple floating panel through to themed models and interior textures that change to match the on-screen visuals. Results showed that Ornamentations matching the show's genre were sufficient to provide an engaging and immersive experience, but Ornamentations themed to the show which changed based on the scene further elevated the experience. This means it is possible for passengers to have an immersive experience while commuting without significantly reducing their awareness of their environment. We also reflect on the implications of our work for an existing ARTV framework and propose the inclusion of several new aspects to encourage designers to consider the unique challenges and affordances of ARTV Ornamentations.

CCS Concepts

• **Human-centered computing** → **Mixed / augmented reality**; *Virtual reality*.

Keywords

ARTV, Augmented, Reality, Television, Immersive, Media, AR, XR, Ornamentation, Passenger, Train



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1 Introduction

Augmented Reality Television (ARTV) experiences enhance the TV viewing experience [37, 45, 47] with additional virtual content, ranging from contextual information, as in the case of Amazon Prime's X-ray[2], to rendering additional 3D models around the TV, such as a turtle swimming around the room in a *Blue Planet* nature documentary [37]. ARTV Ornamentations are the subset of these augmentations that aesthetically match the content in the video and aim to extend the video into the real world; they have successfully been shown to increase content immersion and viewer enjoyment [11, 37]. Whilst prior work on ARTV has concentrated on watching content in a home setting, the way we consume media is changing. According to eMarketer, the number of mobile video viewers rose from 1.43 billion in 2016 to 1.87 billion in 2018 and was projected to reach 2.33 billion by 2021[13]. Similarly, a Statista survey found 79% of American 18-34 year olds watched video content on their smartphones [9]. Usage on trains echoes these trends, as demonstrated by the steady increase in passenger mobile phone usage reported by each subsequent UK *National Rail Transport Survey* [22]. However, the small screen size of smartphones, which makes them well suited for media consumption on public transportation [43], has been shown to adversely impact viewer immersion when watching videos [34]. Extended Reality (XR) devices afford a mobile video experience without the constraints of a physical screen. Current consumer devices such as the XReal Air 2 glasses and the Apple Vision Pro market themselves as allowing the user to watch media content on a large virtual screen, anytime, anywhere [3, 52].

In this paper, we evaluate different implementations of ARTV Ornamentation and explore the use of ARTV in the *mobile context*

of commuting by train. Instead of consuming content via a traditional screen, such as a smartphone or tablet, we envision the user watching TV while wearing AR glasses [16] that visually augment the surroundings and environment with Ornamentations, comprising themed texture replacement of the interior of the vehicle and 3D models, [11] to enhance the viewing experience. The issues of a passenger's awareness of their stop and of other passengers are inherent in the use of VR on public transport [7]; AR circumvents these, as it does not fully occlude a user's vision of their real travel environment.

Previous ARTV studies [11, 37] have exclusively focused on nature documentary content with nature-based or informative augmentations. As a result, there remains a gap in understanding how ARTV Ornamentations - themed augmentations placed in the users surroundings - could be adapted for other genres. We contribute the first study to investigate the application of ARTV Ornamentations outside of nature documentaries, studying TV Drama to explore the impact of generic and themed virtual objects presented alongside the TV content. We are interested in how ARTV Ornamentations might be adapted to complex genres which, like drama, might, first, be more narratively-driven, potentially influencing the impact of Ornamentations, which are environmentally-focused, and, second, be more likely to take place across multiple in-media environments (e.g. changing from a snowy arctic-like biome to a sandy desert between scenes).

With the prospective mass consumer adoption of everyday AR devices and the likely use of these devices in shared spaces and environments such as trains, it warrants considering ARTV Ornamentations not just in terms of media immersion and engagement but also social impact. It is worthwhile understanding ARTV Ornamentation through the lens of HCI as we need to know both the benefits it may bring to the user experience of mobile content consumption and heightened media immersion as well as any possible drawbacks once deployed in the wild, such as a reduction in a passenger's awareness. Our experiment examines the viewing of several scenes from *Game of Thrones* [15], a high budget, high production value fantasy medieval drama, in a travel context. We evaluate the effect of changing the ARTV Ornamentations in parallel with environmental scene changes in the content and passenger willingness to use AR for media consumption over traditional solutions such as phones and laptops. Ornamentations were based on the general *genre* of the content (e.g. the viking/middle-ages fantasy aesthetic), the visuals and iconography of the specific *show* (e.g. Game of Thrones house sigils), and on the *biome* of the current scene (e.g. forest, desert, or winter landscape). They could remain fixed throughout the viewing experience or be content-adaptive - changing as the scenes change throughout an episode.

We compared four different levels of ARTV Ornamentation: *Baseline* - video displayed on a floating AR panel in front of the user, a standard AR video watching experience; *Genre-Based Augmentations (GBAs)* - interior retextured to look medieval with medieval themed AR objects placed in the scene; *Show-Specific Augmentations (SSAs)* - interior retextured to look medieval with AR objects from the show, such as famous swords and shields; *Biome-Specific Augmentations (BSAs)* - AR objects from the show placed in the scene and the train retextured to match the environment of each scene. We measured enjoyment, engagement, and immersion (as measured by Film-IEQ, UES SF, and UEQ-S). We found that Biome-Specific Augmentations significantly improved enjoyment and engagement over Show-Specific Augmentations and Genre-Based Augmentations conditions. 95% of participants said they would be interested in watching ARTV on a train using Biome-Specific Augmentations instead of a phone or laptop, followed by Show-Specific Augmentations at 80%, Baseline at 65% and Genre-Based Augmentations at 60%. There was no significant difference in enjoyment, engagement, or immersion between Genre-Based Augmentations and Show-Specific Augmentations conditions. When participants were asked to rate their environmental awareness there was no significant difference between the Baseline condition and the Genre-Based Augmentations condition, or the Baseline condition and the Show-Specific Augmentations condition. This evidences that ARTV Ornamentations can be applied to drama content to enhance immersion and enjoyment without significantly reducing passenger's awareness of their surroundings.

2 Related Work

2.1 XR use on Passenger Transit

Passengers entertain themselves on journeys using electronic devices such as phones and laptops, with the number of passengers using these devices increasing as the technology matures [22, 43]. It is likely that we will see passengers turning to XR devices such as the Apple Vision Pro [3] and Meta Orion [27] for entertainment as that form factor gains widespread adoption. Current devices such as the XReal Air 2 [52] market their primary use case as consuming planar display content when mobile. There is additionally significant commercial interest in XR entertainment in vehicles, with companies such as Holoride partnering with Audi to bring VR gaming to car passengers [4]; Meta have similarly worked with BMW to bring this technology to consumers [26]. Despite these circumstances, little work has been undertaken to investigate how best to make the media consumption experience in private vehicles and on public transportation more immersive and engaging.

VR is one subset of XR devices that has been explored for this purpose. A study by Li *et al.* [21] explored Virtual Reality for car passenger productivity. Participants thought the technology was better suited to watching videos and had an appetite for using the device for entertainment rather than work-related tasks. In the paper by Bajorunaite *et al.* [6], attitudes to the use of VR on aeroplanes were explored. Respondents exhibited a strong interest in using this technology (65% somewhat or very interested). In a similar result to Li et al., entertainment was highest ranked when participants ordered their interest across the three use cases of entertainment, communication, and work.

The major disadvantage of VR is that it requires the removal of all of a user's awareness of the real world, leaving them unaware and vulnerable. In an effort to address this, Bajorunaite *et al.* explored the concept of reintroducing awareness of the environment in VR through the integration of *Reality Anchors* - elements of the real world, such as other passengers and current stop signage, to keep the user aware [7]. Allowing users to know where other passengers were located increased participants' perceived level of safety. However, this creates a potential trade-off between seeing real world components and the ability to attend to, and be immersed

in, the content being viewed. Compared to VR, ARTV offers reality awareness by-default and, thus, could provide a route towards experiencing immersive media that would be more compatible with passenger safety concerns.

The current consumer standard for ARTV is a larger floating screen [3, 52]. Previous work by Medeiros *et al.* [24] investigated the placement of AR panels across a range of transport modes. There was a trade-off between the physical comfort (e.g. placing the display at head level in front of the user) and social comfort (not obscuring another passenger's face). Different users had different priorities. Correspondingly, such a system would ideally need to be customisable to cater for user preferences for display placement. Medeiros et al. suggested that the use of further AR modifications and diminished reality techniques might alleviate the social discomfort of looking towards another passenger while using a virtual screen. ARTV Ornamentations could serve this purpose, by placing them in then environment to reduce this social discomfort by occluding other passengers.

2.2 Adaptive AR

Mathis surveyed 60 participants to gather perspectives on how different types of AR augmentations could assist them with everyday tasks. Drawing on the responses they generated hypothetical usecases, each corresponding to tasks with shared properties, in which the types of assistive augmentations selected are a function of he user's context. When a user needed to be aware of the world around them, such as when driving, OverlayMR draws attention to relevant elements, by for instance highlighting other cars. Conversely, a user might opt for FocusMR, which diminishes real world sounds and visuals, when engaging in a task such as studying, where they wish to use AR to remove distractions. Though wanting neither to highlight or block out their environment, the forgetful user at the supermarket might benefit from MemoryMR, which provides in-situ recall support such as replaying relevant instructions they had been told earlier.

The taxonomy for *Pervasive Augmented Reality* similarly suggests adapting AR augmentations based on the user's physical context [14]. There are different demands on the user when working versus navigating the world and the AR assistance should correspondingly be different. Previous work adapted planar content, such as word documents, to the position of a knowledge worker as they moved about the office based solely on the layout of their physical environment. Content could be placed on the walls or move the content as the user moves. The contents of the documents themselves did not factor into their placement [20].

