

# Feeling Moved in VR Concerts

Author: David J Aguilar

Senior Supervisor: Heide Lukosch

Co-supervisor: Andrew Phelps

Co-supervisor: Cindy Zeiher

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## Abstract

This research explores the user experience design elements necessary to evoke the emotion called kama muta, most commonly known as “being moved” or “being touched”, in a virtual reality concert.

Previous research has been able to mediate this emotion using video, nevertheless, to the best of my knowledge, no work has been done related to evoking kama muta in Virtual Reality. Accordingly, a VR experience prototype was created to simulate the performance of a fictional pop singer called X-ABC, who would have been dealing with grief as a consequence of his brother being missing and decides to share his feelings with the audience. Twenty participants took part in a between subjects’ study, in which they reported their emotional state using the KAMMUS Two, and Bailenson’s social presence questionnaires. Ultimately, participants’ answers were analysed using quantitative and qualitative methods.

Overall, the findings suggest that it is possible to elicit kama muta in a simulation by featuring a narrative that increases the intensity of communal sharing relationships, such as loss, reunion, or memories of loved ones. It was also found that the user-experience design elements that contributed the most to the emotional response were a set of floating screens with portraits of the siblings when they were children, a believable voice acting and a character with emotional facial animations which were also lip-synced with the acted voice.

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# 1 Introduction

Human emotion is an intrinsic component of human experience which has captivated the curiosity of psychologists, neuroscientists, and philosophers throughout history. Such a complex phenomenon has been subject of extensive research and study, which has resulted in a variety of theories and frameworks which seek to understand it. Over time, the exploration of emotions has expanded to encompass new technologies such as electroencephalograms (EEGs), electrodermal activity (EDA), electrocardiograms (ECGs), electromyography (EMG), pulse waves, etc [1]. More recently, with the emergence and progressive adoption of immersive technologies, researchers have been exploring the potential to evoke emotional responses in virtual environments (VE) [2] [3], which is the intention of this thesis, in particular, the emotion labeled as being “moved” or “touched” [4] in the context of music concerts.

Psychologists have long sought to understand the intricate mechanisms underlying human emotional states [5]. The study of emotions has revealed their multifaceted nature, involving cognitive, physiological, and behavioral aspects. From pioneering works by William James and Carl Lange proposing the theory of emotion as a bodily response [6], to research utilizing neuroimaging techniques to uncover neural correlates of emotions [1] [7], scholars have endeavored to reveal the mysteries of affective experiences. To shed light on the conditions necessary to evoke the emotion label as ‘being moved’, this research uses the work from T. W. Schubert, J. H. Zickfeld, B. Seibt, and A. P. Fiske [4], who proposed the term *kama muta* to universally identify the emotion labelled as begin “moved” or “touched” across cultures and languages. Alan P Fiske’s Relational Theory [8] is also used as a guiding framework to understand the different elements that may come to play to evoke *kama muta* in a musical experience in virtual reality.

In recent years, the advent of immersive technologies, such as virtual reality (VR) and augmented reality (AR), have led the surge of interest from professionals and scientist to incorporate it into different fields, such as education, defence, entertainment, healthcare, sports, engineering, and arts [9], [10]. Particularly, VR, which opens new possibilities to elicit emotions taking advantage of multisensory environments to engage human senses.

Within this landscape, the domain of live music can be seen as a testing ground for exploring the correlations between VR and emotion. Music, with its intrinsic ability to elicit emotions [5], has been a central component of human culture for centuries. Live concerts, in particular, have been revered as transcendent experiences, where artists and audiences come together in a shared, emotionally charged environment [11]. The power of live music lies not only in the auditory stimulation but also in the connection forged between performers and attendees.

Music is not only an art but also a very popular form of entertainment which has been featured in numerous studies on immersive experiences, most prominently computer games. However, research has not been limited to art scholars or the entertainment industry, it has also been conducted to test the combined effect of music and VR in the treatment of anxiety, depression, and other mental health conditions.

This study will explore people’s experience of emotions in relation to music in immersive virtual environments (VE), for this reason, previous work in psychology has been sought as a guiding framework, leading to the incorporation of concepts such as Social Presence [9], Communal Sharing and Empathic Concern [12] as essential components of this research.

## 2 Theoretical Background

### 2.1 Relational theory

Relational Models Theory was proposed in Alan P. Fiske's doctoral dissertation in 1985 [13] and fully developed later in his book: Structures of Social life [14] and a subsequent article which summarized the concept [8]. It posits that people relate to each other following four models: Communal Sharing, Authority Ranking, Equality Matching, and Market Pricing. These models explain corresponding interactions based on what people have in common, when they present aspects of ordered differences, when people attend to additive imbalances, or action are coordinated in proportions or ratios. Humans use these structures to plan and generate their own actions, understand and anticipate others and to coordinate collectives and institutions.

The theory suggests that four relational structures, along with culturally relevant social norms and values define most social action, thought, and motivation [15].

Kama muta theory [4] supports itself on Relational Models Theory, particularly on the concept of Communal Sharing Relationships (CSRs) as a fundamental construct. Hence, this thesis makes frequent references to it to justify the decisions made around methodology and experiment design. The main aspects of the construct applied to this study are discussed below.

#### 2.1.1 Communal Sharing Relationships (CSRs)

CSRs is one of the models proposed in Relational Model Theory and the cornerstone in this study. A *Communal sharing relationship* is defined by Fiske as an equivalence relationship where people within a group share something of significance (i.e. a bloodline, land, language) that makes them think they belong to such group on equal standing[15].

According to Fiske:

“Communal sharing (CS) relationships are based on a conception of some bounded group of people as equivalent and undifferentiated. In this kind of relationship, the members of a group or dyad treat each other as all the same, focusing on commonalities and disregarding distinct individual identities”[8, p. 2]

A particular feature in CS is that as members of the group are not differentiated, they have equal access to the resources a community possesses. An example of a communal sharing relationship is that amongst children in a nuclear family, since they have the same guardians (the parents), share the same physical space, food, and recreation. However, they also share responsibilities, such as looking after the toys, or keeping a secret from their parents. Moreover, they will come to defend a bullied sibling, or will protect the younger from the rain or the cold, which illustrates how people in CS relationships, especially in close kinship, are compelled to express solidarity and altruism with other members of the group.

CS relationships (CSR) is a foundational concept of kama muta, and consequently, critical to the design of a mediated experience that looks to evoke it. The brotherhood element present in the simulation's narrative has been drawn directly from the need to show a CS relationship that can be appraised by subjects in this study as described in the section below and in section 0 where the research method is discussed.

## 2.2 Kama Muta

Researchers have previously explored the affective states frequently described with the labels “being moved” or “being touched”. In most cases they have theorized that “being moved” is a distinct emotion providing evidence of its valence, motivation and typical appraisals [16]. However, none of those studies investigated its universality across cultures and languages which is what the kama muta framework aims to provide [4].

The labels given to emotions often do not carry the same meaning when translated to other languages and cultures as they are frequently expressed in vernacular lexemes. For instance, “been moved” in Spanish, “Ser movido”<sup>1</sup>, can only have its literal meaning which is been moved from one place to another; or Schadenfreude, a German term that means the joy at another's misfortune, an emotion for which nor Spanish neither English have a name. Kama muta theory (Sanskrit, “moved by love”) serves as a framework to universally identify and measure the feeling labelled as “being moved” or “being touched” [17]. Accordingly, five features have been identified as archetypical of kama muta.

First, Kama muta is triggered by the sudden intensification of communal sharing relationships [18] as Fiske et al explained:

“An intensification might be the formation of a new communal sharing relationship, the reestablishment of a former relation, or the contrast between the ground of loss or separation and the foregrounded figure of a distinct feeling or memory of love. An intensification often occurs including such a contrast with certain difficulties in the background, but it does not necessarily need to” [4, p. 8].

Regular occurrences of intensification include engagements and weddings, reunions, the feeling of being one with nature, union with the divine, childbearing, being subject of extraordinary kindness, sacrifices for others, and fond memories of love and friendship [4]. Other *kama muta* instances can also encompass a wider range of labels associated with *identity* such as “patriotism”, “nostalgia” or “rapture” [17]. Nevertheless, these labels will depend on the context, accordingly, “patriotism” will be salient in the context of international sports competitions such as the Olympic Games or during the commemoration of an important historic battle, whereas “nostalgia” is more likely to appear when people listen to a song constantly played in their childhood years.

Not only the **perception** of the sudden intensification of CSRs between an individual and other entities such as animals, deities or artefacts, evokes kama muta, but also, the **observation** of an unfolding intensification can cause it, as described by Fiske et al:

“The CSR that suddenly intensifies may be initiated by the person who feels kama muta, or

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<sup>1</sup> The expression in Spanish that would carry the same meaning would be “estar conmovido”

someone else may act to intensify the relationship with the person who consequently feels kama muta. And people often feel kama muta when they observe the sudden intensification of CS between other beings—real, fictional, or imagined” [17, p. 76].

This notion that kama muta can be somewhat induced by observation has been consigned by Schubert et al:

“Experiences of kama muta will also be ‘shared’ in the other sense: actively transmitted to others. This can be observed in social media, where we found our stimuli because they were shared (with the intention to evoke kama muta in others, presumably) and commented upon as moving and touching” [19, p. 21]

Second, kama muta has been qualified as a positive emotion. Schubert, Zickfeld and Fiske have conducted experiments that consistently showed people liked the experience, seek it out, and wanted to share it with others they care about [17] [19]; which attests to its positive valence.

Third, kama muta is characterized by specific bodily sensations [17] such as:

- A pleasantly warm pleasant feeling in the centre of the chest (“heart”).
- Moist eyes or tears.
- Goosebumps, chills, or shivers.
- Choked up (lump in throat), with difficulty speaking or a creaky voice.
- Placement of one or both open hands to the chest, palm inwards
- A deep breath and/or a pause in breathing.
- Feelings of buoyancy, lightness, floating, rising
- Exhilaration, being energized, feeling refreshed, optimism

The authors also clarify that not always all the sensations are present in all cases as in the excerpt below:

“When it is mild, many people experience few or no sensations, but when it is strongly felt, most (but not all) people usually have some of the following sensations and/or show some of the following signs” [17, p. 76].

This important distinction is considered during the presentation of the results and the discussion of this thesis.

Fourth, “being moved” motivates individuals to act communally [16] and to strengthen, repair, and sustain the CSR.

“kama muta generates devotion and commitment to repair, sustain, strengthen, or engage in communal sharing relationships, or in other words to act communally, with kindness and compassion”[4, p. 11]

Finally, depending on the context and culture, people may use the labels “moved”, “touched”, “heart-warming” or “poignant” to describe kama muta [4].

These five features, also referred as to **components** [20], are the building blocks of the KAMMUS Two questionnaire, or KAMMUS scale [4], which was developed in the study *“Kama muta: Conceptualizing and measuring the experience often labelled being moved across 19 nations and 15*

*languages*” by Zickfeld et al [4] to measure kama muta. During the formulation of the KAMMUS scale, the researchers measured communal sharing by asking participants to report on their assessment of *closeness, physical sensations, motivations, valence and labels* after watching a series of videos <sup>2</sup>.

In this study, virtual reality is used to show a communal sharing relationship (CSR), more specifically, brotherhood. The participants were exposed to a music concert in VR to witness the relationship between the protagonist and his brother as an example of CSR. The content, pace, and other design elements in the experience aimed to afford the increase of the intensity in the observed CSR and ultimately elicit kama muta. Moreover, the KAMMUS Two [4] scale is used to measure the components

## 2.3 Empathic concern and Empathy

*Empathic concern* is widely understood as empathy [12] in the sense that it refers to the *other-centered* emotional response of perceiving “someone in need” [21]. This response is usually described as having compassion and tender feelings motivating to help someone [22]. The person experiencing *empathic concern* may also refer to their emotional state as “being moved”, therefore there is an intersection between this concept and *kama muta*.

As Zickfeld et al argue:

“Empathic concern can be understood as a special case of kama muta that occurs in response to a specific social situation, namely when perceiving a person (or animal or other agent) in need” [12, p. 1]

This study aims to use virtual reality to mediate kama muta, an emotion caused by the sudden intensification of *communal sharing*. Consequently, to properly define a research experiment, it is critical to understand the emotion and the social circumstances in which it is produced. For instance, as noted in section 2.2, *kama muta* can be evoked by appraisals of CSRs, therefore, the VR experience needs to allow participants to make judgments on the actions performed by other actors. Additionally, taking measurements of *social presence* is necessary since the research will also evaluate how the user’s participation in the place where CSRs unfold affects *kama muta*.

## 2.4 Sense of presence

The sense of presence can be explained as the psychological perception of existing in a virtual environment as defined by Slater [23]. Commonly referred to as the feeling of “being there”, presence is achieved through *immersion* and it is arguably the most subjective characteristic of virtual reality. Therefore, to have a notion of what presence in VR is, it is necessary to explain some of the systems and abstractions that facilitate *immersion*.

Human beings experience the world through their senses: vision, smell, touch, proprioception, and taste. Also known as sensory systems, they collect the data used by our brain to create what is called

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<sup>2</sup> Materials and other details of the study can be found on the official website <https://kamamutalab.org/>

the “internal model” [24], which can also be described as *all that comprises our understanding of the real world and its mechanics*. The purpose of VR technology is to deliver the ability to perceive these mechanics in a computer-generated environment through sensory substitution devices [25],[26] which afford participants to use *natural sensorimotor contingencies* [27]. It is this technical capability what characterizes *immersion* in a VR system.

If the users can naturally use their body to move around and interact with a VE, their perceptual systems interpret that as the real world, which according to Slater et al [28] constitutes the “Place Illusion” (PI). PI can take place in environments where no events occur, for example, a person can be in a virtual room with unanimated objects and still perceive “being there”. However, when events happen and their interactions are believable enough, for they match the user’s internal model, a greater illusion that the events are really happening called “Plausibility” (Psi) rises [26]. Presence, as per Slater’s definition, refers to both PI and Psi, and this is the definition this work will follow.

## 2.5 Social Presence

Earlier definitions of Social Presence, defined as the feeling of being in presence of others and perceived by others, derive from Goffman’s work, *Behaviour in public places: notes on the social organization of gatherings* [29], which revolves around one’s physical presence in the present time (here and now) and the reciprocal perception from others. However, it is important to note that the contemporary technical use of the term refers to mediated interactions through telecommunication channels [30]. Accordingly, traditional telephony, teleconference systems, online forums, and social networks are examples of social-presence-enabling technologies, for they deliver “quality and degree of mutual visibility and social availability” [9, p. 80] .

Different theories have been developed to understand social presence, which, according to Harms and Biocca, have provided definitions that were not only vague, but also did not facilitate measurements to differentiate amongst different mediums [31]. Therefore, this study adheres to the rationale Harms and Biocca later formulated as a broad theoretical construct of social presence [32], which proposes six dimensions - co-presence, attentional allocation, perceived message understanding, perceived affective understanding, perceived affective interdependence, and perceived behavioural interdependence.

Although, detailing these dimensions goes beyond the scope of this study, their mention helps to understand the definition of social presence it follows:

“Social presence in a mutual interaction with a perceived entity refers to the degree of initial awareness, allocated attention, the capacity for both content and affective comprehension, and the capacity for both affective and behavioural interdependence with said entity” [32, p. 1]

In addition to the definition above, it is essential to highlight that although presence can integrate social presence, they do not refer to the same cognitive or perceptual effects. As discussed in section 2.5, presence in immersive environments such as VR and AR, refers to the degree in which the actions of the users in the environment feel natural to them, and how the responses provided by such environment match what they expect in their minds - the so-called internal model; whereas

social presence does not require immersion for it to occur, such as in a phone call, or a chat room where the place illusion does not exist.

This study explores and measures social presence in an immersive virtual environment in relation with an artificial audience composed by computer-controlled characters exposing different qualities in the context of a musical performance. Measurements were obtained by means of the questionnaire developed by Bailenson et al in their study “Equilibrium Theory Revisited: Mutual Gaze and Personal Space in Virtual Environments” [33]. The participants’ views on being amongst a such an audience were also captured and analysed in the qualitative analysis section 6.3.4.

## 3 Related Work

### 3.1 Elicitors of moving emotional states

In 2015, the research “Towards a Psychological Construct of Being Moved “ by W. Menninghaus Et al [16], investigated eliciting scenarios, emotional ingredients, appraisal patterns, feeling qualities, and the affective signature of being moved. In this research “being moved” is not characterized as an emotion on its own right; instead, it is described as a state or episode factoring other emotional states, called emotional ingredients (joy, sadness, anger, fascination, relief, pride, pleasure, disgust and shame). Three studies were conducted for this research.

The first study, intended to identify the elicitors of being moved by asking participants to provide descriptions of events they recalled as being emotionally “moving” (bewegend), “touching” (berührend) or “stirring” (rührend). It was found that significant relationships and important life events accounted for most of the eliciting scenarios which include death, birth, marriage, separation, and reunion.

In the second study, the researchers looked to clearly distinguished the four terms “moving”, “touching”, “deeply moving” (ergreifend), and “stirring”, in terms of valence and arousal, from other synonyms found in the Duden<sup>3</sup> (High German dictionary) such as “gripping” (packend), “exciting” (aufregend), “shattering” (erschütternd), or “elevating” (erhebend). This time, in addition to remembering “moving” events, subjects were asked to write the emotions they felt when experiencing the emotional state, they were assigned to recall. Through cluster analysis, the researchers concluded that in terms of distinctiveness, the four main terms, in addition with “gripping”, are very closely associated in affective space. They also found that episodes of being moved (found in the first study) had been shown to be high in intensity across different elicitors and event types.

The third study, sought to find how the emotion of being moved was subjectively experienced by asking participants to rate the labels for being moved matching them with a set of 40 pairs of semantically opposite adjectives. For instance, in the first row of the questionnaire, subjects assigned a number to the intersection between the labels “moved”, “stirred”, “touched” and “deeply touched” and the pair “joyful—cheerless”. This resulted in feelings of being moved been rated as wide rather than narrow, elevating rather than depressing, fine rather than coarse, warm rather than cold, open rather than closed, soft rather than hard, round rather than angular, feminine rather than masculine, and pleasant rather than unpleasant, which overall attested to the positive valence of the emotion.

The research from Menninghaus et al [16] has been used to find evidence of the scenarios which are more likely to evoke the emotion of “being moved”. Accordingly, important life events such as separation and significant relationships such as brotherhood were chosen to construct the narrative in the VR simulation.

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<sup>3</sup> <https://www.duden.de/>



### 3.2 Kama Muta in Mediated Experiences

In 2020, Dana Swarbrick et al conducted a study called “*Corona Concerts: The Effect of Virtual Concert Characteristics on Social Connection and Kama Muta*” that sought to find the aspects of a virtual concert that would mediate the experience of *social connection* and *kama muta* [34]. To achieve this, participants were asked to report on their feelings when watching a virtual concert as well as to whether and how the COVID-19 pandemic had been mentioned by the performers.

In the research, the salience of the coronavirus pandemic was seen as a trigger for *empathic concern* in the participants, and as a shared life experience with the performer and the other attendants (in addition to the fact of being sharing the concert experience) which would increase *communal sharing*.

The researchers used a reduced version of the KAMMUS Two [4] questionnaire they called KAMMUS-S to measure *kama muta* and the findings indicated that *kama muta* was mediated by social connection when the coronavirus crisis was highlighted.

In the proposed study, the communal sharing will be facilitated by a virtual environment featuring a simulated audience and a virtual musician instead of video. The topic the artist in the experience refers to is not the COVID-19 pandemic, but a personal life event as the trigger for empathic concern.

### 3.3 Feeling of Presence in Mediated Experiences Featuring Music

In 2017 Asa Linder investigated the key factors for the feeling of presence during a music experience in VR using 360 degrees video [35]. In this study the researcher compared the feeling of presence of two groups watching a VR- Movie of an organ concert. The first group used an HMD and the second one a flat screen. The quality of the video, the audio and the realism of the surroundings were evaluated using a survey. The results of the research concluded that most participants using HMD felt more present than the ones watching the flat screen, however, it is pointed by the author that 360 videos pose a rigid limitation on the interaction between the users and the virtual environment and further investigation needs to be done.

Also in 2017, Deacon et al, in their study, The Objects VR Interface, looked for design patterns applicable to experiences where users interact with objects in the VE to create sounds [36]. They designed a system where twenty-three (N=23) participants identified the relationships among 3D geometric shapes, colour, motion, and sound, to interact with three tracks representing the drums, bass, and synth, plus an additional one for sound effects. As it was an exploratory study, rather than testing hypotheses the researchers studied the users’ natural understanding of the environment assessing their exploration behaviours. The researchers evaluated the system comparing the users’ expertise operating music and audio generation technology using surveys such as Interaction Analysis (IA), Creative Support Index (CSI)[37], The Spatial Presence Experience Scale (SPES) [38], and Sonic Interaction Design (SID) [39]. The results suggested that participants, regardless of their level of expertise in music technology, felt present in the environment and that they have agency over the objects and the sound they produced. It was also found that most users enjoyed the experience, despite the confusion caused by some shapes such as spheres and prisms. Such confusion was experienced by subjects who did not relate these two shapes to their feedback function, which was indicating that some object did not belong in the space the user was trying to assign to it.

### 3.4 Virtual Audiences

Computer simulations allow people to analyse situations that if carried in real life would be either onerously expensive or extremely dangerous. Furthermore, as VR simulations deliver high levels of presence, they can be used to study human's reactions to the behaviour of other individuals, including big crowds, without the need to hire hundreds of people and avoiding any exposure to abuse or physical peril.

One application of crowd simulations in VR is the treatment of people who suffer public speech anxiety. Their main feature is that they provide control over simulated virtual audiences to trigger reactions from the speakers and evaluate their reactions. For instance, in 2002, Pertaub et al [40] created a system to assess anxiety of people making short presentations in front of different types of simulated audiences, which is similar to one used in the study run by Kahlon et al [41] who tried Virtual reality exposure (VRET) to treat teenage populations with public speaking anxiety.

Audience simulation also has applications in education such as in Fukuda et al [42] where the researchers developed an teachers training system in Japan, or more recently, Glémarec et al who published their work on the development of their system called STAGE [43] designed to supervise public speaking training in university seminars. In addition to research oriented systems, there are commercially available products such as VirtualSpeech [44] from VirtualSpeech and VRSpeaking from Ovation [45].

VRET has also been used on music performance anxiety (MPA) [46]. In this study, nine subjects, three of them in active treatment with anxiolytic medication, were exposed to a series of four virtual environments simulating different audience sizes which sequences of applause, whispering, coughing, candy wrap noises, etc. The first with twelve persons, the second with forty persons plus three judges, the third simulation only had three judges, and the fourth one showed an empty venue. The simulations were run in a CAVE setting instead of an HMD and the results revealed a significant decrease in MPA and an improvement in performance quality between sessions, however, the researchers clarify that the results are not generalizable yet.

### 3.5 Emotions in Virtual Reality

In 2015, Jackson et al, developed a VR platform that would help researchers to study some dimensions of human social interactions, especially empathy. The Empathy-Enhancing Virtual Evolving Environment, or EEVEE [47], aims to benefit studies in areas such as pain communication, social cognition deficits and empathy optimization, through a set of components that support the production of high-resolution avatars, the measurement of neurophysiological and motor responses and the translation of those responses into avatar reactions. The avatars created with this tool can display different emotional expressions based on the Facial Action Coding System (FACS) [48] to different degrees of intensity with the intention of triggering empathic responses from subjects. EEVEE demonstrates that, today, there is applicable technical capacity to create integrated software systems to measure and study empathy in VR.

In 2022, Barreda-Ángeles and Hartmann published their work in which they examined the psychological benefits users obtained while using social VR platforms in terms of relatedness, self-expansion and enjoyment, and their association with presence in the context of COVID-19 pandemic

[49]. They surveyed 220 participants online, who identified themselves as users of different social VR platforms which included VRChat, Rec Room, AlterSpace. The study used questionnaires to measure spatial presence (SPES) [50], social presence (Internal Consistency and Reliability of the Networked Minds Measure of Social Presence) [32], relatedness (Basic Psychological Need Satisfaction and Frustration Scale) [51], self-expansion (boundary expansion scale) [52] and enjoyment (fun scale) [53]. The researchers found that social relatedness was achieved by users engaging in VR conversations rather than by doing activities together such as playing games, exploring or co-creation. In addition, there was an overlap found between self-expansion and relatedness as they suggest:

“Social self-expansion might hint at users not using their actual identity when interacting with others, but relying on a different (and, thus, expanded) version of themselves in social VR platforms” [49, p. 10]

Which they later linked to the fact that users may change their behaviour depending on the avatar characteristics citing Gorisse et al [54]

### 3.6 Related Work Summary

The studies mentioned in the previous sections show that research on human emotion in VR is largely focused on the generation of virtual agents capable of simulating one or more persons to whose actions participants are expected to respond. Accordingly, audience simulators are frequently found since they allow consistent replicability of behaviours that can be identified by subjects as manifestations of emotion. For instance, the reproduction of facial expressions in avatars has proven to be effective at evoking empathy, an emotion of which it has been argued to be a case of kama muta.

Also, avatars may also be worn by users, i.e., VR social networks. In such case, studies have found that people experience social connection, which is a component of communal sharing relationships, a phenomenon that needs to be replicated in a virtual environment to elicit kama muta.

As per kama muta research in social psychology, the fact that different studies used video as a tool to trigger emotions such as in Fiske, Schubert and Seibt [17] and Swarbrick [34], suggests that not only Virtual Reality could be a valid medium to evoke kama muta, but also, that the questionnaire designed for those experiments, KAMMUS Two [4], can be also applied in this thesis.

## 4 Research Question and Hypotheses

Kama muta is an emotion caused by the sudden intensification of Communal Sharing Relationships, a concept that integrates, or is closely related, to *empathic concern (empathy) and social connection*. The method used by researchers to study it required exposing participants to a series of videos commonly labelled as “moving” or “touching” such as the in study in [19]. Nevertheless, to the best of my knowledge, studies on emotion mediated by VR have not explored *kama muta*, which raises the question of:

How to design a game or experience capable of evoking *kama muta* in *Virtual Reality*?

This study seeks to elicit *kama muta* through a VR concert where the participants can watch a realistic CGI generated pop-singer (X-ABC) giving a moving speech ( [Figure 1](#)~~Figure 1~~) where he mentions his missing brother (Leo), and later performing the song “See You Again” by Khalifa and Charlie Pugh ( [Figure 2](#)~~Figure 2~~).



Figure 1: X-ABC giving a speech

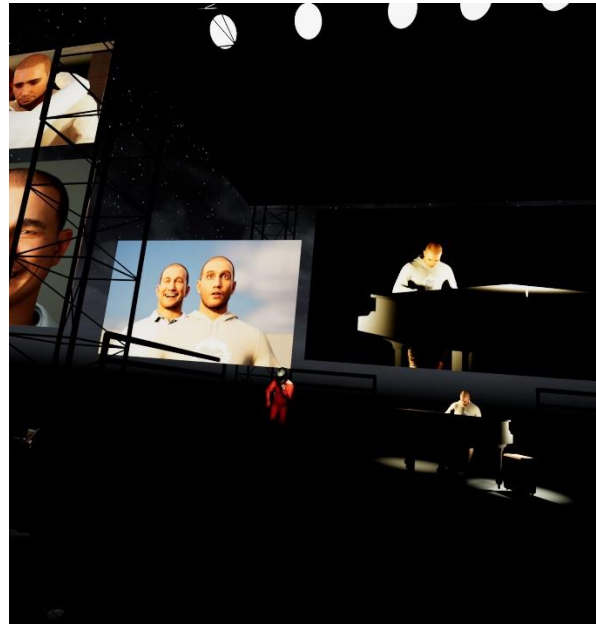


Figure 2: X-ABC Singing while the side screens show memories of him and his brother

To increase the participants judgment of social closeness, six virtual floating screens display photos of the brothers right before the song starts. These photographs show the siblings at different stages of their lives including childhood and adolescence.