AR adaptations might conversely be tied to the content displayed rather than user surroundings. For instance, two AR panels displaying planar content of two separate social media websites might be positioned in space side by side creating difficulty for the user in identifying the panel from which an audio notification originated. *Lindlbauer et al.* overcome this angular discrimination error by adapting the AR experience to play the notification sound not from the panel itself but from a location clearly distinct from the other panel [10]; two panels placed in front of the user with audio sources offset by 5 degrees might instead have their audio sources offset by 180 degrees clearly to the left and right of the user. This allows the user to clearly understand that a noise from the left corresponds to the leftmost panel. Similarly, our study will use this content-adaptive AR concept by having the augmentations change dependent upon the current on-screen visuals in the video being watched.

2.3 XR and Television

Augmented Reality Television alters and enhances the TV experience by adding augmentations around the viewer [17, 18, 46]. These could include contextual information about the scene and actors displayed in AR in the space surrounding the TV, showing alternate camera angles on AR screens, or displaying 3D models related to the content around the viewer.

ARTV is a much broader concept than just AR glasses for video consumption – the current commercial focus [52] – or passthrough VR for ARTV as seen in the Vision Pro [3]. Vatavu et al. describe a continuum between physical and virtual TV, which includes additional screens such as laptops and phones, projector-based augmentations on the walls of the room and in the area around the TV, AR headset augmentations, and, at the extreme end, watching television in Virtual Reality [48]. Our implementation falls at position 7 along their continuum - *Augmented World / Virtual TV*.

Popovici and Vatavu's exploratory study [33] examined user preferences and priorities with respect to 20 distinct ARTV scenarios. The scenarios rated third, fourth and fifth in perceived value were: *Very large field of view using video projections in the entire room*, *A larger field of view using video projections on the wall behind the TV*, *Real objects coming out of the TV*. Our paper caters to the expressed desires for increasing the field of view of the TV beyond its physical limits and for objects coming out of the TV by theming user surroundings based on what is displayed on screen and placing themed ARTV Ornamentations around the user.

ARTV has previously been categorised into distinct dimensions and themes [36], which were then revised and updated [39]. With respect to the classifications proposed in that work, our research can be described as:

- Framed TV with Unframed AR Content
- Visual and Auditory Experience
- Pre-recorded Viewing
- Synchronised AR Content
- One Viewer Experience with Bystanders
- No Interaction
- Unfamiliar Viewing Location
- Public Indoor Location
- Content Augments the Space
- Content Affected by the Geometry of the Space
- Content Does Not Augment Objects

Another study by Saeghe *et al.* [38] explored the effects of adding AR artefacts to an existing TV show using a Microsoft Hololens. Their findings suggested augmenting the TV can result in increased participant engagement. A further study [40] looked at how user experience was impacted by changing the start position for a moving sea turtle hologram. A notable finding was that the more engaging the hologram was, the less attention viewers paid to the programme. Users expressed that dividing their attention gave them the feeling they would be missing out on something either on TV or the

hologram. For this reason, the ARTV Ornamentations used in this paper does not move about the environment. We aimed for the Ornamentations to be supportive and not disruptive. We solicited participants' opinions on our moving particle effect Ornamentations in case even these were too distracting.

2.4 ARTV Ornamentation

Where Saeghe *et al.* used a broad range of AR artefacts – additional screens, a virtual viewer, and holograms related to the show – Christie *et al.* [11] focused solely on the latter, investigating the use of ARTV Ornamentations to increase immersion when watching video on a train. The train environment and the use of AR was simulated using a VR headset, an approach we followed in our experiment. It was found that immersive ARTV Ornamentation required a device with a field of view (FOV) in line with modern VR headsets, which is larger than currently available see-through AR devices. However, more appropriate consumer devices for ARTV Ornamentation are likely to come to market in the near future with the release of Meta's Orion glasses and its 70° FOV [27]. On high FOV pass-through AR devices, ARTV Ornamentations which combined objects and the retexturing of the train interior were successfully able to achieve similar levels of immersion to watching video fully immersed in VR [11]. ARTV Ornamentation also allowed for awareness of the environment, not possible in VR due to the occlusion of the real world that it necessitates, making AR a much more suitable solution for use in real world travel.

Christie's work only considered nature documentary TV content occurring in a single biome (one on screen location and one persistent theme to the augmentations) to influence the design of the AR Ornamentations presented. Nature content is often examined for ARTV [37, 40] but there are many other TV genres for which the utility of ARTV remains unexplored. Other genres, such as drama, are arguably more character and narrative driven than nature documentaries. Correspondingly, the user may already be more attentive, potentially lessening the impact of ARTV Ornamentations. Additionally, no work has yet examined TV content with frequently changing biomes - a common theme in drama where, for instance, the environment may switch frequently in line with changing narrative threads. Jungle Ornamentations which remain consistent when the characters move indoors could, for example, negatively impact immersion. It is therefore necessary to understand the challenges presented to the design and use of Ornamentations by such multi-context narratives. As the number of distinct TV shows and movies far outweighs the number of genres, it would be preferable to theme the ARTV Ornamentations by genre rather than by show. It is unknown whether this would be sufficient for a meaningful increase in immersion; hence, this paper seeks to determine if genre-based ARTV Ornamentations are able to provide an immersive experience.

3 Study - ARTV Objects & Biomes

This paper examines the effects of ARTV experiences in which the AR Ornamentations of the video content change with scene changes during the ARTV experience. Previous work on ARTV focused solely on nature documentaries. The visuals on screen did not change significantly, as a jungle was shown in all clips during the study [11] and, accordingly, the ARTV Ornamentations did not require altering to remain consistent with the theming of the video content. This is not the case with many other shows, where the narrative may show the viewer different real or fictional environments, countries, and even planets. The nature documentary chosen by Christie et al. might feasibly be swapped with any other jungle documentary and the ARTV Ornamentations are likely to be just as effective. What is unknown is which Ornamentations should be used for a show with more distinct iconography such as *Game of Thrones*. Is it sufficient to continue to use generic genre-based ARTV Ornamentations for an immersive experience or are we required to use Ornamentations specific to the show being watched or are the two effectively interchangeable?

We therefore investigate the impact that three distinct approaches to providing ARTV Ornamentations have on immersion, engagement, and enjoyment when watching an extract from *Game of Thrones* while travelling on a simulated train. Those three approaches are:

(1) *Genre-Based Augmentations* (GBAs) - Retexturing the train environment to look medieval with generic medieval themed AR objects;
(2) *Show-Specific Augmentations* (SSAs) - Retexturing the train environment to look medieval with specific objects from the show, such as famous swords and shields;
(3) *Biome-Specific Augmentations* (BSAs) - Retexturing the train environment to match the scene environment (castle, sand, snow) of each scene with specific objects from the show.

Our baseline condition emulates the current AR media consumption experience provided by devices like the NReal Air. Such baseline devices may have infrared sensors to understand the physical world (as a present on the Apple Vision Pro and Meta Quest 3). We can use this to augment their environment. We then build upon this in the Genre-Based Augmentations condition with the use of ARTV Ornamentations themed to the genre of the content. If GBAs prove comparable to the other solutions, then the workload to develop ARTV Ornamentations only needs to be undertaken on a per genre basis rather than a per TV show basis. This would save implementation time for the entertainment companies developing ARTV. We hypothesise that including recognisable iconography from the TV show might increase enjoyment, immersion, and engagement in the experience, over the use of generic objects. This was the reason for comparing GBAs with SSAs which implement this change. Similarly, we then contrast SSAs, which have a fixed retexturing of the physical world to resemble a medieval interior, with BSAs, in which the physical world is retextured to match the on-screen environment– i.e. the physical world is augmented to look like a medieval interior during a scene inside a castle but then the physical world is augmented to look like a desert during a desert scene. We seek to understand the extent of Ornamentation required for an engaging user experience. How reusable between shows could these Ornamentations be or is a bespoke experience required for each episode of a show?

We have included snow and sand particle effects, when appropriate, within the train carriage in this condition to further match the on-screen visuals. In pilot testing, it was remarked that it seemed strange that in the show it was snowing but in the train it was

not. These particles give the impression of snow falling around the user and between them and the screen. The motivation for the BSA condition is that having the on-screen visuals match the ARTV Ornamentations during every scene may increase user enjoyment, engagement, and immersion beyond what is possible with static ARTV Ornamentations. Our research questions are as follows:

- **RQ1 Genre or Show Specific Objects:** Should the AR Ornamentations with which we populate the passenger environment be show-specific (SSA), or is it sufficient to have them themed by genre (GBA)? In answering this, we could simplify the process of designing engaging AR environments to accompany TV shows;
- **RQ2 Biome Ornamentations:** Can we enhance immersion by going beyond themed Ornamentations and bringing the biome of the current scene into the passenger cabin? In answering this, we explore whether we can bridge the gap between the immersiveness of AR and VR for passengers;
- **RQ3 Willingness to Use:** Does the provision of ARTV Ornamentations encourage the use of AR media consumption for passengers over existing media? In answering this, we seek to understand if passengers find the use of ARTV worthwhile for this use case.

3.1 Study Design

We used a within-subjects design. Participants experienced 4 conditions: Baseline- video displayed on a floating AR panel in the train carriage; Genre-Based Augmentations (GBAs) - interior retextured to match show genre with generic medieval themed AR Ornamentations and objects placed in the scene; Show-Specific Augmentations (SSAs) - interior retextured to look medieval with AR Ornamentations from the Game of Thrones show, such as famous swords and shields; Biome-Specific Augmentations (BSAs) - AR Ornamentations from the show are placed in the scene and the train interior is retextured to match the on-screen visuals of each scene and snow/sand particle effects are used when appropriate.