In addition to the photos, an artificial audience (AA) reacts to the speech by cheering, standing and applauding at specific points in time. The experiment aims to find whether these reactions affect the users’ appraisal of communal sharing and consequently the intensity of the reported components of

emotion: appraisals, valence, sensations, motivations, and labels. As such, the variable to manipulate is the reaction of the AA, from which the two experimental conditions are derived:

Condition	Description
Supportive Audience (SA)	The artificial audience (AA) cheers, applaud and stands during the experience
Indifferent Audience (ID)	The AA remains quiet at all times

Table 1: Experiment Conditions

- H1. The reported intensity of the five components of emotion: ***appraisals, valence, sensations, motivations, and labels***, will be higher in the supportive condition compared to the indifferent condition.
- **H0. states that there is no difference in the intensity of all five components between the SA condition and the IA condition.**

These questions and hypotheses will be tested using the scenario called “The missing brother” which will be explained in the research method section below.

## 5 Research Method

The experiment in this study involves exposing subjects to a concert simulation in VR telling a story called *“The missing brother”*. Brotherhood and separation are the topics driving the narrative, chosen from the themes researchers have found to elicit the emotion of being “moved” or “touched” such as death, birth, marriage, separation, reunion [16] and nostalgic memories of friendship or love [4] [12]. The decision is also supported by arguments suggesting that close kinship involves a major component of communal sharing [8]. Accordingly, the story revolves around the protagonist’s grief, for the loss of his sibling and the sharing that feeling with the audience as shown below:

*The Tale of The Missing Brother*

*X-ABC is a big pop star giving a concert in a big venue with hundreds of attendants. He approaches the piano and once there he greets the audience.*

*Right after the greeting, X-ABC pronounces words of gratitude while he plays a slow-paced melody. Then, he gives a motivational speech where he tells the attendants about his struggle with anxiety and depression as a consequence of his brother being missing after a mission with the UN, and extends a message of hope, which he learnt from his brother.*

*The experience finalizes with X-ABC singing the song “see you again” by Charlie Pugh and Wiz Khalifa, as a dedication to his brother and all members of the audience who might be dealing with the feeling of loss.*

Once users completed the VR experience, measurements of social presence and kama muta were taken through a survey based on Bailenson et al. [33] and kama muta with the KAMMUS Two [4] questionnaire respectively. Finally, a semi-structured interview was conducted to capture participants insights.

The Bailenson et al. [33] questionnaire was chosen due to its simplicity and evident focus on finding how the users of a system detect the presence of others as describe in a meta-study on presence by Giuseppe Riva:

“The Bailenson et al. (2001) Questionnaire aimed to measure purely social presence and asked five direct and focused questions which would likely be effective in measuring social presence in general virtual environment settings such as virtual meetings, etc.” Riva et al [9, p. 86]

On the other hand, the KAMMUS Two [4] questionnaire is a tool used to measure the intensity of five components of emotion: bodily sensations, appraisals, valence, motivations, and labels. Each component is disaggregated in a number of measurements or items: twelve bodily sensations, four appraisals of closeness, four motivations to attend to communal sharing relationships, one measurement for valence and two for labels for being “moved” or “touched. Users are asked to provide a quantification of intensity ranging from 0 to 6 for each item. Literature suggests [55, p. 89] that not all the 23 items have to be reported to consider subjects have experienced kama muta, nevertheless, accounting for positive feelings and labels must exist. KAMMUS Two [4] questionnaire can be found in section 0.

An easy route to validate H1 is to test first whether there is a difference between the intensity of items measured in both conditions. Therefore, the **null hypothesis  $H_0$ , states that there is no difference in the intensity all five components between the SA condition and the IA condition.**

## 5.1 Prototype

The main objective of the design was to locate the user in a virtual environment where they could observe communal sharing relationships (CSR), as its appraisal facilitates the occurrence of kama muta.

It is assumed that the users would feel kama muta if the simulation was plausible in terms of the venue, the virtual artist's facial expressions and the believability of the speech. Nevertheless, greater emphasis was put on the main character since he was expected to be the main focus for the participants.

### 5.1.1 Venue design

To provide an experience that would feel familiar to participants, the stage and the audience needed to be allocated in traditional seating sections. Therefore, a full layout including front, west, east, and south seats was created.

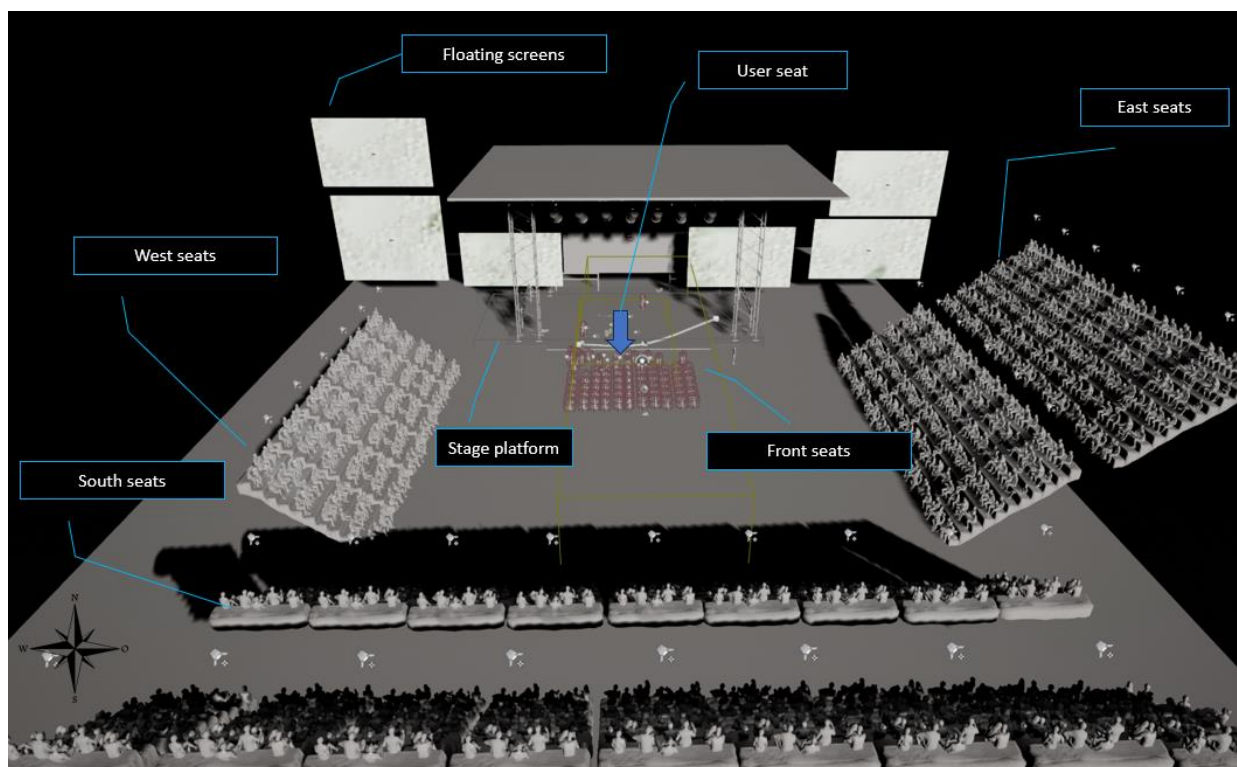


Figure 3: Venue layout



Figure 3, shows the layout of the venue in greyscale to indicate the position of the user, the crowd, and the stage.

During development tests, it was found that a big number of realistic characters in the vicinity would cause a significant drop in frame rate and subsequent system failure given the complexity of the textures they need. Consequently, two decisions were made to provide a sense of realism and minimize rendering issues, firstly, to surround the user with characters that vary in quality depending on their distance to him/her, and secondly, use a curated low-light setting.

#### 5.1.1.1 Audience

As mentioned in the previous section, to balance the need of good graphic performance and realism three different type of characters have been allocated in the venue: static-realistic, animated-unrealistic and hyper-realistic.

**Static-realistic characters** account for most of the audience since they only exist to fill the venue and provide a sense of realism. They are repeated instances of 20 static meshes in a sitting position, as seen in Figure 4, which are laid in two different ways; one as part of concrete stairways that make up for the east, west and south wings of the venue as in Figure 5.

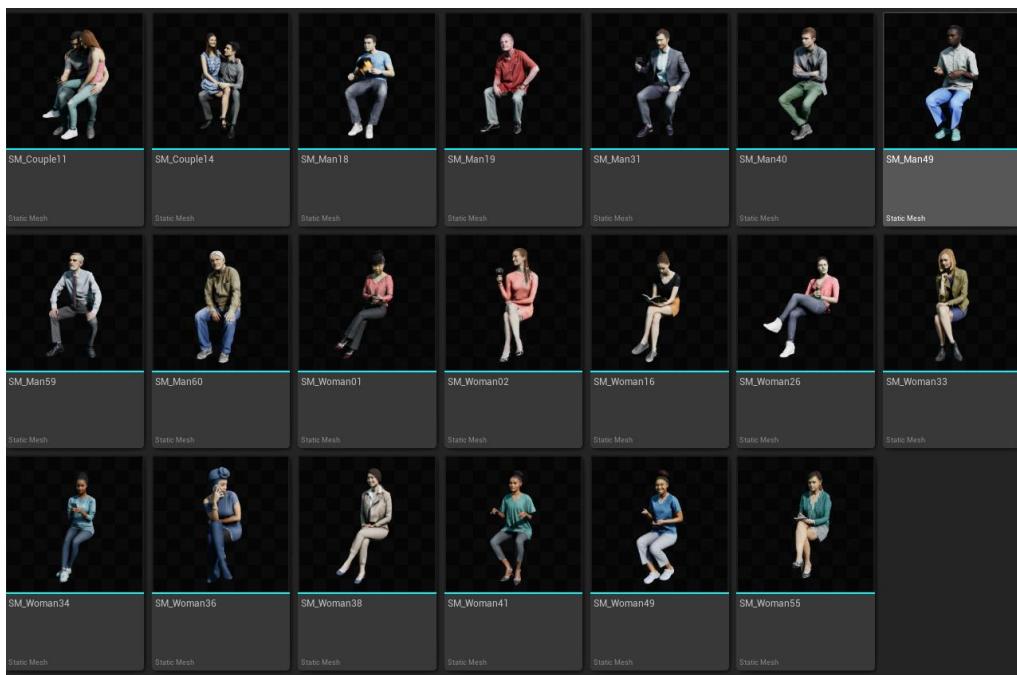


Figure 4: Static realistic mesh collection





Figure 5: Concrete stairway with sitting characters

The second use for these characters is to be part of the crowd behind the participants in the virtual environment. They are instances of a component which renders one mesh, selected randomly from the collection of 20 items, and puts them on a chair. Therefore, every time the system runs, a different character will be seen at each of the different positions in the front seat section as illustrated in Figure 6.

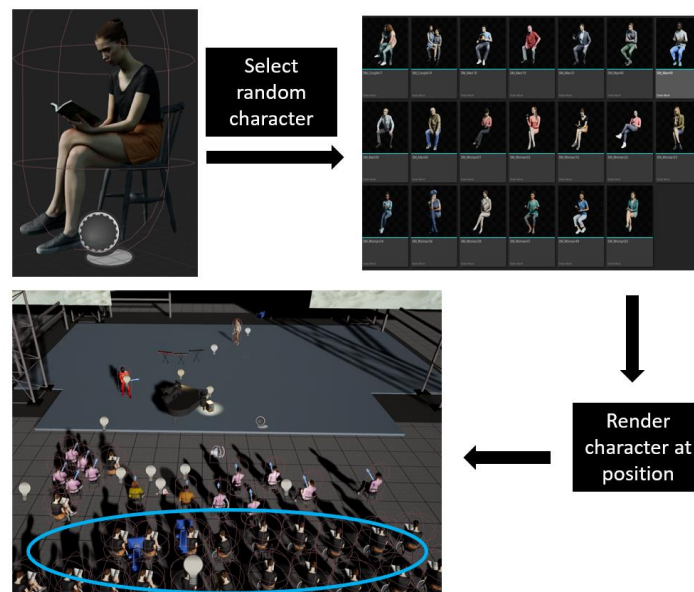


Figure 6: Randomized character rendering

The other category of characters is the **unrealistic-animated**; who are stationed at the front seat section beside the two hyper-realistic characters. Their purpose is to elicit reactions from participants going through the SA condition as they cheer, stand, clap, and make noises in response to the music and X-ABC's speech.

To ensure that the system can handle the animations without causing any failures due to high load, these characters are designed to be less realistic than others. They have simple skin and clothes textures and their faces do not move.

As these animated characters are all copies of the same mesh, they are located further to the sides of the user's peripheral view. This allows the users to perceive only the movement of "other people" while reducing their interest in the imperfections of the implementation. The design view of the character is shown in Figure 7, while the game play view can be seen Figure 26 and Figure 27 under section 5.1.4



Figure 7: Animated unrealistic character

The third category of characters is the **hyper-realistic**, which are two characters build using Epic Games' metahuman technology. These characters have complex skeleton meshes and highly detailed skin and clothes' texturing as shown in

[Figure 8](#) ~~Figure-8~~ and

[Figure 9](#) ~~Figure-9~~. They are placed next to the user; the female to the left and the male to the right, both playing a simple breathing animation to provide a greater sense of realism should participants turn their heads around. Variations of the animations are described in the section 5.1.4.