3.2 TV Media Choice

We used an excerpt from *Game of Thrones* - a medieval fantasy drama. Drama is a genre that has not been explored in previous ARTV papers and the medieval fantasy setting is popular. *Game of Thrones* features several unique biomes, including: the snow of the North and the Starks, the medieval castle interiors of King's Landing, and the sand and desert of Dorne[1]. This variation allows us to determine if the theme of ARTV Ornamentations can be the same throughout a TV show series or if it should change with the visual scene as the biome changes.

Game of Thrones differs from the nature documentaries previously used in more ways than just the environments. Nature documentaries tend to take a more detached view of the content than dramatic TV shows, which endeavour to make the viewer care and become invested in the characters on screen. *Game of Thrones* has many narrative threads the user is expected to follow throughout the show, whereas documentaries can be much more compartmentalised.

[1]https://gameofthrones.fandom.com/wiki/Great_House Last Accessed: 29/08/24

Participants watched the same 9 minute clip (8:19 to 17:32) from Season 2 Episode 2 of the show. A continuous clip was chosen to create an immersive experience with a cohesive narrative, avoiding any breaks in presence [23] caused by changing between unrelated clips. If we had used a series of disconnected short clips, it would not accurately represent the experience of watching a TV show with a continuous narrative. The clip had scene changes from medieval interior, to snowy exterior, to sandy exterior (the Lannister's castle at King's Landing, Jon Snow at Craster's Keep, Daenerys Targaryen in The Red Wastes), giving 3 distinct biomes. All of the scenes were dialogue-based with no fighting. All participants recruited were required to have previously watched *Game of Thrones* before taking part in the study, so that they would recognise the iconography used in the Show-Specific Augmentations condition. All conditions were counterbalanced using a Latin Square.

All conditions were simulated using VR to mimic an AR experience. This approach has been successfully used in previous studies [7, 24, 49]. We follow a methodology previously contributed by Christie *et al.* [11] to examine AR in simulated passenger VR contexts. The study was constrained to the "perfect space" and a single novel genre in order to focus on understanding the differences between Genre-Based Augmentations, Show-Specific Augmentations and Biome-Specific Augmentations in a controlled environment. Controlled examination in VR is an important first step. It is safer for participants, has fewer potential confounding variables, and is highly replicable and repeatable. The work of this paper would then be bolstered by work that prioritises greater ecological validity at a later stage. This approach enabled us to conduct a controlled experiment with a repeatable scenario prior to a more costly and challenging *in situ* evaluation. Modified textures had 15% transparency to simulate optical see-through AR displays with the original texture being slightly visible beneath. ARTV Ornamentation objects had 5% transparency, again to resemble what is seen with AR headsets. Objects were placed throughout the simulated train carriage with the majority within the participant's immediate surroundings and in the periphery of the screen. They were arranged in a manner consistent with the layouts used in Christie *et al.* [11], which prioritised visibility of objects around the central TV content, leveraged the spatiality of the surroundings, and emphasised aesthetic augmentations. The other passengers in the train were displayed using avatars from Adobe Mixamo [1] and had basic idle animations, such as shuffling their weight in their seat and moving their arms slightly. Passengers did not stand up nor did they move about the carriage.

3.2.1 Conditions. The conditions were (see Figure 1 for participant's view):

Baseline. The participants sat in an unmodified VR train environment representing a real train carriage and watched the clip on an AR screen in front of them. The interior stayed the same throughout the experience.

Genre-Based Augmentations. The participants sat in a modified VR train environment with the interior surfaces being retextured to resemble a medieval tavern. Genre-based objects and Ornamentations such as medieval books and tankards were added

(a) Baseline Condition with unmodified train interior, no ARTV Ornamentations, and a floating AR panel showing GoT.

(b) Genre-Based Augmentations with modified train interior textures (medieval interior) and generic medieval themed ARTV Ornamentation (coins, leather bag, dagger, book), and floating AR panel.

(c) Show-Specific Augmentations with modified train interior textures (medieval interior), show specific ARTV Ornamentation (Lannister shield, Stark Wolf, Wildlings shield and dagger), and floating AR panel. Similar to GBA but with objects from the show instead of generic medieval objects.

(d) Biome-Specific Augmentations during a snow scene with modified train interior textures (snow, stone, and ice), show specific ARTV Ornamentation (Lannister shield, Stark Wolf, Wildlings shield and dagger), and floating AR panel.

(e) Biome-Specific Augmentations during a desert scene with modified train interior textures (sand and sandstone), show specific ARTV Ornamentation (Lannister shield, Stark Wolf, Wildlings shield and dagger), and floating AR panel.

Figure 1: Participants' view in each of the conditions.

to the environment to enhance the experience. The interior stayed the same throughout.

Show-Specific Augmentations. This condition was the same as the Genre-Based Augmentations condition, except that Show-Specific Ornamentations such as famous swords, shields, and family crests were added to the environment. The interior stayed the same throughout.

Biome-Specific Augmentations. This condition was the same as the Show-Specific Augmentations condition except that when the scene changed, the textures of the train changed to match–from a medieval interior, to a snowy exterior, to a sandy exterior. This was achieved by increasing the transparency of one texture while decreasing the transparency of the other. Particle effects were included to further enhance the experience with snow falling for the snowy outdoor scene and sand for the desert scene.

We decided to investigate the use of objects and textures in the same condition rather than separate ones because the *Low Augmentation* condition in Christie *et al.* [11], which placed a limited number of plant models in the environment, was significantly less immersive than their *High Augmentation* condition, which included objects and textures. Adding a number Game of Thrones objects commensurate with the number of plant objects used in their *Medium Augmentation* condition did not create what we deem to be a comparable level of immersion – the result appeared cluttered as these objects are more diverse and distinct than plants, and correspondingly do not coexist and compound in the same way. For this reason, we were concerned with investigating the difference in immersion when using Genre Based objects compared to Show Specific objects as they would likely be used in practice with a retextured interior. Similarly, fixed and content-adaptive train interior retexturing was examined with the use of augmented objects.

3.3 Measures

Participants completed the *Film Immersive Experience Questionnaire* (Film-IEQ) [35], and the short versions of both the *User Experience Questionnaire* [42] and the *User Experience Survey* [31]; these questionnaires give insight into different aspects of the user experience such as engagement, immersion, and understanding and have previously proven effective in discerning differences across this form of content [37]. Each questionnaire captures multiple aspects of the experience in each of its respective sub-scales:

- **Film-IEQ** Captivation, Real World Dissociation, Comprehension, Transportation [35]
- **UEQ-S** Pragmatic, Hedonic [42]
- **UES SF** Focused Attention, Perceived Usability, Aesthetics, Reward (combination of success of interaction, users' willingness to recommend to others or engage with in future, novelty, and sense of being drawn in and having fun) [31]

Participants were also asked to indicate how much they agreed with two statements on a 5-point Likert scale from Strongly Agree to Strongly Disagree: "*I was aware of other passengers whilst watching the video*" and "*I was aware of the augmentations*". We aimed to gain an understanding of the impact the presence of the ARTV Ornamentations have on the participant's awareness of the environment and their awareness of the ARTV Ornamentations themselves.

After experiencing all conditions, participants filled in an exit questionnaire asking them to rank the conditions in order of preference. For each condition, it asked them to indicate their agreement (on a 5-point Likert scale) with the statement "*I would be interested in watching a video on a train using this condition instead of a phone or laptop*". Participants were then engaged in a short semi-structured interview to discuss the reasoning behind their answers and their opinions on the ARTV Ornamentations. During the interview participants were asked 3 core questions:

(1) Can you explain why you ranked the conditions in the order that you have?
(2) Did you find the transition between scenes distracting?
(3) What did you think of the sand and snow particle effects in the sand and snow scenes during the BSA condition?

The participants were asked follow-up questions based on their responses to obtain a better understanding for the reasoning behind their answers. Recordings were transcribed offline using WhisperX [5]. The transcripts were analysed using a thematic analysis approach [41].

3.4 Procedure

Before the study began, participants were given an information sheet and then gave consent for the study and interview logs to be recorded. Participants provided basic demographic information– their age, gender, and familiarity with Game of Thrones. During the study, each participant was seated on a static chair and wore a Meta Quest 3 headset plugged into a computer running the VR scene in Unity via Quest Link. After experiencing each condition, participants completed the Film-IEQ, UEQ-S, and UES SF and answered the Likert scale questions about their awareness of the passengers and augmentations. After experiencing all four conditions, participants then ranked the conditions in order of preference and, for each condition, indicated their interest in using it on a real commute. The experiment took 60 minutes to complete and was approved by our university's ethics committee.

3.5 Analysis

For the Film-IEQ, UES-SF, UEQ-S, and each of their subscales a Shapiro-Wilk test for normality was conducted to confirm applicability of the Aligned Rank Transform (ART) [51]. We then conducted an ANOVA based on the results of the ART, and for any significant results, we conducted an Aligned Rank Transform Contrast test (ART-C) [12].

3.6 Participants

Twenty participants (14 men and 6 women) were recruited from university mailing lists, ranging in age from 19 to 60 (mean=31, SD=10.4). All participants had watched at least one season of the show before taking part in the experiment. After the study was completed, participants were given a £10 Amazon Voucher for compensation.