Figure 8: Hyper-realistic character  
to the left of participants

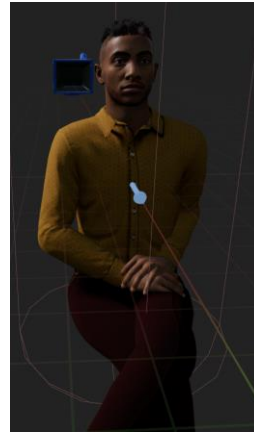


Figure 9: Hyper-realistic character  
to the right of participants

The location of the three categories, in relation to the user is illustrated in Figure 10 where they form small character clusters shown in coloured circles; blue for animated non-realistic, yellow for hyper-realistic and green for static realistic.

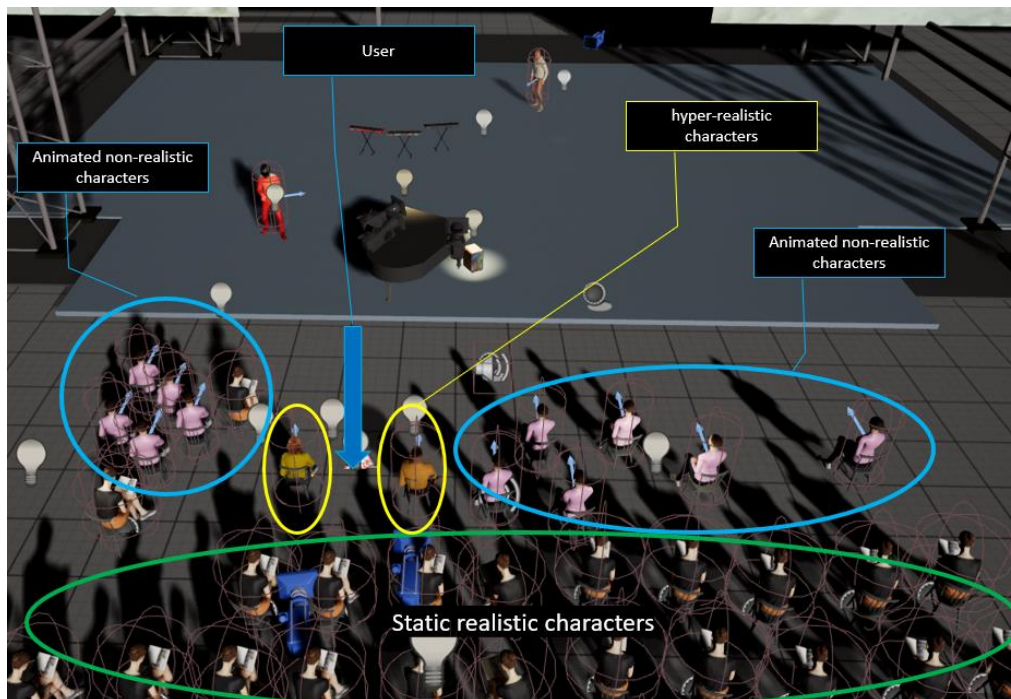


Figure 10: Position of audience character types

These small groups of audience characters are lit using point lights placed at strategic points so that the amount of light they receive allows the users to appreciate the hyper-realistic characters, and the cheering animations of the non-realistic ones while hiding their plastic appearance as much as possible. The lighting layout for the front-seats section is shown in Figure 11.

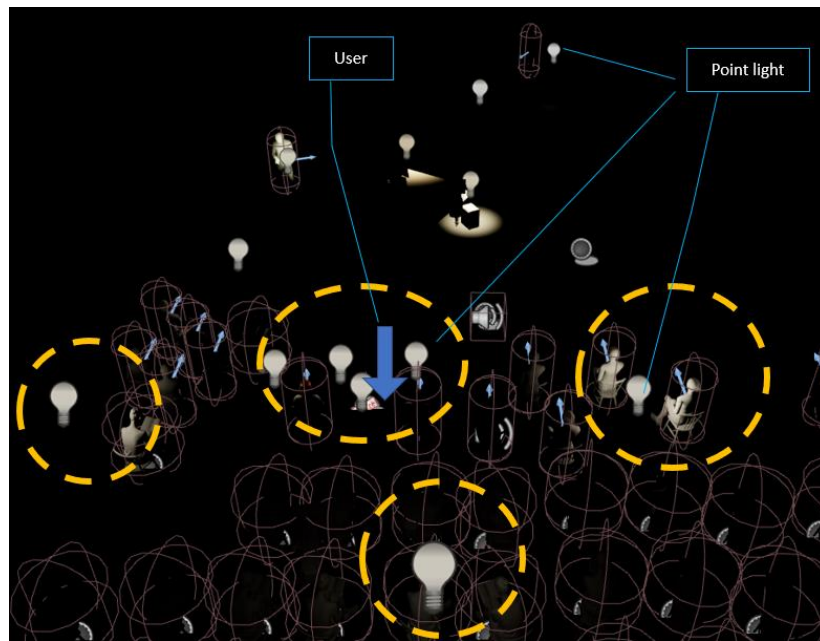


Figure 11: Audience lighting

### 5.1.2 Main screen

One of the main elements in the system design is a large display at the center of the stage, right above the level of the character's height. This element is referred to as the "main screen".

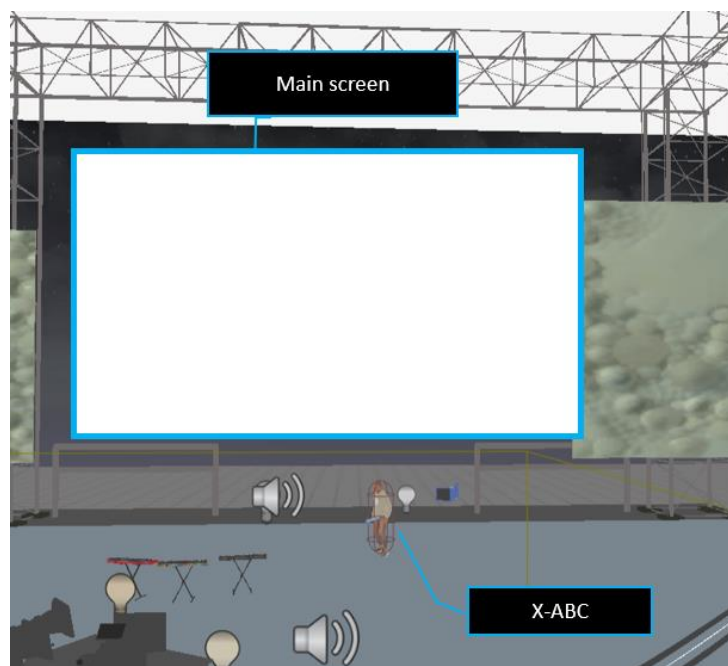


Figure 12: Central screen

The purpose of this device is to convey the emotional state of the protagonist throughout the simulation. During the speech phase, for instance, users are too far to appreciate how the main character moves his mouth to make sense of his calmness and gratitude when he plays the piano. The main screen displays such image as its function is to communicate those states. See Figure 13



Figure 13: Speech start - talking and playing the piano

Further ahead, the screen aims to portray more complex emotional moments such as the transition between a feeling of grief to an attitude of determination when X-ABC pronounces the words “I’ll go and find you”, illustrated in Figure 14 and Figure 15.

During the musical performance phase, X-ABC moves his head in flow with the music and his lips are in synchrony with the lyrics to keep the experience as consistent as possible and to maximize the feeling of presence. See Figure 16 and Figure 17.



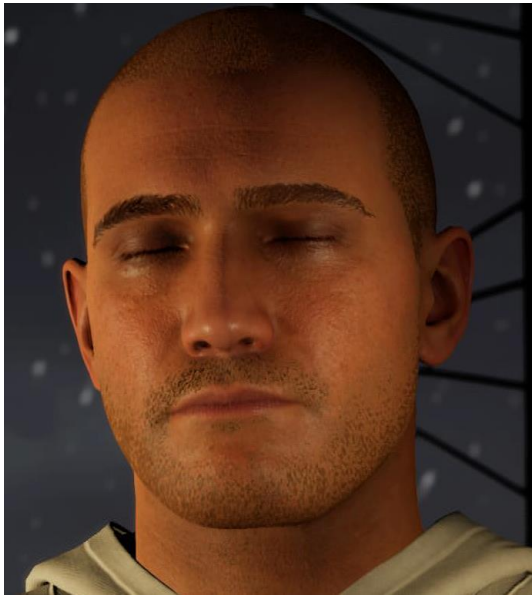


Figure 14: Facial expressions during the speech - grief-1

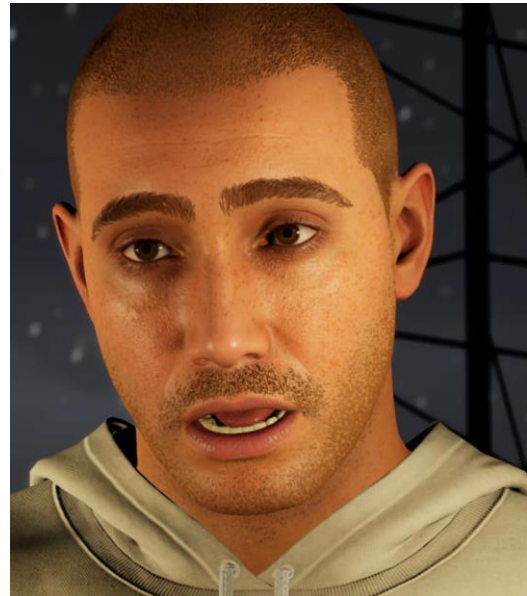


Figure 15: Facial expressions during the speech - grief 2



Figure 16: Facial expressions performance 1



Figure 17: Facial expressions performance 2

### 5.1.3 Production

Two alternatives were considered for displaying content on the main screen. The first alternative involved casting the action in the virtual environment in real-time to the screen. The second alternative required crafting pre-recorded video sequences which should be synchronized with the live simulation.

Technical tests conducted on VR game casting live video of itself, showed that this approach would demand a considerable amount of computing resources. Moreover, the complexity of the few hyper-realistic characters and the animations of the audience would further degrade its performance causing a significant drop in frame rates, animation jittery and system halt; all these would ultimately result in participants experiencing cybersickness.

Consequently, the most convenient approach was to produce a sequence of videos that would be controlled by code and synchronized with the characters' actions in the simulation. Such objective was achieved by setting up a virtual production environment using the same elements in the game.

Considering that Unreal Engine (UE) 5.1 was the tool used to create the game, and its reputation as a virtual production environment, choosing this tool to create the required videos was the most appropriate decision. Otherwise, all the assets would have needed to be migrated to a different tool, including the cognitive load of learning a new tool-set.

For all the experience two videos were shot; one for the speech and the other for the music performance. They were shot separately using UE Sequencer feature.

To obtain realistic facial animations, facial motion capture was implemented by connecting X-ABC's face skeleton to Epic Games' Live link app, which was run on an iPad pro 2. Although the audio was not rendered in the final video, it was attached to the face animation sequence to allow making corrections and smoothing some facial transitions.

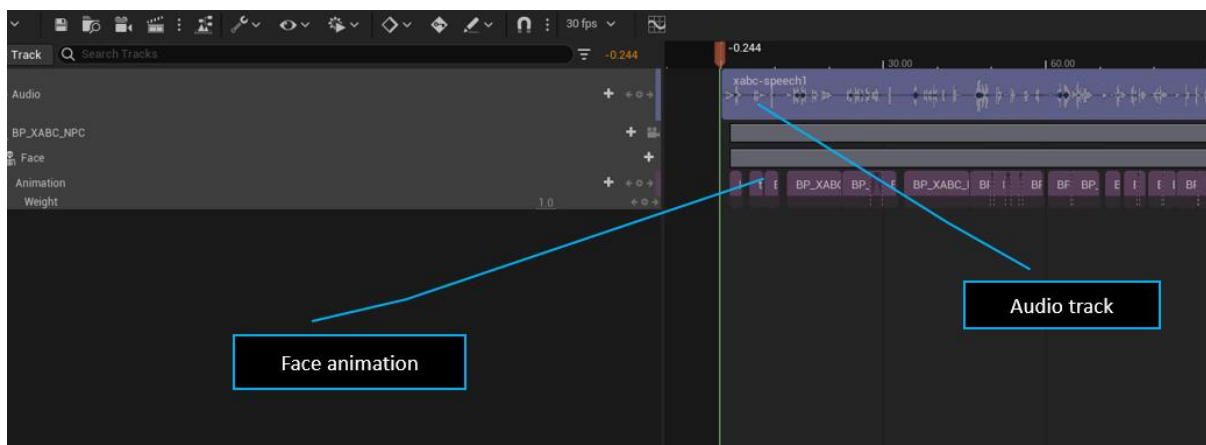


Figure 18: Sound track attached to facial animations

The resulting facial animations were then attached to a piano-playing full-body animation obtained from Adobe’s Mixamo <sup>4</sup> and retargeted to X-ABC’s metahuman skeleton.

Once the character was assembled, both videos were shot using three cinema cameras configured for three different shots; a front close-shot, a medium-shot and a left close-shot. The left close-shot was attached to a camera rail to capture X-ABC’s walk towards the piano. However, shooting this walk was finally discarded as several imperfections were found in the animated transitions from waking to sitting that would become a distraction for users. The location of the cameras from the operator perspective is illustrated in [Figure 19](#).