4 Results

4.1 Quantitative Results

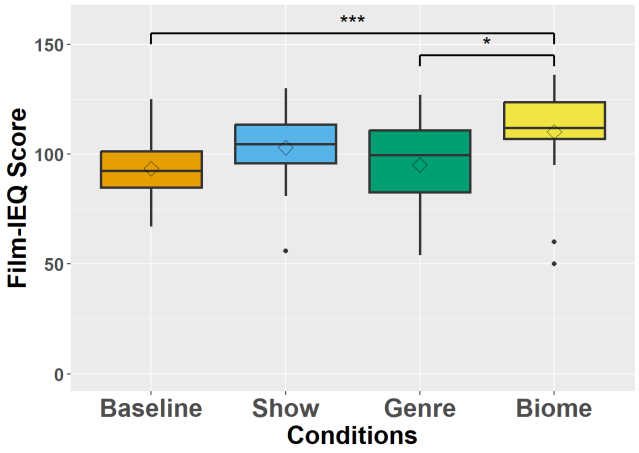
Scores for the overall scales and sub-scales for each questionnaire were calculated according to their respective procedures [31, 35, 42]. Results can be found in Table 1 and Figure 2.

4.1.1 Comparison to Baseline. The results showed significant improvement across several scales and subscales for engagement, enjoyment, and immersion between Biome-Specific Augmentations and Baseline. Namely, in the scores for *Film-IEQ*; Overall, Captivation, and Transportation, *UEQ-S*; Overall and Hedonic, *UES SF*; Overall, Focused Attention, Aesthetics, and Reward.

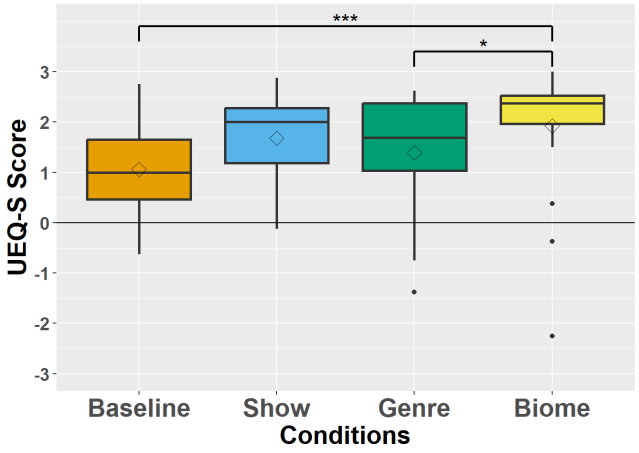
There was a significant increase in the scores for GBAs compared to *Baseline* for *UES SF* Aesthetics and Reward subscales. This means GBAs provided a more engaging and enjoyable experience. SSAs had a significantly higher scores compared to *Baseline* for *Film-IEQ* Transportation, which means SSAs were a more immersive experience. Similarly, the significant increase in scores for *UES SF*

Table 1: Aligned Rank Transform ANOVAs for each subscale, including degrees of freedom and effect sizes, and statistically significant contrast tests.

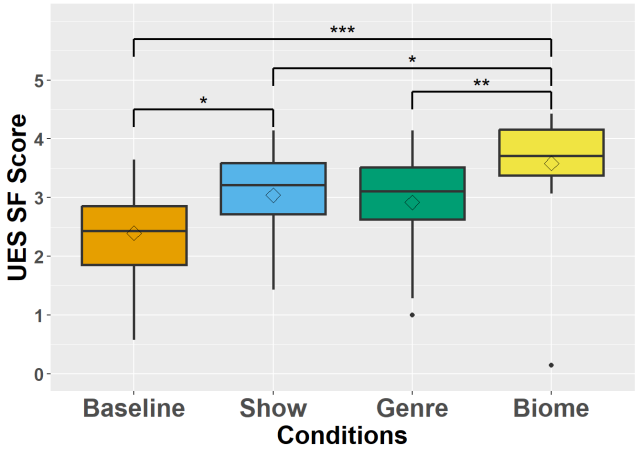
		ART ANOVA			Significant ART Contrasts		
Survey	Subscale	**F** (df)	**p**	Effect Size η_p^2	Comparison	**p**	Cohen's d
Film Immersive Experience Questionnaire	**Overall**	**6.28 (3, 57)**	**<0.01**	**0.25**	**Baseline - Biome**	**<0.01**	**-1.30**
					Genre - Biome	**0.01**	**-1.04**
	Captivation	**3.84 (3, 57)**	**0.014**	**0.17**	**Baseline - Biome**	**0.03**	**-2.86**
					Genre - Biome	**0.02**	**-2.95**
	Real World Dissociation	1.18 (3, 57)	0.32	0.06			
	Comprehension	0.95 (3, 57)	0.42	0.05			
	Transportation	**11.89 (3, 57)**	**<0.01**	**0.38**	**Baseline - Show**	**<0.01**	**-1.12**
					Baseline - Biome	**<0.01**	**-1.89**
					Genre - Biome	**<0.01**	**-1.12**
Short User Experience Questionnaire	**Overall**	**6.40 (3, 57)**	**<0.01**	**0.25**	**Baseline - Biome**	**<0.01**	**-1.38**
					Genre - Biome	**0.05**	**-0.85**
	Pragmatic	1.82 (3, 57)	0.15	0.09			
	Hedonic	**11.65 (3, 57)**	**<0.01**	**0.38**	**Baseline - Biome**	**<0.01**	**-1.87**
					Show - Biome	**<0.01**	**-1.11**
					Genre - Biome	**<0.01**	**-1.23**
User Engagement Scale Short Form	**Overall**	**12.19 (3, 57)**	**<0.01**	**0.39**	**Baseline - Show**	**0.02**	**-0.95**
					Baseline - Biome	**<0.01**	**-1.94**
					Show - Biome	**0.02**	**-0.99**
					Genre - Biome	**<0.01**	**-1.15**
	Focused Attention	**12.80 (3, 57)**	**<0.01**	**0.40**	**Baseline - Biome**	**<0.01**	**-1.91**
					Show - Biome	**<0.01**	**-1.25**
					Genre - Biome	**<0.01**	**-1.45**
	Perceived Usability	2.59 (3, 57)	0.06	0.12			
	Aesthetics	**12.39 (3, 57)**	**<0.01**	**0.39**	**Baseline - Show**	**<0.01**	**-1.16**
					Baseline - Genre	**0.01**	**-1.04**
					Baseline - Biome	**<0.01**	**-1.95**
					Genre - Biome	**0.03**	**-0.91**
	Reward	**11.27 (3, 57)**	**<0.01**	**0.37**	**Baseline - Show**	**0.03**	**-0.91**
					Baseline - Genre	**0.05**	**-0.84**
					Baseline - Biome	**<0.01**	**-1.88**
					Show - Biome	**0.02**	**-0.96**
					Genre - Biome	**0.01**	**-1.03**
I was aware of other passengers whilst watching the video		**4.34 (3, 57)**	**<0.01**	**0.19**	**Baseline - Biome**	**0.03**	**0.93**
					Genre - Biome	**0.02**	**0.98**
I was aware of the augmentations		**14.09 (3, 57)**	**<0.01**	**0.43**	**Baseline - Show**	**<0.01**	**-1.28**
					Baseline - Genre	**<0.01**	**-1.41**
					Baseline - Biome	**<0.01**	**-2.04**



(a) Film-IEQ scores for each condition.



(b) UEQ-S scores for each condition.



(c) UES SF scores for each condition.

Figure 2: (a) Film-IEQ scores, (b) UEQ-S scores, and (c) UES-SF scores for each condition (Baseline, Show, Genre, and Biome). * marks significant differences at p<0.05, ** at p<0.01, and * at p<0.001. Diamonds represent the mean, the central line indicates the median, and the box's length corresponds to the interquartile range.**

Overall, Aesthetics, and Reward scales tells us SSAs were a more visually appealing, engaging, and enjoyable experience.

4.1.2 Show Specific Objects Had Little Impact. When conducting the ART Contrast tests, we found no significant differences in the scores between Genre-Based Augmentations and Show-Specific Augmentations for any of the subscales. See Table 1. This suggests that ARTV Ornamentations using objects and iconography from the show did not noticeably improve the experience over more generic objects.

4.1.3 Comparison to Biome-Specific Augmentations. Aside from the question *I was aware of the augmentations*, every other scale, sub-scale, and question which had a significant ANOVA result also had a significant contrast test for Genre-Based Augmentations and Biome-Specific Augmentations. This indicates that the enjoyment, immersion, and engagement achieved with the use of ARTV Ornamentations can be further enhanced when the interior texture augmentations also change to match the scene displayed on screen.

There were several significant contrast tests for Show-Specific Augmentations and Biome-Specific Augmentations. *UEQ-S Hedonic*, *UES-SF*; *Overall*, *Focused Attention*, and *Reward*. This illustrates that matching the ARTV Ornamentations with the on-screen visuals throughout scene transitions results in an improved user experience compared to the use of static Ornamanmentations.

4.1.4 Situational Awareness. Participants were asked to assess their own awareness of other passengers after each condition. There was no significant difference between Baseline and Show-Specific Augmentations or Baseline and Genre-Based Augmentations. There was, however, a significant difference between both Baseline and Biome-Specific Augmentations, and Genre-Based Augmentations and Biome-Specific Augmentations. This suggests that the Biome-Specific Augmentations condition, although most immersive, had a negative impact on the participant's environmental awareness.

4.2 Condition Preferences

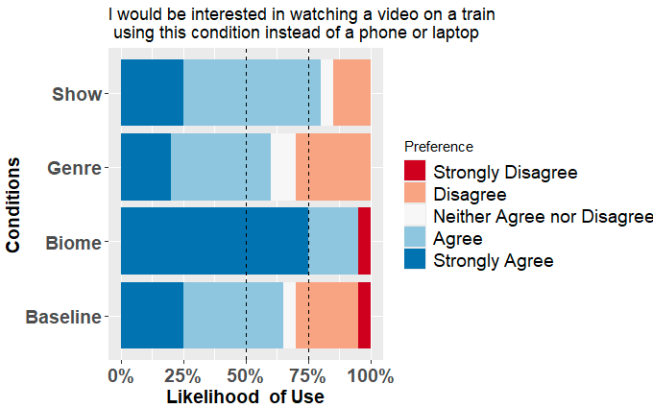


Figure 3: Participants' response to *How much do you agree with the following statement - I would be interested in watching a video on a train using this condition instead of a phone or laptop. Dotted black lines signify 50% and 75%.*

As can be seen in Figure 3, more than half of the participants would be interested in using any of the conditions instead of the traditional methods of watching video on a train. 75% were interested in using the *Biome* condition. It is worth noting that the participant that strongly disagreed with both *Baseline* and *Biome* did not like the concept at all. This is covered in Section 4.3.7.

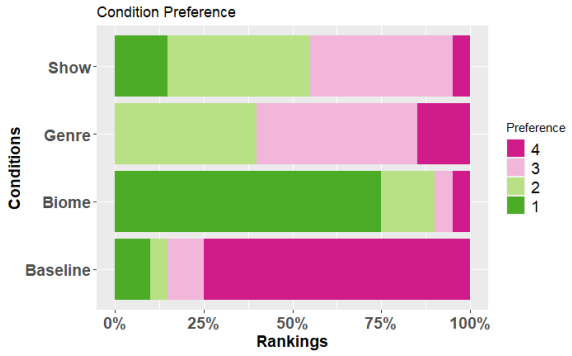


Figure 4: Participants ordering of the conditions from 1 *Most Preferred* to 4 *Least Preferred.*

Figure 4 shows us that *Biome* was the most preferred condition followed by *Show*, then *Genre* with *Baseline* the least preferred. Similar to Figure 3, the one participant who ranked *Biome* as least preferred had a strong dislike of the entire concept (Section 4.3.7).

4.3 Qualitative Results

A single coder inductive thematic analysis was performed using QCAmap to identify key themes from the post experiment semi-structured interviews following the process described by Saldaña [41]. Participant quotations in the following sections have been slightly edited for clarity and brevity. The key themes were:

4.3.1 *Baseline.*

Baseline Comparatively Boring (n=3). P1, P13, P15 suggested that the *Baseline* was boring after experiencing the other conditions.

4.3.2 *Genre-Based Augmentations.*

Retextured Train is Immersive (n=5). P2, P4, P6, P16, and P17 all made comments relating to the change of textures of the train interior. P6 said *"I felt the wooden chairs and the floor and the ceiling more so than the objects made the environment feel more in keeping with the theme".*

4.3.3 *Show-Specific Augmentations.*

Show - Interesting and Thematic (n=7). Seven participants (P5 and P8-P13) all commented on the appropriateness of the objects. As P12 said *"I like the Game of Thrones objects more than the medieval objects because that was something you can relate with the show and these are like iconic things that are there".*

Game of Thrones Objects Distracting or Out of Place (n=9). P1, P2, P4, P13, P14, P16, P17, and P20 found the Game of Thrones objects distracting or out of place. P16 said *"[It's] maybe a bit more distracting if there are things that are particular because you're like, oh, why is that there? What's that? It distracts your brain".* A similar comment was made by P2 *"with objects laying around, every once in a while I was just tempted to see what was there, which then takes the focus away from the screen".*

since the objects were constant throughout the clip, even for the *Biome* condition, participants made reference to the objects not always fitting what was shown on screen – for instance, objects featuring the heraldry of one family being present during a scene depicting their rivals. P20 explained it *"in the first scene, where it was at king's landing, there were Stark banners which were incongruous to the scene itself".*

4.3.4 *Biome-Specific Augmentations.*

Biome - Immersive (n=13). P1, P2, P3-P5, P7-10, P13, P15, and P16 all remarked on the increase in immersion they experienced with the *Biome* condition. P16 said *"I liked that, when it was snowing, I kind of always imagined feeling cold and when it was in the desert, the sort of the heat rising. Yeah, almost got a smell. It really evoked the senses and I liked that".*

Scene Change Transition. P2, P3, P13, and P19 asserted that the change of interior from medieval to snow to sand distracted them. The other participants did not find this scene changing to be distracting. When asked if they found it distracting, P10 said *"No, it felt like more involved because the background of the scene was also snow when the scene was snow and the decorations were sand when the scene was sand desert, so it was more engaging rather than distracting".*

4.3.5 *Particle Effects used in the Biome condition.*

Particles Made it Feel More Alive (n=3). P2, P14, and P18 commented on the particle effects. P18 said *"It added a lot to the experience because it was aligning with what I was seeing, the environmental changes, the particle effects happening. Those particle effects made it feel more real overall for me".*

Particle Effect Placement. P1, P10, P14, P15 commented that they appreciated the particle effects as they were implemented, appearing in front of the screen. On the other hand, P2, P5, P6, P11, P16, P17, and P20 suggested that the particle effects should not come in front of the screen and occlude it but should instead be behind the screen or made invisible as they pass in front of the screen.

4.3.6 *Generic or Themed Objects.*

Five participants, P4 and P14-P17, preferred the generic objects used in the *Genre* condition instead of the themed objects used in the Show-Specific Augmentations condition. P4 said *"The generic medieval sort of fits all three scenes whereas the Game of Thrones things only really fit mostly the second scene".* In contrast 8 participants, P5, P8-P13, and P20, preferred the themed objects. P5 said *"The generic objects after a while just faded away. I didn't really care about them. But the Game of Thrones specific objects were much more interesting and it was much more in theme".* There were four participants, P1, P6, P7, and P18, who did not have a distinct preference.

4.3.7 *Alternative Perspective.*

The quantitative results of P19 for Biome-Specific Augmentations for each of *Film-IEQ*, *UEQ-S*, and *UES SF* were extreme outliers Figure 2. Their scores for Genre-Based

Augmentations and Show-Specific Augmentations were also outliers but not as extreme. There scores were included in all analysis. P19 found all of the additions distracting and preferred traditional TV. This participant was an outlier in Figure 2a, 2b,2c and ranked *Biome* last in Figure 4 and Strongly Disagreed with the statement in Figure 3. P19 commented *"I just didn't like the moving things. It was distracting and fake and not for me"* and *"Yeah, I just like the way television is, and I don't think ARTV Ornamentation adds anything else"*.

4.3.8 Home Use. Four participants, P14, P17, P18, and P20, expressed a desire to use this at home in their living rooms when watching films.

4.4 Limitations

We deployed a previously used simulated AR-in-VR train environment [11] in this study which gave us full control over the scene. ARTV Ornamentations were applied in a controlled representative passenger setting for a detailed lab-based evaluation providing a high fidelity and wide field of view display allowing us to explore potential future applications of AR without the limitations of today's AR headsets. By running a controlled experiment, our study is missing social elements; a real-world environment would be much more dynamic with more possible distractions which could impact immersion and engagement. Our work provides a baseline for future research that should take the study into a real world setting to test how the Ornamentations work in that context.

Although we conduct this study in VR simulating AR use on a train, the concept of ARTV is feasible to implement in practice with modern XR devices. With the release of *Meta Quest V71*[2] it is now possible to use Meta's recent *Depth API* and *Room Understanding* [28] to detect surfaces within a room or vehicle and augment them directly or place augmentations upon them. These technologies were not available at the time of the study which prevented an "in the wild" study from being conducted. Creating a mock commute environment in a lab would have been arguably less ecologically valid than using VR to simulate one, given the availability of high detail 3D modelled passenger environments.

Due to the difficulty in finding four clips from the show of suitable length that covered the same three biomes (interior, snow, sand) without any objectionable content, we decided to repeat the same clip for all conditions. We attempted to mitigate any issues of repeat viewing by counterbalancing the conditions. However, the order in which the scene transitions occurred was the same across all conditions (interior to snow to sand). It is possible that this fixed ordering may have had an impact on the results due to familiarity. The next stage of the work would be to apply the Ornamentations in a more dynamic way to general content by, for example, using scene information in the programme's metadata to indicate when to change.

The decision to include house-specific iconography (e.g. Stark wolf head) throughout all scenes may have impacted immersion, as some participants mentioned that they found it incongruous during a Lannister scene to have Stark banners being shown. Similarly, the placement of certain particularly attention-grabbing Ornamentations within the immediate surroundings of the screen may have diverted attention away from the screen. These objects were placed in the scene in a manner appealing to the authors but it is possible that not enough consideration was given to this set dressing, resulting in a distracting experience for some participants. Using generic Ornamentations, although less popular with our participants than Biome-Specific Augmentations, would solve the problem of incongruous material, as their inclusion would never be particularly out of place. However, a particularly attention grabbing generic augmentation could be similarly distracting. In order to avoid this, careful design and placement of the Ornamentations is required, similar to set design for physical set dressing.

We are unable to reflect on the psychological effect of the increase in immersion in this study. We chose a show that was unlikely to elicit a significant effect and we did not measure for this. It is however possible that should media such as a horror movie be used with ARTV Ornamentation that such an effect may be measured, as can be seen in VR gaming. [50]

We could have looked at a best case scenario high fidelity approach and examine only the placement of ARTV Ornamentations. Augmentations in an immediate border around the display, or in the immediate surrounding of the user, or on floors and tables only, or on walls only. Although that specific question of placement remains unanswered we prioritise understanding the minimum fidelity required to create an engaging user experience.

5 Discussion

Our results show that ARTV Ornamentations can be effective outside of the nature documentary genre – the only genre considered by previous studies [11, 37] – and that we can apply this technique to narrative-driven multi-scene content.