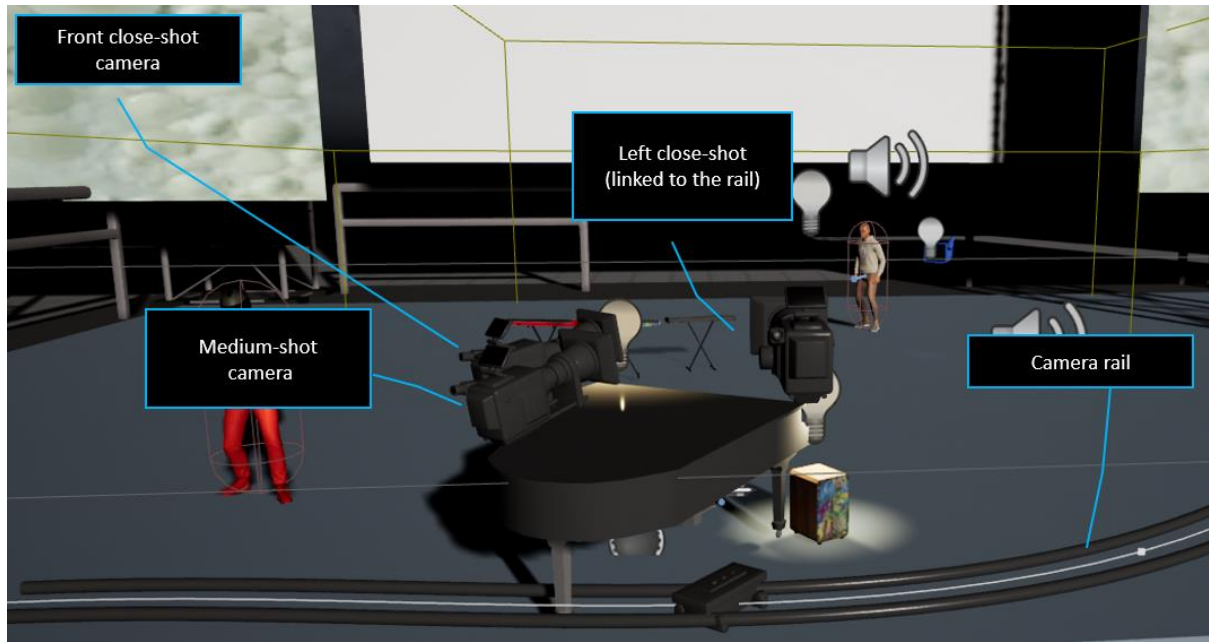


Figure 19: Shooting setup

Finally, the summary of the tools used to produce the system is listed in Table 2.

Component	Technology
Game engine	Unreal Engine 5.1 (UE 5.1)
Main character (X-ABC)	Epic Games MetaHuman
	Epic Games Live Link 2.0
	Live Link Control Rig 1.0
Audience - close distance	Epic Games Metahuman
Audience – mid distance	Adobe Mixamo character library
Audience – static meshes	Mega-scans static meshes
Programming language	UE Blueprints
Face motion capture	UE livelink + iPad Pro

Table 2: Simulation technology stack

<sup>4</sup> <https://www.mixamo.com>



#### 5.1.4 Speech recording

The speech was written to match the narrative of the missing brother and inspired by different clips of live performances found online such as the ones in [56] and [57] where the artists address the audience. Accordingly, the speech was voice acted as emotionally as possible and recorded in a small studio using Ableton Live 9.0 and subsequently lip-synced with X-ABC's mesh during several facial-mocap sessions in Unreal Engine 5.1 (find content of the speech in appendix-F).

#### 5.1.5 Simulation phases

The simulation consists of three main phases, **user adjustment (phase 1)**, **speech delivery (phase 2)** and **musical performance (phase 3)**.

##### 5.1.5.1 Phase 1

In phase 1, participants land in a VE with only two realistic characters sitting next to them. One female to their left, and one male to their right as shown in Figure 20 and Figure 22 respectively. When users look at the front they would see clouds, stars and a floor made up of tiles. The purpose of this initial stage is to ensure there are no rendering issues such as jittery, dropping frame rates or missing textures before the concert begins.

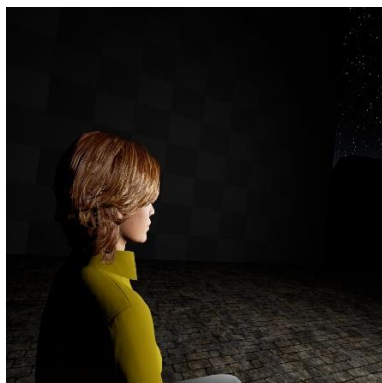


Figure 20: Phase 1 - left view

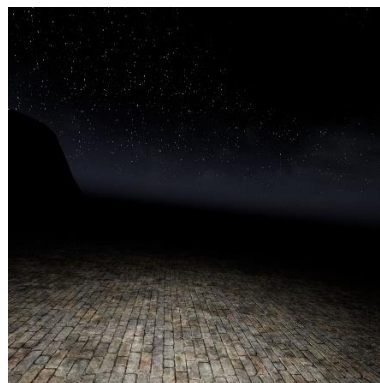


Figure 21: Phase 1 – centre view

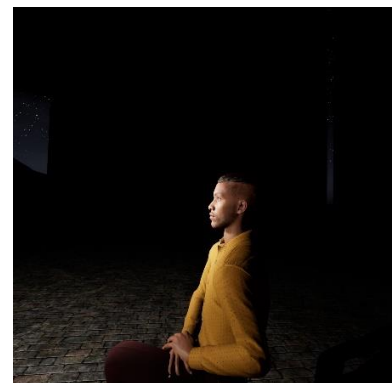


Figure 22: Phase 1 - right view

#### 5.1.5.2 Phase 2

The second phase is the speech delivery, in which users are first transitioned to the venue. This transition is instantaneous with no locomotion required. Therefore, the participants are set in the same low-light environment facing the main stage (as in Figure 23) in the same position relative to the characters they had just seen. The position of the users in the virtual world, in terms of height and orientation, is aligned with those characters for them to feel they are sitting as they are in the real world. The participants are expected to remain in a sitting position all the time, nevertheless, they are free to move their heads or rotate the chair; such movement is reflected in the virtual environment as well.

Participants have a few seconds to look around before the show starts. In its initial state, only the piano and the box beside it are illuminated by a spotlight at the top. The main screen starts with no projection and is completely dark. Then, they can see X-ABC emerging from the shadows as he approaches the piano as shown in Figure 23.

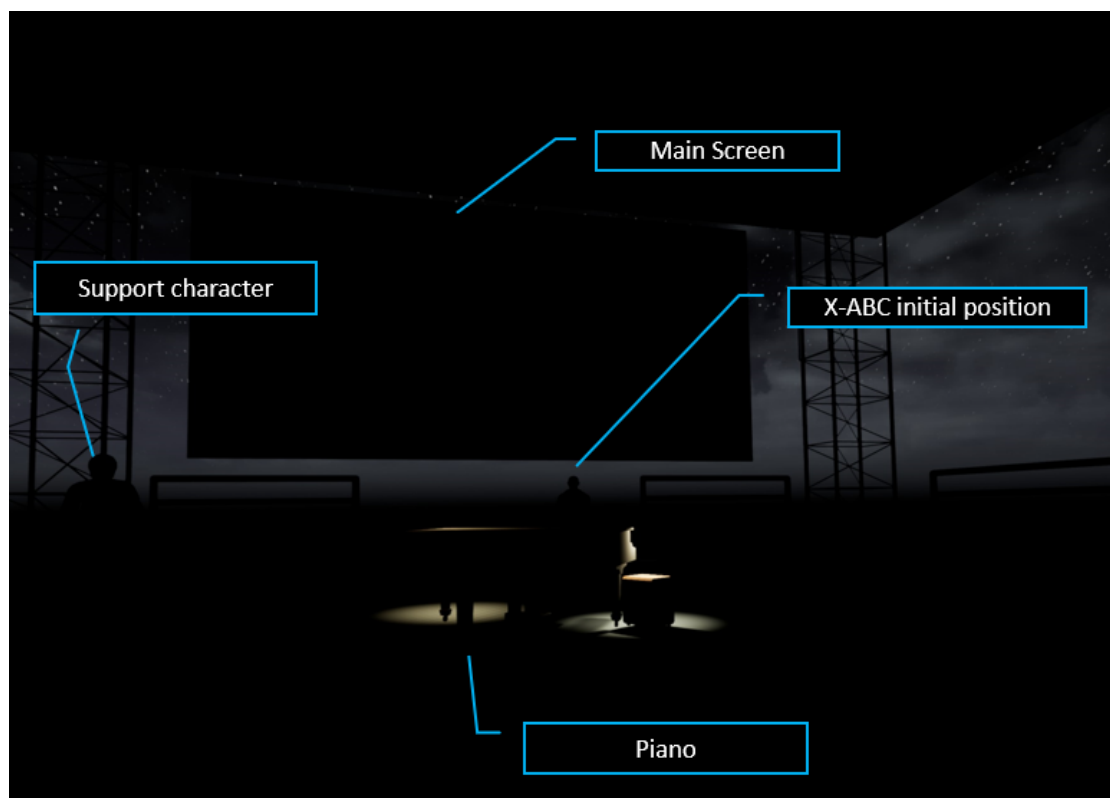


Figure 23: Speech Stage - X-ABC approaches the piano.

The venue is fully populated; the three types of characters can be seen to the left and to the right of the users as in Figure 24 and Figure 25.

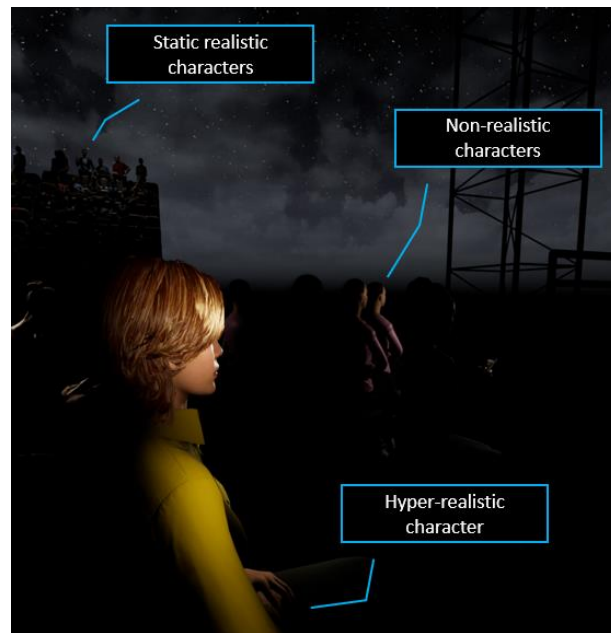


Figure 24: Venue characters - left view



Figure 25: Venue characters - right view

Under the SA condition, the audience applauds and makes loud noises while the artist walks and greets them. The animated non-realistic characters stand up executing two different applauding animations which are selected randomly.

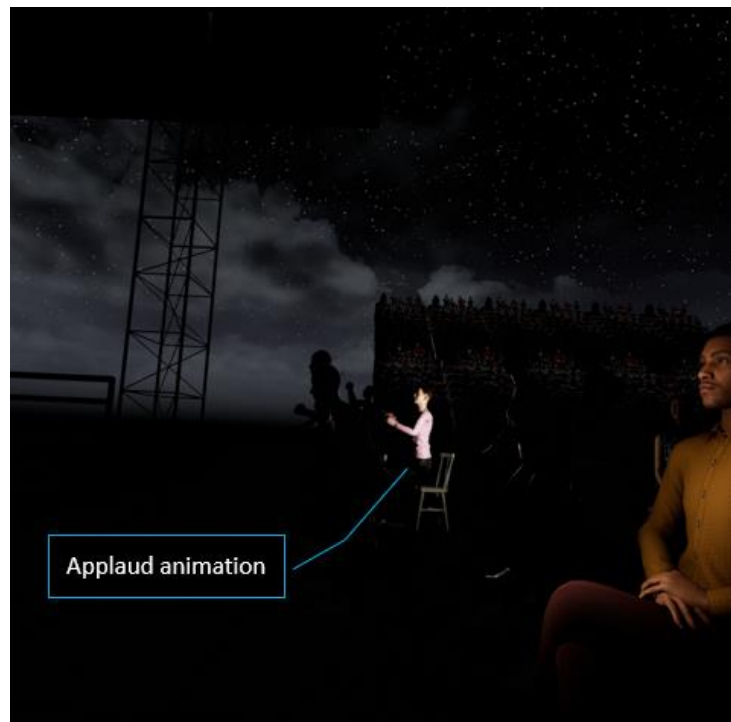


Figure 26: Characters applauding in SA condition.

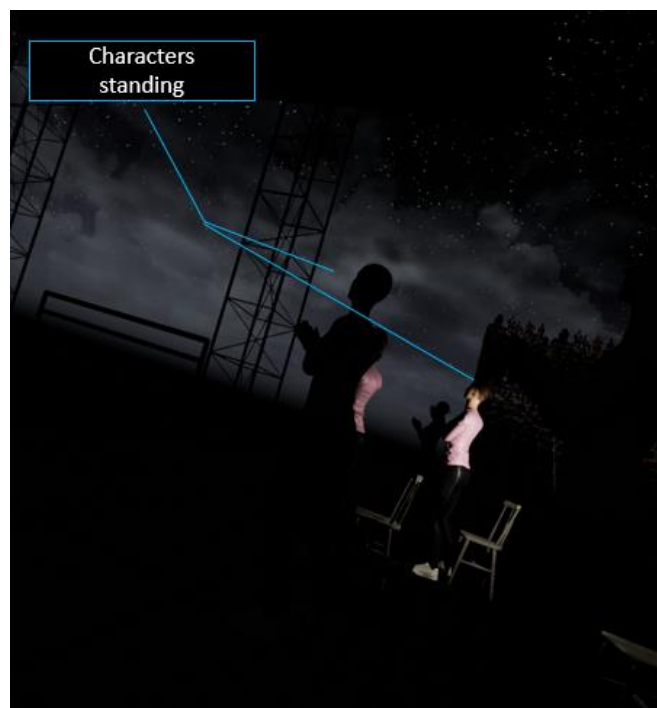


Figure 27: Standing characters on the right in SA condition



Figure 28: Standing-applaud characters on the left in SA condition

During the speech phase, X-ABC sits behind the piano and starts playing. Then the main screen starts projecting the performance from different angles as seen in Figure 29 and Figure 30.