5.1 RQ1: Should ARTV Ornamentations Be Show Specific or is Genre Sufficient?

Both the Genre-Based Augmentations and Show-Specific Augmentations conditions resulted in significantly more engaging, enjoyable, and immersive experiences than experienced in the *Baseline* condition. This can be seen from the pairwise comparisons for both the *Aesthetics* and *Reward* subscales for the UES-SF Table 1. We did not find any significant differences between Genre-Based Augmentations and Show-Specific Augmentations themselves, which means the extra effort of curating objects per show may not be necessary to create an engaging and immersive experiences for users.

Participants who were fans of the show found the mismatch between the provenance of displayed Ornamentation objects and the on-screen context distracting or incongruous. It is possible that it is not sufficient to change only the train interior with the scene, but that the objects must also be changed so that they are in keeping with the current narrative. For the generic objects in *Genre*, this was not an issue. The ARTV Ornamentations included may benefit from being designed by those who make the show and could therefore tailor them more precisely to the storyline. This would increase the production overhead associated with using ARTV Ornamentations

[2]Meta Quest V71 Update https://www.meta.com/en-gb/blog/quest/meta-quest-v71-update-horizon-os-refresh-calendar-remote-desktop/ Last Accessed 11/11/2024

(e.g. creating and time-stamping digital assets) but would also allow for a bespoke experience.

Further research is needed to confirm if Genre-Based Augmentations and Show-Specific Augmentations truly result in similar user experiences. However, to provide an increase in enjoyment, immersion, and engagement, it is sufficient for ARTV Ornamentations to match only the genre of the show. This answers **RQ1 - Genre or Show Specific Objects**: for every subscale we found no significant difference between the two conditions.

If Genre-Based Augmentations and Show-Specific Augmentations do result in similar user experiences, then it would save development/design effort and means similar ARTV Ornamentations can be used for many different shows and films, not only those that can afford to hire a developer/designer to curate a show-specific ARTV experience. A robust implementation of ARTV Ornamentation would correspondingly only necessitate the identification of several distinct sets of 3D models and textures whose use would cover the majority of common genres and biomes.

5.2 RQ2: Should We Adapt Ornamentations Dynamically Based on Changes in Scene Biomes?

The Biome-Specific Augmentations condition, in which the retexturing of the interior was updated with each scene transition to match the on-screen visuals, had significantly higher Film-IEQ, UEQ-S, and UES SF scores compared to the Genre-Based Augmentations condition. Biome-Specific Augmentations also had a significantly higher UES SF score for the Show-Specific Augmentations condition. This preference is echoed in the interviews, with 11 participants directly remarking on how immersive it felt when the ARTV Ornamentations matched the current scene and how it improved the experience. 95% of participants agreed or strongly agreed that they would be interested in watching videos this way (Figure 3). 90% of participants ranked *Biome* as either their first or second preference, showing a strong willingness to use this technology. Therefore our second research question **RQ2- Biome Ornamentations** is supported; using Biome-specific Augmentations improves enjoyment, engagement, and immersion, and is preferred by the participants.

Many participants appreciated the sand and snow particle effects, but there was no clear consensus on whether the particles should occlude the screen. This indicates that it would be best to allow the user to choose based on their preference. P18 commented that having the particle effects present outside the train windows is noteworthy. New tools, such as Meta's Depth API [29], which allow for augmentations to be occluded by real world objects, could make this possible.

5.3 RQ3: Do ARTV Ornamentations Encourage the Use of AR for Immersive Passenger Media Consumption?

The use of ARTV Ornamentations improved passenger immersion, enjoyment, and engagement when watching *Game of Thrones* as compared with the standard AR video watching experience on a floating 2D panel. Only 25% of participants said they *Strongly Agreed* that they would be interested in using the Baseline condition, which represented the current AR media consumption experience, instead of a phone or laptop when watching video on a train. The use of ARTV Ornamentation in the Biome-Specific Augmentations condition increased this to 75%. This clearly answers **RQ3 Willingness to Use** - ARTV Ornamentations encourage the use of AR for passengers over existing media.

Users showed a desire to immerse themselves in their media. This includes bringing the environment depicted on-screen into their own passenger environment. For the first time, because of AR's ability to preserve reality awareness, it is possible to do this safely. This is a key component of passenger XR experience that drives passenger comfort and perceived acceptability of XR use [6, 49].

5.4 Reflecting on the Applicability of ARTV Ornamentations Across Genres

We now know that both nature documentaries and dramatic TV shows can benefit from the use of ARTV Ornamentation. Although *Game of Thrones* is a medieval fantasy drama it is reasonable to consider that audiences of other genres and shows may experience a degree of improved enjoyment and immersion. Any dramatic TV show might benefit as they would be likely to be similarly narratively driven and include a variety of locations.

However, if we consider other genres with different characteristics, we do not yet know whether the experience of watching them might be improved through the use of ARTV Ornamentation. Sitcoms, for example, tend to limit themselves to only a handful of sets, which prevents drastic changes to the user's environment as seen in Biome-Specific Augmentations. This could potentially put a limit on how immersive we can make such a show. Would watching *Seinfeld* whilst sat in Jerry's apartment, or surrounded by themed Ornamentations of familiar objects and items from the show result in an appreciable increase in enjoyment and immersion? There are genres that do not prioritise immersion by design. Soap operas, for instance, were deliberately constructed such that housewives could follow the plot whilst distracted with other tasks; the focus is on auditory more than visual communication [30]. Despite them being similarly narratively-driven to dramas, attention to the environment has never been the focus of soap operas, and they might therefore not be an effective use case for Ornamentations. This phenomenon is notably not dissimilar from the need for Netflix shows to be more "second screen" friendly and easy for the distracted viewer to understand [19]. In such cases, is an increase in immersion possible and/or warranted? Future work should consider exploring the range of TV genres available and further examining where ARTV Ornamentations benefit, or indeed hinder, media immersion.

We do not imagine ARTV Ornamentation would be used for every type of 2D media consumption. There are certain types of media in which users may not wish to be immersed. For example, in the context of a news programme reporting from an active warzone, immersion may exaggerate distress in users.

5.5 ARTV Design Guidelines

Given that the *Genre* and *Show* conditions did not result in a significant reduction in self-reported awareness compared to the *Baseline* condition, it would seem that passengers can retain the reality awareness required for acceptable use in transit under certain variations of ARTV Ornamentation. We have illustrated the benefit of matching the augmented interior of the transit environment to the theme of what is currently being viewed on screen; the *Biome* condition was significantly more immersive and enjoyable than the *Genre* condition in which a single augmented interior persisted across changes in the on-screen biome.

The findings in this paper illustrate that ARTV Ornamentation provides for a much more immersive, entertaining, and engaging experience for the end user than traditional AR video consumption approaches. ARTV Ornamentation offers significant benefits to passengers in balancing immersion and reality awareness. Its usage alters attitudes to the use of AR and could provide for a 'killer app', software which drives hardware sales, for XR headsets. Interview participants expressed a strong interest in using this technology to watch media; if the goal of XR headsets is to provide new and immersive media experiences then those devices should support ARTV Ornamentation. For prospective designers who wish to create experiences using ARTV Ornamentation we make the following suggestions:

Guideline 1: XR Headset manufacturers and software developers who wish to provide an immersive video experiences should consider implementing support for ARTV Ornamentations, such as theming based on the genre of the show. ARTV Ornamentation designers who wish to design the **most** immersive experience possible should ensure that the Ornamentations change to match the on-screen biome.

Guideline 2: Designers of ARTV experiences for XR headsets should consider if the magnitude of the benefit provided by Show-Specific Augmentations over Genre-Based Augmentations is worth the increased development and curation time to create custom Ornamentations.

Guideline 3: Designers should consider introducing particle effects which match the biome (e.g. sand in a desert) for increased immersion. However, mechanisms should be introduced to allow the user to personalise their interaction with the screen– or to turn them off completely.

6 Extending the Augmented Reality Television Framework

Our results emphasised the importance of a number of ARTV features which have not previously been addressed in existing ARTV frameworks. To account for this we propose an extension to the framework proposed by Saeghe et al. [39]. ARTV Ornamentations have unique challenges, design considerations, and interactions with already modelled dimensions which may be overlooked by ARTV designers using the original framework. We further nuance existing dimensions with considerations highlighted by the use of Ornamentations in our context – specifically, *Content Placement*, *Bystander Integration*, and *Confined Space Interactions*. For readability, we have illustrated only the subset of the framework relevant to ARTV Ornamentations and our new extensions. Items in coloured rectangular boxes were already present in the framework [39], items in oblongs with dashed borders are novel extensions we make to the framework based on the work of others, and items in solid blue borders relate to our own work Fig. 5.

6.1 ARTV Ornamentation

Our first addition is the explicit consideration of *ARTV Ornamentation*. Although *AR Content* already had a place within the ARTV framework Fig. 5, we argue that explicitly considering *ARTV Ornamentation* as a subset of it is worthwhile. ARTV Ornamentation presents unique challenges not encapsulated by considering AR content more broadly. There are different ways in which we can theme ARTV Ornamentations; this is what is captured by *Theming Type*. The two types considered in this paper are genre-specific and show-specific theming. These emerged out of our specific consideration of *Game of Thrones*, a show which belongs to an established genre but also has its own recognisable iconography. This more granular approach arose from the consideration of how these aspects of content more complex than the nature documentaries used in previous work could impact upon the design of ARTV Ornamentations.

6.2 Content Adaptive

The *Content Adaptive* subcategory refers to whether ARTV Ornamentations change dynamically in line with scene changes or remain static throughout the experience. In the case of a sci-fi space exploration show, for instance, the former would see the Ornamentations change as the crew moves from a snowy planet to a desert one; in the latter case, Ornamentations might be made to resemble the interior of the ship, even as its crew moves between locations.