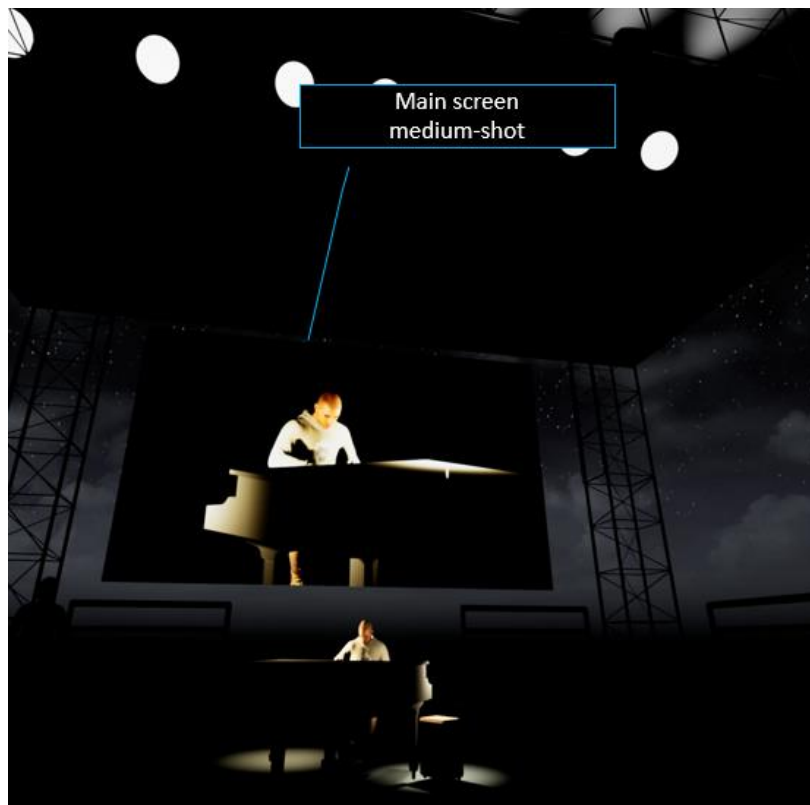


Figure 29: X-ABC performance medium-shot

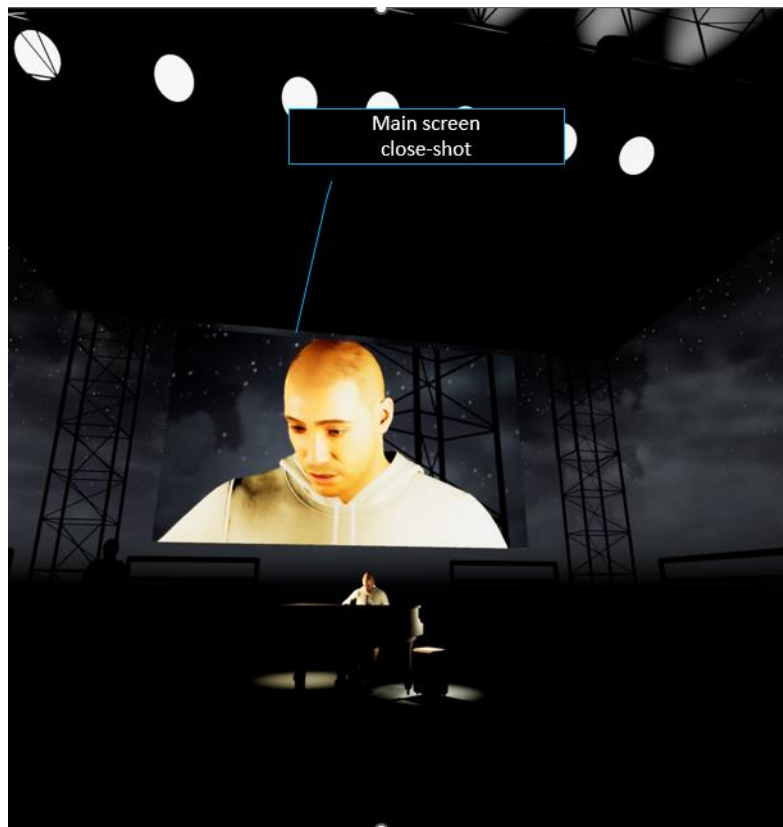


Figure 30: X-ABC performance medium close-up shot.

In the pictures above, it can also be appreciated that the complementary floating screens are invisible. The focus point for the user should be the facial expressions and the content of the speech in which X-ABC shares his grief and gives words of hope to the attendants, who will cheer him in the SA condition (supportive audience) of the experiment.

The end of the second phase is marked by the main screen and the lights over the singer fading out and the sentence singer saying “to him and all those you love”.

#### 5.1.5.3 Phase 3

Finally, on the musical performance phase, the lights and the main screen fade in again while the song “See you again” begins. During this phase the same shots of X-ABC are displayed as in the second phase.

The music piece has three verses, the first one played after the first and the second chorus, whereas the last verse is played at end of the song following the bridge. These verses are rapped; hence, a red rapper character was created to perform such parts.

When the rapper makes his appearance, he transitions from a still standing position in the shadows by fading into the scene playing variations of the same hip-hop animation which changes slowly after 30 seconds. When the chorus is about to start, he fades back out to the original stand-still position in the dark. The images in Figure 31 and Figure 32 show the variations in the animation, the former in a

full-body animation which looks more energetic while the latter show an upper body motion in which he only moves his arms at a slower pace.

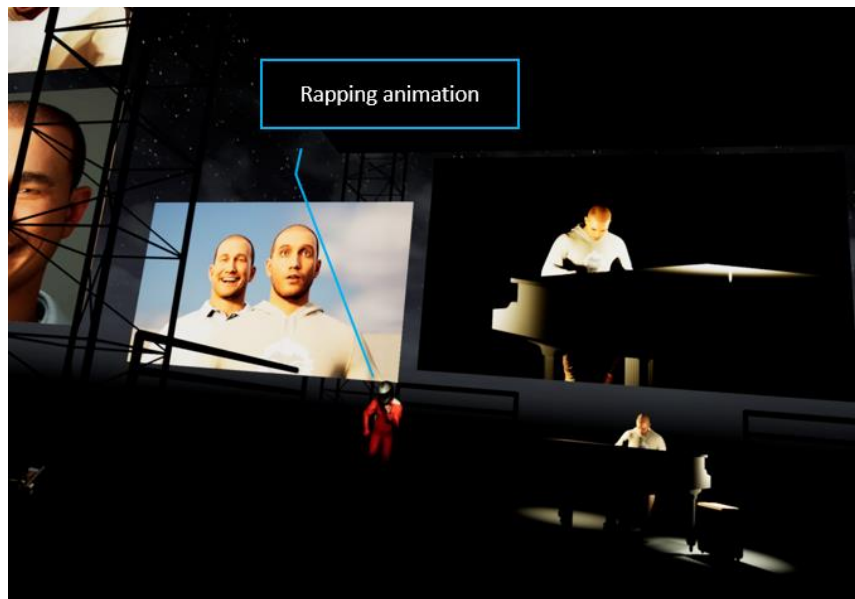


Figure 31: Rapper full body animation

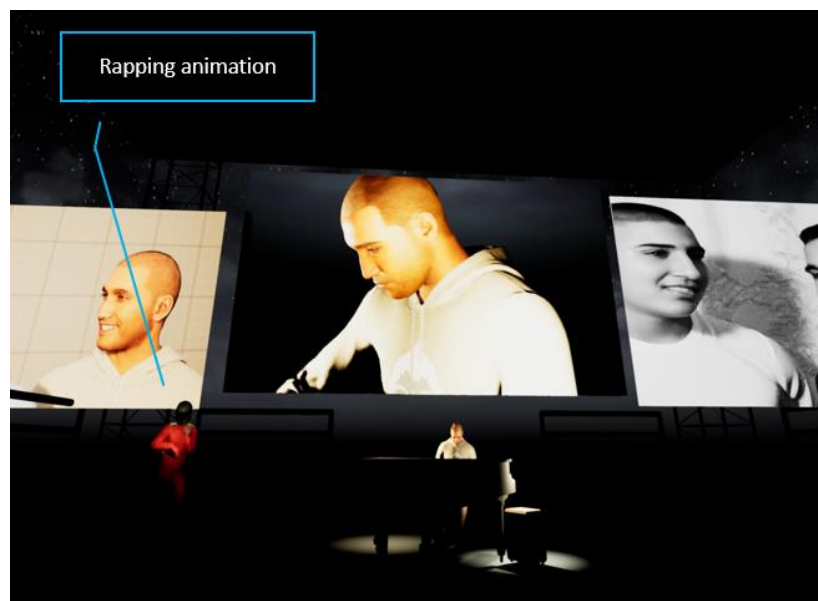


Figure 32: Rapper upper body slower animation

While the chorus is played in the SA condition, the female character on the left side of the user sings the along the artist; she can be seen by users moving her mouth and making facial expressions, which are exactly the same as X-ABC's since both characters play the same facial animation.

## 5.2 Procedure and materials

Participants were greeted at the HIT Lab NZ at the University of Canterbury in Christchurch, and guided to the experiment room where they were asked to read the project sheet and sign off the consent form.

Once participants have agreed to the procedures described in the project sheet, they were asked to read some manufactured headlines designed to look like real on-line newspapers. Such headlines were intended to provide participants with context to understand the nature of the events and the speech in the simulation. The fictional news excerpts tell about X-ABC's latest hit, his touring around the world and the tragic disappearance of his brother which media speculated could bring the tour to a halt. Details of the headlines can be found in section 0

After the users read the headlines, they were told to sit on a designated chair and put the headset on. The experimenter spent the necessary time to make sure participants were comfortable before launching the simulation. The location of the adjustment features in the headset was indicated by the experimenter, first with spoken instructions and if this failed by guiding their hands to the strap at the top and to the adjustment wheel on the back of their heads. The position of the build-in headphones was indicated as well.

At the first stage of the simulation, the experimenter asked the participants whether they were able to see the virtual environment clearly, especially the two characters on each side. This with the purpose of avoiding unwanted visual defects that could lead to cyber sickness or a poor experience.

With the confirmation from users that everything was working correctly, the experimenter proceeded to video record them and launched the second phase of the VR experience. At the end of the simulation, users were asked to move to another chair after removing the headset.

When they were comfortable and rested, a tablet device was handed over to participants in which they completed the KAMMUS Two [4] and the presence questionnaire, and a final a semi-structured interview which was voice recorded.

The equipment used for the VR simulation was an HTC Vive pro2 tethered to a PC with an Intel Core i7-10700, 32 GB of RAM and NVIDIA GeForce RTX 2080 super.



## 6 Results

### 6.1 Population

The total number of participants was 21, however, participant 5 has been removed from the sample, as it was discovered this participant could not comprehend the content of the simulation or communicate effectively due to poor English skills. Therefore, the size of the sample was twenty (N=20). Seven (7) Females, twelve (12) males and one (1) non-binary. The average age was 32 years-old with a standard deviation of 9.28 as shown in Table 3.

N	20
Mean	32.0
Standard deviation	9.28

Table 3: Population average age and standard deviation

As observed below, seventy percent (70%) of the participants were between 25 and 40 years-old as shown in Table 4

Age bracket	Counts	% of Total
18-24	3	15.0 %
25-30	7	35.0 %
31-40	7	35.0 %
30-40	1	5.0 %
41-60	2	10.0 %

Table 4: Age bracket distribution

## 6.2 Quantitative Analysis

Under this section the results collected with the KAMMUS Two [4] and the Bailenson et al questionnaires [33] are presented in two types of tables. First, the tables showing descriptive statistics which include the mean, the median, the standard deviation and the Shapiro-Wilk tests. The measurements which did not pass the Shapiro-Wilks normality test, that is where the p value is less than 0.05, have been highlighted in red.

The second type of table contains the hypothesis test results. These are found after each descriptive section. As not all measured items presented a normal distribution, it was decided to use the non-parametric tests for hypothesis testing, more specifically the Mann-Whitney-U tests. The measurements passing the hypothesis test are shown in bold.

### 6.2.1 KAMMUS Two

The measurement of kama muta is achieved through the KAMMUS Two [4] questionnaire, consisting of five questions which assesses five corresponding components of emotion: sensations, appraisals, valence, motivations, and labels.

For Q1: "Please indicate whether you experienced any of the following sensations, feelings, or actions, and if so, to what extent" it was found that, in average, users under SA condition reported higher intensity of sensations than those in the IA condition.

Accordingly, Table 5 shows higher median values for "Moist Eyes" and "Goosebumps or hair standing up" and "Chills or shivers" in the SA condition with 1.50, 2.0 and 1.5 compared to 0.00, 0.50 and 1.00 on the AI Condition respectively.

The Shapiro-Wilk tests indicate that the distribution of the values for "Moist Eyes", "Tears", "Goosebumps or hair standing up" in the IA condition and "Tears" under the SA condition are not normal. See read values on Table 5

	Experiment Condition	Moist Eyes	Tears	Goosebumps or hair standing up	Chills or shivers
Mean	SA Condition	2.10	0.900	2.20	2.00
	IA Condition	0.300	0.100	0.900	1.10
Median	SA Condition	<b>1.50</b>	0.00	<b>2.00</b>	<b>1.50</b>
	IA Condition	0.00	0.00	0.500	1.00
Standard deviation	SA Condition	1.60	1.73	1.75	2.16
	IA Condition	0.483	0.316	1.10	1.10
Shapiro-Wilk p	SA Condition	0.295	< .001	0.473	0.085
	IA Condition	< .001	< .001	0.019	0.067

Table 5: KAMMUS Two- Q1 descriptives part 1

Table 6 shows the median values for “A warm feeling in the centre of the chest”, “Some feeling in the centre of the chest” were higher in the SA condition, with both measurements at 3.00, compared to 2.00 (for the same two measurements as well), in the IA condition.

By contrast, the items “Choked up” and “A lump in the throat” presented higher medians in the IA condition, at 1.00 and 0.500, respectively, than in the SA condition, both with 0.0.

The Shapiro-Wilk tests tell that “Choked up” and “A lump in the throat” distributions are not normal.