6.3 Type of ARTV Ornamentation

The *Type of ARTV Ornamentation* should also be considered. Immersion can be improved by the simple introduction of 3D objects, the re-texturing of the user's surroundings, or a combination of both [11]. An experience might exclusively make use of 3D models, such as placing plants in the viewer's environment, or also make use of the geometry of the user's location and visually alter their sofa to resemble a rock. It could alternatively or additionally use particle effects as part of the experience, perhaps to replicate a sandstorm.

6.4 Personalisation

We also suggest introducing the concept of *Personalisation* into the framework. This refers to potential user control over the positioning and quantity of AR content that they experience. This is an important factor for real-world usability. As identified in prior work [11], users desire a different amount of AR content dependent upon their personal Immersion-Awareness threshold, particularly when using XR in transit. As seen from the condition preferences in this study, there is no one size fits all approach. The placement of the content will also effect a user's comfort in the experience [24]. An ideal experience will be highly customisable by the user. For example, we saw in the interviews different participants would

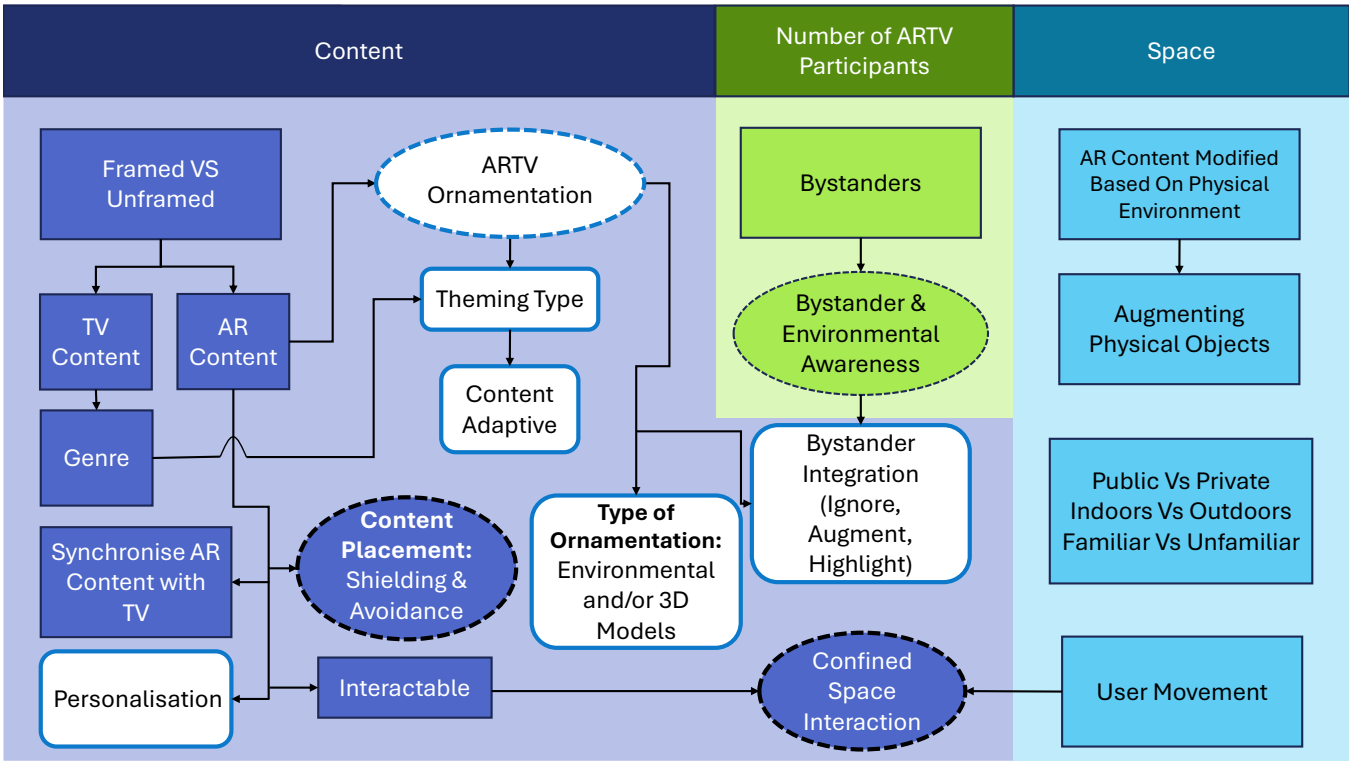


Figure 5: Augmented Reality Television Framework with extensions drawn from prior work and specific considerations developed within this paper.

find the same Ornamentation either supportive or distracting. P13 said *"I could see the wolf head ... I felt more in the spirit for Game of Thrones with that"* whereas P2 said *"I think that was quite distracting because every once in a while I just like look up at the wolf and be like, oh wait."* This highlights the need for individual personalisation of ARTV Ornamentations so that users can tailor the experience to be immersive to them. Personalisation also allows the user to balance immersion and reality awareness ensuring that they feel safe throughout the experience. This threshold changes across individuals which means personalisation is required. To make ARTV Ornamentation enjoyable and comfortable for as many people as possible, users must be able to customise both the level of AR ornamentation and the content itself and the placement of the content within their environment. There may be a disconnect between the ARTV Ornamentations that a designer wishes to use and the feeling they wish to elicit from the user and the user's personal immersion-awareness tradeoff. By altering the designer's vision might this create a lesser experience for the user? It is unknown at what point the placement and design of the ARTV Ornamentations become an intrinsic part of the experience.

6.5 Bystander Integration

Bystanders, such as other passengers, are given some consideration in the original framework, but we propose a more detailed and nuanced approach to handle their inclusion or occlusion. It is not enough for designers to merely consider if there will or will not be bystanders present in the experience; designers should consider how bystanders will effect the experience. As identified in prior work, there is a choice to be made regarding bystanders [6, 11, 24, 32]: users may prefer the bystanders be integrated into the experience, being augmented to match the other visuals (e.g. putting an AR cowboy hat on other passengers when watching a western) or they may prefer they be ignored, with content possibly placed in front of them which would obscure them from view. Alternatively, bystanders could be highlighted in some way to maintain user awareness (e.g. a cut out in the ARTV Ornamentations where the bystander is sitting [8]).

6.6 Content Placement

The next concept we consider is the placement of the content – both the augmentations and the ARTV screen itself. In the interviews given in prior work [11], participants remarked on their desire to place augmentations in front of distracting passengers or to avoid placing them in front of friends and family members. Similarly, Medeiros et al. found that participants elected to place virtual monitors in different egocentric locations dependent upon context and other passengers [24]. For this reason, it is worthwhile to give explicit consideration to the placement of AR content for ARTV experiences.

6.7 Confined Space Interaction

The original framework asks designers to give thought to whether the ARTV experience will be interactive or not. ARTV Ornamentations thus far have only been considered as static environment theming but there is no reason that they could not be interactive. Interactivity is already included within the original framework but designers must be mindful of the inclusion of interactivity within the ARTV experience when outside the home, as this can lead to problems with invading the personal space of others or physical collisions with the user's environment [25]. At home, the user will have an entire room in which to swing their arms and possibly move about should the application support it – this is not the case when in public transport. Hence, we included the consideration of *Confined Space Interaction* in our extended framework Section 6.

If future designers make use of this extended framework, then they will be more cognizant of the design decisions and challenges associated with ARTV and ARTV Ornamentation.

7 Towards ARTV Ornamentations In-Practice

In Section 3 our ARTV Ornamentation implementation would only be possible in practice if the AR headset had the following capabilities:

Scene Understanding Sense, obtain, and augment, the physical geometry of the user's environment

World-Locked, Context-Appropriate Placement Place 3D models within the environment in locations that make sense

Media and Scene Appropriate Visuals Alter the ARTV Ornamentations to match the on-screen visuals as the TV show changes scenes

It is now possible, using the latest version of Meta's *Mixed Reality Utility Kit* to build such an application for the Quest 3 headset. Meta's *Passthrough* API allows us to develop AR experiences for the Quest 3. It uses the device's cameras to provide the user a view of their real environment. This is necessary since *Christie et al.* found ARTV Ornamentations were ineffective on current "see-through" AR devices due to their low FOV [11]. We use the *Room Understanding* and *Mixed Reality Utility Kit (MRUK)* [28] APIs to augment the physical surroundings of the user and to place 3D models within the environment. We have the ability to assign textures to floors, walls, ceilings, chairs, and tables in the user's environment and we can also place objects in relation to them.

Currently, when using the Meta APIs, it is necessary to complete a set-up step and scan the room in advance with the headset before we can access and use the geometry data of the room. This is a software restriction put in place by Meta and not a fundamental hardware issue. If the headset software was designed with a use case such as ARTV Ornamentation in mind, a set up step of the same rigour may not be required.

With the advent of MRUK V75 it is possible, while on public transit, to change the textures of the user's environment to match the on-screen visuals of the show, place relevant 3D objects on appropriate surfaces around the user, and avoid rendering the ARTV Ornamentations on top of other passengers. This means that it is now possible to recreate every aspect of our ARTV Ornamentation design in practice.

8 Future Work

8.1 Application to Other Genres and Shows

With prior work finding ARTV Ornamentations beneficial for nature documentaries and this paper showing their use is effective for fantasy shows such as Game of Thrones, it is still not clear for which genres such an approach would be most effective, as discussed in Section 5.4. It is also worthwhile evaluating generic and themed objects with different shows even within a given genre, as our results were inconclusive and may have been a result of the incongruity of objects being shown in unrelated scenes.