	Experiment Condition	A warm feeling in the centre of the chest	Some feeling in the centre of the chest	Choked up	A lump in the throat
Mean	SA Condition	2.70	3.10	0.400	0.400
	IA Condition	2.30	2.30	1.11	1.00
Median	SA Condition	<b>3.00</b>	<b>3.00</b>	0.00	0.00
	IA Condition	2.00	2.00	<b>1.00</b>	<b>0.500</b>
Standard deviation	SA Condition	1.95	1.45	0.516	0.516
	IA Condition	1.34	1.83	1.27	1.25
Shapiro-Wilk p	SA Condition	0.135	0.330	< .001	< .001
	IA Condition	0.067	0.201	0.018	0.008

Table 6: KAMMUS Two-Q1 descriptives part 2

The median values for “I smiled”, “Buoyant or light”, “Refreshed, energized, or exhilarated” in the SA condition were higher, at 3.00, 1.50 and 3.50, respectively, than the medians in the IA condition for the same variables at 1.00, 0.00 and 1.00 as shown in Table 7.

Two measurements did not pass the Shapiro-Wilk normality tests in the IA condition, “Difficulty speaking”, and “Buoyant or light”, whereas in the SA condition, “Difficulty speaking” did not pass. See values in red on Table 7.

	Experiment Condition	Difficulty speaking	I smiled	Buoyant or light	Refreshed, energized, or exhilarated
Mean	SA Condition	0.00	3.10	1.80	3.40
	IA Condition	0.300	1.20	0.700	1.30
Median	SA Condition	0.00	<b>3.00</b>	<b>1.50</b>	<b>3.50</b>
	IA Condition	0.00	1.00	0.00	1.00
Standard deviation	SA Condition	0.00	2.13	1.75	1.84
	IA Condition	0.675	1.14	1.06	1.25
Shapiro-Wilk p	SA Condition	NaN	0.519	0.232	0.569
	IA Condition	< .001	0.055	0.002	0.102

Table 7: KAMMUS Two-Q1 descriptives part 3

To summarize, eight (8) out of the twelve (12) measurements had higher medians in the SA condition than under the IA condition. Accordingly, “Moist Eyes”, “Goosebumps or hair standing up”, “Chills or shivers”, “A warm feeling in the centre of the chest”, “Some feeling in the centre of the chest”, “I smiled”, “Buoyant or light” and “Refreshed, energized, or exhilarated”, had medians of 1.50, 2.00, 1.50, 3.00, 3.00, 3.00, 1.50 and 3.50, respectively, which are higher than the medians in the IA condition at 0.00, 0.500, 1.00, 2.00, 2.00, 0.00, 0.00 and 0.00 in that same order.

However, non-parametric test shows that the statistical difference between IA and SA conditions is only significant for “Moist eyes” (p value 0.002), “Goosebumps or hair standing up” (p value 0.043), “I smiled” (p value 0.020) and “Refreshed, energized, or exhilarated” (p value 0.008) as shown in Table 8.

		Statistic	p
Moist Eyes	Mann-Whitney U	12.5	<b>0.002</b>
Tears	Mann-Whitney U	39.0	0.128
Goosebumps or hair standing up	Mann-Whitney U	27.5	<b>0.043</b>
Chills or shivers	Mann-Whitney U	40.0	0.228
A warm feeling in the centre of the chest	Mann-Whitney U	44.0	0.335
Some feeling in the centre of the chest	Mann-Whitney U	34.5	0.124
Choked up	Mann-Whitney U	29.0	0.931
A lump in the throat	Mann-Whitney U	39.0	0.833
Difficulty speaking	Mann-Whitney U	40.0	0.936
I smiled	Mann-Whitney U	23.0	<b>0.020</b>
Buoyant or light	Mann-Whitney U	30.5	0.065
Refreshed, energized, or exhilarated	Mann-Whitney U	18.0	<b>0.008</b>

Note.  $H_a: \mu_{SA\ Condition} > \mu_{IA\ Condition}$

Table 8: KAMMUS Two Q1 Mann-Whitney U tests on SA Condition vs IA Condition

Results for Q2, “Please rate to what extent each of the following statements is true” only two of the items measuring appraisals, “I felt/I observed an incredible bond” and “I felt/I observed a unique kind of love spring up” showed higher median values in the SA condition, with 4.00, 3.50, 4.00 and 3.00, compared to 2.00, 3.00, 2.00 and 2.00 under the IA condition. The remaining measurements were greater or equal than in the IA condition as shown in [Table 9](#).

Regarding the Shapiro-Wilk normality tests, “I felt/I observed an incredible bond” in the IA condition and “I felt/I observed a unique kind of love spring up” in the SA condition did not pass. See values in red on [Table 9](#).

	Experiment Condition	I felt/I observed an incredible bond	I felt/I observed an exceptional sense of closeness appeared	I felt/I observed a unique kind of love spring up	I felt/I observed an extraordinary feeling of welcoming or being welcomed
Mean	SA Condition	3.50	3.10	3.10	2.70
	IA Condition	3.10	3.30	2.70	2.70
Median	SA Condition	<b>4.00</b>	<b>3.50</b>	<b>4.00</b>	<b>3.00</b>
	IA Condition	2.00	3.00	2.00	2.00
Standard deviation	SA Condition	2.01	1.91	1.97	1.70
	IA Condition	1.73	1.89	2.41	1.95
Shapiro-Wilk p	SA Condition	0.211	0.076	0.040	0.541
	IA Condition	0.040	0.275	0.093	0.500

Table 9: KAMMUS Two Q2 descriptives

The Mann-Whitney test run on the data show that there is no statistical difference between the two conditions with all **p**-values greater than 0.05 as indicated in Table 10.

		Statistic	p
An incredible bond	Mann-Whitney U	42.5	0.293
An exceptional sense of closeness appeared	Mann-Whitney U	48.5	0.561
A unique kind of love spring up	Mann-Whitney U	46.0	0.394
An extraordinary feeling of welcoming or being welcomed	Mann-Whitney U	49.0	0.485

Note.  $H_a: \mu_{SA\ Condition} > \mu_{IA\ Condition}$

Table 10: KAMMUS Two Q2 Mann-Whitney U tests

For the question Q3 “Please indicate whether you had each of the following feelings just afterwards, and if so, to what extent” the items “I felt like telling someone how much I care about them” and “I wanted to do something extra nice for someone” presented greater median values in the SA condition at 3.00, 4.00 and 3.00, respectively, compared to 2.50, 2.50 and 2.00 in the IA condition. See Table 11.

Shapiro-wilk test indicate that only “I wanted to hug someone” under the SA condition does not have a normal distribution.

	Experiment Condition	I felt like telling someone how much I care about them	I wanted to hug someone	I wanted to do something extra-nice for someone	I felt more strongly committed to a relationship
Mean	SA Condition	3.10	2.70	3.30	2.80
	IA Condition	2.60	2.60	2.60	2.00
Median	SA Condition	<b>3.00</b>	1.50	<b>4.00</b>	<b>3.00</b>
	IA Condition	2.50	<b>2.50</b>	2.50	2.00
Standard deviation	SA Condition	1.73	2.26	1.83	2.10
	IA Condition	2.01	1.96	2.41	1.76
Shapiro-Wilk p	SA Condition	0.874	0.025	0.516	0.444
	IA Condition	0.717	0.555	0.116	0.350

Table 11: KAMMUS Two Q3 descriptives

As shown in Table 12, none of the values measured shows a significant difference between the two conditions in the tests with all p values greater than 0.05.

		Statistic	p
I felt like telling someone how much I care about them	Mann-Whitney U	42.0	0.282
I wanted to hug someone	Mann-Whitney U	48.5	0.469
I wanted to do something extra-nice for someone	Mann-Whitney U	40.0	0.234
I felt more strongly committed to a relationship	Mann-Whitney U	38.5	0.198

Note.  $H_a: \mu_{SA \text{ Condition}} > \mu_{IA \text{ Condition}}$

Table 12: KAMMUS Two Q3 Mann-Whitney U tests

On question Q4 “Please rate to what extent each of the following statements is true”, which measure positive valence, saw a higher number in the SA condition than in the IA condition with 4.7 for the former and 3.4 for the latter as shown in Table 13 below.

	Experiment Condition	I had positive feelings
Mean	SA Condition	4.70
	IA Condition	3.40
Median	SA Condition	5.00
	IA Condition	3.00
Standard deviation	SA Condition	1.06
	IA Condition	1.17
Shapiro-Wilk p	SA Condition	0.051
	IA Condition	0.108

Table 13: KAMMUS Two Q4 descriptives

After the Mann-Whitney U tests, the difference has been shown to be statistically significant with p values of 0.018. See Table 14.

Independent Samples T-Test				
		Statistic	df	p
I had positive feelings	Student's t	2.60	18.0	0.018

Table 14: KAMMUS Two Q5 Mann-Whitney U tests

For Q5, “Please indicate whether each of the following was true, and if so, to what extent”, although all three labels showed higher values in the SA condition compared to the IA condition, the label “it was heart-warming” showed the greatest difference with 4.8 vs 3.7. See Table 15

	Experiment Condition	It was heart-warming	I was moved	I was touched
Mean	SA Condition	<b>4.80</b>	<b>3.80</b>	<b>3.80</b>
	IA Condition	3.70	3.10	3.20
Median	SA Condition	5.00	4.00	4.00
	IA Condition	3.50	3.00	3.00
Standard deviation	SA Condition	0.919	1.40	1.40
	IA Condition	1.16	1.91	2.04
Shapiro-Wilk p	SA Condition	0.149	0.609	0.609
	IA Condition	0.328	0.398	0.665

Table 15: KAMMUS Two Q5 descriptives

Despite all the three labels showing higher averages in the SA condition, only “It was heart-warming” was statistically significant, with a p value of 0.035 as shown in Table 16

		Statistic	p
It was heart-warming	Mann-Whitney U	22.5	<b>0.035</b>
I was moved	Mann-Whitney U	36.0	0.294
I was touched	Mann-Whitney U	40.0	0.466

Table 16: KAMMUS Two Q5 Mann-Whitney U tests

The summary of Mann-Whitney U tests, which tested the hypothesis of the values in SA Condition being greater than in the IA condition, is shown in Table . Here, “Most eyes”, “Goosebumps or hair standing up”, “I smiled”, “Refreshed, energized, or exhilarated”, “I had positive feelings”, “It was heart-warming” show p values below 0.05 which tells that the difference between these measurements in the SA Condition and the IA Condition are statistically significant.

Measurement		Statistic	p
<b>Moist Eyes</b>	<b>Mann-Whitney U</b>	<b>12.5</b>	<b>0.002</b>
Tears	Mann-Whitney U	39.0	0.128
<b>Goosebumps or hair standing up</b>	<b>Mann-Whitney U</b>	<b>27.5</b>	<b>0.043</b>
Chills or shivers	Mann-Whitney U	40.0	0.228
A warm feeling in the centre of the chest	Mann-Whitney U	44.0	0.335
Some feeling in the centre of the chest	Mann-Whitney U	34.5	0.124
Choked up	Mann-Whitney U	29.0	0.931
A lump in the throat	Mann-Whitney U	39.0	0.833
Difficulty speaking	Mann-Whitney U	40.0	0.936

Table 17: KAMMUS Two tests summary



Measurement		Statistic	P
<b>I smiled</b>	<b>Mann-Whitney U</b>	<b>23.0</b>	<b>0.020</b>
Buoyant or light	Mann-Whitney U	30.5	0.065
<b>Refreshed, energized, or exhilarated</b>	<b>Mann-Whitney U</b>	<b>18.0</b>	<b>0.008</b>
An incredible bond	Mann-Whitney U	42.5	0.293
An exceptional sense of closeness appeared	Mann-Whitney U	48.5	0.561
A unique kind of love spring up	Mann-Whitney U	46.0	0.394
An extraordinary feeling of welcoming or being welcomed	Mann-Whitney U	49.0	0.485
I felt like telling someone how much I care about them	Mann-Whitney U	42.0	0.282
I wanted to hug someone	Mann-Whitney U	48.5	0.469
I wanted to do something extra-nice for someone	Mann-Whitney U	40.0	0.234
I felt more strongly committed to a relationship	Mann-Whitney U	38.5	0.198
<b>I had positive feelings</b>	<b>Mann-Whitney U</b>	<b>20.5</b>	<b>0.012</b>
<b>It was heart-warming</b>	<b>Mann-Whitney U</b>	<b>22.5</b>	<b>0.018</b>

Note.  $H_a: \mu_{SA \text{ Condition}} > \mu_{IA \text{ Condition}}$

Table 17 (continued): KAMMUS Two tests summary.

### 6.2.2 Social Presence

The social presence questionnaire from Bailenson et al [33] was added at the end of the KAMMUS two [4] questionnaire with the purpose to obtain all answers in a single task. This questionnaire asked users to rank their perception of other entities in a likert scale.

The descriptive statistics in Table 18 , Table 19 and Table 20 are the mean, median, standard deviation and Shapiro-Wilk normality test. The numbers in red designate the variables not passing the normality test whereas the bold values indicate higher medians.

For the item ‘I felt that the person was watching me and was aware of my presence “, users in the IA condition showed a higher median at 3.50 compared to 3.0 in the SA condition. There was no difference between the two conditions on the item “I perceived that I was in the presence of another person in the room with me” as shown in Table 18.

	Experiment Condition	I perceived that I was in the presence of another person in the room with me	I felt that the person was watching me and was aware of my presence
Mean	SA Condition	4.60	3.20
	IA Condition	4.60	3.70
Median	SA Condition	4.50	3.00
	IA Condition	4.50	<b>3.50</b>
Standard deviation	SA Condition	1.71	1.48
	IA Condition	1.35	1.83
Shapiro-Wilk p	SA Condition	0.591	<b>0.158</b>
	IA Condition	<b>0.440</b>	0.713

Table 18: Presence questionnaire part 1

Table 19 shows that on the item “the person appeared to be sentient (conscious and alive) to me”, participants under the SA condition marked a higher median than those under the IA condition with 5.0 and 4.0 respectively. Again, there was no difference between the two groups on the item “the thought that the person was not a real person crossed my mind often”, both at 5.50.