8.2 Bystander Integration

Although we did not modify or deliberately obfuscate bystanders in any of our conditions, other work points to the benefit of allowing end users this level of personalisation [11, 24]. It is possible that users could find benefit in dressing up other passengers in thematically appropriate clothing. Future work could investigate the impact this has on passenger awareness and immersion.

8.3 Other Passenger Contexts

In this paper, we have only evaluated ARTV Ornamentations in the context of a simulated train environment. Commuters also take the bus or travel as a passenger in a car or plane. These contexts present unique challenges with more limited surfaces and space for placing ARTV Ornamentations. It is likely that the use of ARTV Ornamentations would have a similar immersive effect, but this needs to be evaluated.

8.4 Duration and Novelty

Though limited, the duration of the experiment was long enough to immerse the participant; Zhang *et al.* found a peak in immersion for video clips seven minutes in duration [53]– our clip was nine minutes long. Mai *et al.* [23] had participants draw on a graph their sense of immersion over time during a VR experience and found that 21% of the graph was used for the transition between starting the experience and being immersed. This equated to 3 minutes. However, 9 minutes may not have been long enough for the novelty effect of the ARTV Ornamentations to wear off. Scores may have been different had participants watched an entire episode (or indeed season) under each of the conditions. A longer-term study would be needed to investigate this. Future work should examine user behaviour over extended durations to understand long-term user engagement, cognitive fatigue, attention trade-offs, content retention, and usability over an extended duration.

8.5 Generating ARTV Ornamentations from Metadata

It is possible to generate an immersive ARTV experience without the need for a human to create the experience by hand, as was done in this paper. TV programmes and films already have *Audio Descriptions* which describe the on-screen activity aurally for visually impaired viewers. Other available metadata includes the show genre description and synopsis, which can be obtained from TV and movie database websites and can include photos from or related to the show.

This information could be utilised as input into an image generation tool such as *DALL-E* or Microsoft's Image Generator. The output images from that could then feed that into another tool to create 3D objects from images such as *DreamGaussian* [44]. With this said, we acknowledge the potentially problematic nature of generative AI, whose training materials may include works from creators who have not given permission for their use.

8.6 Evaluating ARTV Ornamentation on Real Public Transport

There is a need to evaluate the use of ARTV Ornamentation on a real passenger transport service to better understand the concerns and issues around social acceptability and reality awareness which may be present when using such a technology in public. This was not possible at the time of writing due to the lack of *Room Understanding* support when in *Travel Mode* but is becoming feasible with the release of *Meta Quest V71* [3].

9 Conclusion

In this paper, we applied ARTV to a genre other than nature documentaries for the first time. This was done in the context of a train environment where a user is watching an AR TV display showing Game of Thrones. We investigated the difference that generic and themed ARTV Ornamentations had on enjoyment, engagement, and immersion. We also investigated the effects of changing the ARTV Ornamentations to match on-screen visuals.

Our results show that matching the ARTV Ornamentations to the on-screen visuals (*Biome*) significantly improves enjoyment and engagement as compared with having fixed ARTV Ornamentations (*Show* and *Genre*). However, fixed objects are a significant improvement over the baseline of simply placing a virtual TV screen in front of the train passenger. Over 80% of users in our study said they would be interested in using *Show* or *Biome* Ornamentations instead of a phone or laptop when watching media on a train. Passengers are able to immerse themselves in their media while maintaining their reality awareness. Our work demonstrates the improvement that content-adaptive, themed ARTV Ornamentation makes over a simple ARTV display, we contribute an extension of a pre-existing ARTV framework to aid designers in creating ARTV Ornamentation experiences and provide guidelines for stakeholders looking to apply this technology in a consumer context.

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A Full Stats Table

		ART ANOVA			Significant ART Contrasts		
Survey	Subscale	**F** (df)	**p**	Effect Size η_p^2	Comparison	**p**	Cohen's **d**
	Overall	**6.28 (3, 57)**	**<0.01**	**0.25**	Baseline - Show	0.12	-0.72
					Baseline - Genre	0.86	-0.26
					Baseline - Biome	**<0.01**	**-1.30**
					Show - Genre	0.47	0.47
					Show - Biome	0.29	-0.58
					Genre - Biome	**0.01**	**-1.04**
	Captivation	**3.84 (3, 57)**	**0.014**	**0.17**	Baseline - Show	0.54	-0.43
					Baseline - Genre	0.99	0.03
					Baseline - Biome	**0.03**	**-0.92**
					Show - Genre	0.48	0.46
					Show - Biome	0.44	-0.49
					Genre - Biome	**0.02**	**-0.95**
Film Immersive Experience Questionnaire	Real World Dissociation	1.18 (3, 57)	0.32	0.06	Baseline - Show	0.55	-0.43
					Baseline - Genre	0.86	-0.26
					Baseline - Biome	0.29	-0.58
					Show - Genre	0.95	0.17
					Show - Biome	0.97	-0.15
					Genre - Biome	0.75	-0.32
	Comprehension	0.95 (3, 57)	0.42	0.05	Baseline - Show	0.98	-0.13
					Baseline - Genre	0.99	-0.05
					Baseline - Biome	0.43	-0.49
					Show - Genre	0.99	0.08
					Show - Biome	0.68	-0.36
					Genre - Biome	0.52	-0.44
	Transportation	**11.89 (3, 57)**	**<0.01**	**0.38**	**Baseline - Show**	**<0.01**	**-1.12**
					Baseline - Genre	0.09	-0.77
					Baseline - Biome	**<0.01**	**-1.89**
					Show - Genre	0.71	0.35
					Show - Biome	0.09	-0.78
					Genre - Biome	**<0.01**	**-1.12**
	Overall	**6.40 (3, 57)**	**<0.01**	**0.25**	Baseline - Show	0.07	-0.81
					Baseline - Genre	0.36	-0.53
					Baseline - Biome	**<0.01**	**-1.38**
					Show - Genre	0.82	0.28
					Show - Biome	0.30	-0.57
					Genre - Biome	**0.05**	**-0.85**
Short User Experience Questionnaire	Pragmatic	1.82 (3, 57)	0.15	0.09	Baseline - Show	0.29	-0.57
					Baseline - Genre	0.97	-0.14
					Baseline - Biome	0.24	-0.61
					Show - Genre	0.53	0.44
					Show - Biome	0.99	-0.03
					Genre - Biome	0.46	-0.47
	Hedonic	**11.65 (3, 57)**	**<0.01**	**0.38**	Baseline - Show	0.10	-0.76
					Baseline - Genre	0.20	-0.64
					Baseline - Biome	**<0.01**	**-1.87**
					Show - Genre	0.98	0.12
					Show - Biome	**<0.01**	**-1.11**
					Genre - Biome	**<0.01**	**-1.23**

		ART ANOVA			Significant ART Contrasts		
Survey	Subscale	**F** (df)	**p**	Effect Size η_p^2	Comparison	**p**	Cohen's **d**
	Overall	**12.19 (3, 57)**	**<0.01**	**0.39**	**Baseline - Show**	**0.02**	**-0.95**
					Baseline - Genre	0.08	-0.79
					Baseline - Biome	**<0.01**	**-1.94**
					Show - Genre	0.96	0.16
					Show - Biome	**0.02**	**-0.99**
					Genre - Biome	**<0.01**	**-1.15**
	Focused Attention	**12.80 (3, 57)**	**<0.01**	**0.40**	Baseline - Show	0.19	-0.65
					Baseline - Genre	0.49	-0.46
					Baseline - Biome	**<0.01**	**-1.91**
					Show - Genre	0.93	0.20
					Show - Biome	**<0.01**	**-1.25**
					Genre - Biome	**<0.01**	**-1.45**
User Engagement Scale Short Form	Perceived Usability	2.59 (3, 57)	0.06	0.12	Baseline - Show	0.99	-0.10
					Baseline - Genre	0.99	0.08
					Baseline - Biome	0.13	-0.72
					Show - Genre	0.94	0.18
					Show - Biome	0.24	-0.61
					Genre - Biome	0.08	-0.80
	Aesthetics	**12.39 (3, 57)**	**<0.01**	**0.39**	**Baseline - Show**	**<0.01**	**-1.16**
					Baseline - Genre	**0.01**	**-1.04**
					Baseline - Biome	**<0.01**	**-1.95**
					Show - Genre	0.98	0.12
					Show - Biome	0.08	-0.79
					Genre - Biome	**0.03**	**-0.91**
	Reward	**11.27 (3, 57)**	**<0.01**	**0.37**	**Baseline - Show**	**0.03**	**-0.91**
					Baseline - Genre	**0.05**	**-0.84**
					Baseline - Biome	**<0.01**	**-1.88**
					Show - Genre	0.99	0.07
					Show - Biome	**0.02**	**-0.96**
					Genre - Biome	**0.01**	**-1.03**
I was aware of other passengers whilst watching the video		**4.34 (3, 57)**	**<0.01**	**0.19**	Baseline - Show	0.25	0.61
					Baseline - Genre	0.99	-0.05
					Baseline - Biome	**0.03**	**0.93**
					Show - Genre	0.19	-0.66
					Show - Biome	0.75	0.32
					Genre - Biome	**0.02**	**0.98**
I was aware of the augmentations		**14.09 (3, 57)**	**<0.01**	**0.43**	**Baseline - Show**	**<0.01**	**-1.28**
					Baseline - Genre	**<0.01**	**-1.41**
					Baseline - Biome	**<0.01**	**-2.04**
					Show - Genre	0.98	-0.12
					Show - Biome	0.10	-0.76
					Genre - Biome	0.21	-0.64