	Experiment Condition	The thought that the person was not a real person crossed my mind often	The person appeared to be sentient (conscious and alive) to me
Mean	SA Condition	4.30	4.40
	IA Condition	5.30	4.10
Median	SA Condition	5.50	<b>5.00</b>
	IA Condition	5.50	4.00
Standard deviation	SA Condition	2.26	1.35
	IA Condition	1.25	2.13
Shapiro-Wilk p	SA Condition	<b>0.025</b>	<b>0.198</b>
	IA Condition	<b>0.034</b>	0.519

Table 19: Presence questionnaire part 2

On the item “I perceived the person as being only a computerized image, not as a real person” users in the AI condition showed a higher median at 5.0 compared to 4.50 in the SA condition.

	Experiment Condition	I perceived the person as being only a computerized image, not as a real person
Mean	SA Condition	4.10
	IA Condition	<b>4.90</b>
Median	SA Condition	4.50
	IA Condition	<b>5.00</b>
Standard deviation	SA Condition	1.97
	IA Condition	1.45
Shapiro-Wilk p	SA Condition	0.060
	IA Condition	0.080

Table 20: Presence questionnaire part 3

Non-parametric tests show that except for the item “The person appeared to be sentient (conscious and alive) to me” with a p value of 3.65, there is no significance difference in the experienced sense of social presence between the two groups as all their p values were higher than the significance level 0.5.

		Statistic	p
I perceived that I was in the presence of another person in the room with me	Mann-Whitney U	49.0	0.546
I felt that the person was watching me and was aware of my presence	Mann-Whitney U	42.5	0.733
The thought that the person was not a real person crossed my mind often	Mann-Whitney U	39.5	0.804
The person appeared to be sentient (conscious and alive) to me	Mann-Whitney U	45.0	<b>0.365</b>
I perceived the person as being only a computerized image, not as a real person	Mann-Whitney U	37.0	0.852

Note.  $H_a \mu_{SA \text{ Condition}} > \mu_{IA \text{ Condition}}$

Table 21: Presence Mann-Whiney tests

## 6.3 Qualitative Analysis

The interview performed after the virtual experience aimed to capture users' expressions regarding their emotional experience which might have been affected by the characters' realism, the venue design, the audience's reaction or the song's content and likability. Since the interview was semi-structured, (See section 0) the same eleven questions were asked to all participants, albeit, not always in the same order.

Participants answers were recorded in audio files which were later transcribed into text and separated by experiment condition creating two datasets, one for supportive audience (SA) and one for indifferent audience (IA).

A thematic analysis was conducted to obtain a clearer picture of participants' views. For this purpose, each question was analysed across all participants to find recurring expressions and their synonyms. Then, those expressions were categorized into the themes enumerated below and further detailed in the following sections.

- Reported feelings.
- The music and its associations.
- Appraisals of brotherhood.
- Analysing participant's reaction to the virtual audience.

### 6.3.1 Reported feelings

Participants were asked about their feelings right after they completed the Bailenson's presence [33] and KAMMUS Two [4] questionnaires. Their answers were divided into three themes. First, the descriptions where feelings are mentioned directly fall under the "Emotional" theme, for instance, the expressions containing words such as "sad" or "happy" are included.

The second theme collects expressions carrying non-emotional statements, such as "I feel ok", "normal" or "I am relaxed".

The third theme includes statements referring to evaluations of the experience. Some of those might be technicalities regarding the simulation's quality or the experiment's design. This theme is called "Assessments".

All participants reported having a good or positive experience across conditions (n=20). Twelve (12) participants reported their experience using emotional descriptions such as "touched", "sad" or "bittersweet", whilst eight (8) reported using non-emotional language as shown in [Figure 33](#)~~Figure 33~~

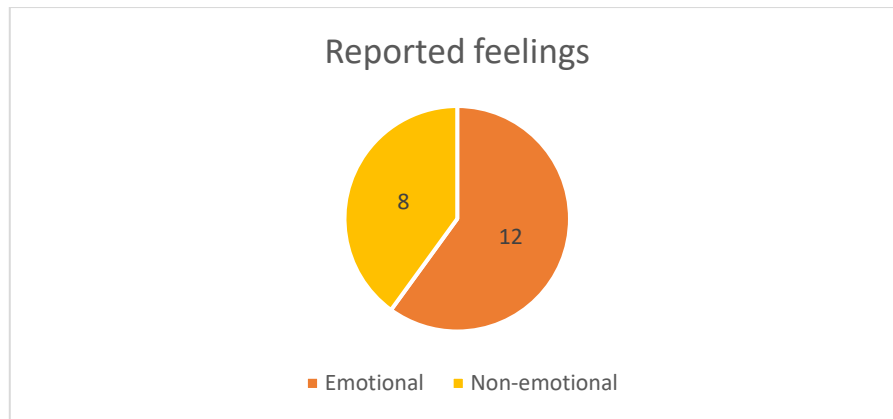


Figure 33: Reported Feelings

More participants reported with emotional language in the IA Condition than in the SA condition with seven (7) users in the former compared to three (3) in the latter. In the SA condition, emotional and non-emotional descriptions were even, accounting for five (5) users each as shown in Figure 34.

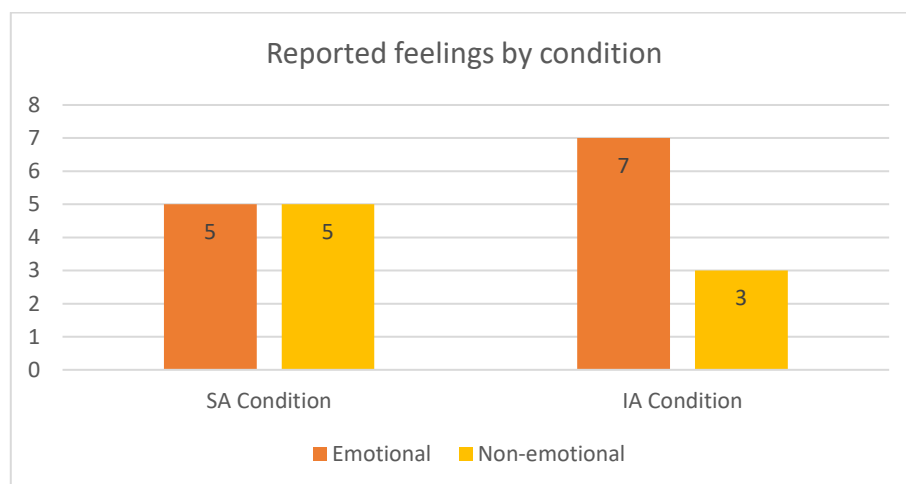


Figure 34: Reported feelings by condition.

#### 6.3.1.1 Emotional

On the SA condition (N=10), five (5) participants reported they experienced emotions by stating they were “touched” or “moved” and adding their recollections of X-ABC addressing the audience which they perceived as “human” like.

To assess how human X-ABC looked to the subjects, they were asked about their thoughts on the main him, specifically whether his attitude resembled a human being with real feelings. In the sections below, I refer to this question as Q2, which can be found in the interview draft in the appendix section.

Subject 3, female 32, started saying “amazing” before any questions were asked.

She proceeded,

*“I can feel the real feeling from a real human”.*

Subject 10, female 32,

*“It looks [sic] real amazing”.*

Later followed by

*“I mean, in the scenes that I saw was like he had an emotion said, like, the way he was saying was, like, literally makes me feel like touched”.*

The appraisal of X-ABC ‘s the humanness prevailed even when some users reported small glitches in the speech’s animation or in the lip-sync when he was singing.

Subject 6, male 30, on his reported feelings,

*“a combination of sad and happy I... bittersweet”*

Later, he elaborates when asked Q2,

*“When he starts at first, yes, when he was talking to them before, he sings. He was very... what he’s saying is translating for us like he was saying that he just... he can’t find his brother and that he will find him”*

Despite this, he reports being taken away from the experience when noticed delays in the characters’ lips movements.

*“Although on the actual singing. I did notice that the lips the... the lips were a bit delayed when you sing the song so it... it did take me off from the experience”*

On the IA condition (N=10), seven (7) participants reported using emotional sentences, whereas three provided non-emotional statements. Moreover, from the emotional reactions, three (3), mentioned sadness as the feeling they had.

Subject 12, non-binary 18

*“Yeah, it’s sort of weird because I want it... you. You sort of looking at it and you’re like, oh, it’s a... it’s a virtual person. But then so many people experience that similar, you know, thing. So, it kind of makes you feel like oh! your heart goes out to, so I feel a bit... bit saddened knowing that that happens. In the world”*

Then, on their response to Q2

*“Yeah, it, it is a little bit. Like you have to remind... maybe remind yourself oh! is this someone who’s real? or is... isn’t real, yeah”.*

#### 6.3.1.2 Non-Emotional

Responses were considered as non-emotional when the participants reported their emotional state using simple qualifiers such as “I feel good”, “it was good” or “it was a good experience”, without adding adverbs of degree such as “very”, “quite”, or “totally”. Their answers were also short yet fluent with no hesitation and using a calmed tone. Common non-verbal indicators used for a answers to be considered as non-emotional were, shrugging while shaking the head, a mouth shrug and silence while shaking the head.

Subject 13, male 42, communicated his answer to the question while he shrugged.

*“Relax”.*

Subject 18, male 25, provides his answer with an explanation as to why he may not be “emotional”.

*“Honestly, fine, no real change. But I guess one reason you could. Add for that though is, I'm not. Usually very emotional verse anyway”.*

Subject 16, male 28, was also short and clear. In addition, he used the word “tries” which suggest his emotional state was not affected by the simulation.

*“Good. Yeah, I think it was. It was. I mean, clearly trying to elicit emotions”.*

#### 6.3.1.3 Assessments

Along with their reported feelings, users also emitted judgments on the quality of the experience or the experimental design. Seven (7) users reported their assessments across all conditions; six (6) of such assessments were made by VR Experts.

Subject 1, male 37, comments on the realistic characters next to him using the word “condition”, referring to an experimental condition.

*“Maybe if they were... I don't know if it's part of the condition of... **If they were moving** or if they were reacting more. In the same way as the people further away, I think maybe that would have...like... make me feel more... engaged in the plot. I think”.*

Subject 11, male 30, makes design assessments regarding the lighting and the central screen.

*“I mean you have... **I really like the way you have handled lighting** and everything. Also, it... it like... like, induces some of the feelings it...it gives. Kind of a sensation, like a kind of more moody feeling. And I realized it... and, **also like you have added that big projector** and I noticed his facial expressions”.*

### 6.3.2 Music and Associations

The objective of this section is to explore how participants perceived the music by examining the answers to the question “What do you think about the song?”. The piece played in the simulations is called “See you again” by Charlie Pugh and Wiz Khalifa which was chosen due to its lyrics and popularity.

As in the feelings section, emotional and non-emotional reactions were reported by subjects, however, they also reported memories associated with the song.

The criteria used to classify a response as emotional or non-emotional consist of the judgements made by the author of this study factoring labels, tone and body language used by participants (briefly mentioned in section 6.3.1.2 as well). Hence, those expressing enthusiasm, joy, nostalgia, sadness, or disgust were categorised as emotional. In contrast, people who only assessed the relevance of the music in the experience, or said they were indifferent to the song, were classified as non-emotional. For instance, a clear distinction was found between two expressions of remembering the song. One, where the users said “I remember that song” or “I know that song” with an enthusiastic and quick tone, which has been interpreted as non-emotional. The other one, where participants used a slow and quiet tone accompanied by an upwards movement of the inner corner of the eyebrows. In some cases, there were more lengthy description of memories. These have been interpreted as emotional.

Overall, across all conditions (N=20), fourteen (14) participants expressed their thoughts about the song in an emotional manner. Twelve (12) liked the song whereas two (2) did not. Six (6) participants were found as non-emotional as seen in Figure 35.

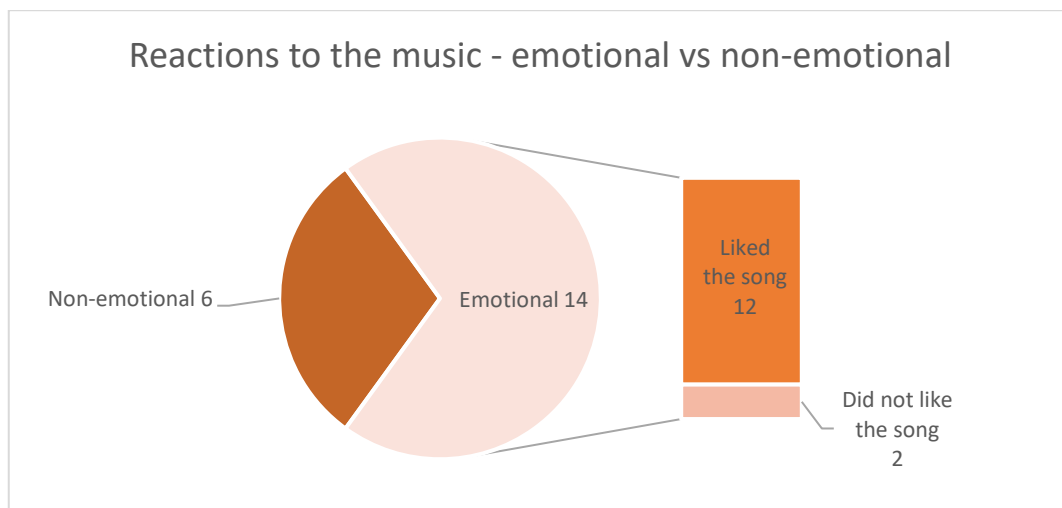


Figure 35: Reactions to the music – emotional vs non-emotional



In line with the reactions in section 6.3.1, most emotional reactions were found in the IA condition accounting for nine (9) users, almost doubling the numbers in the SA Condition with five (5) users as illustrated in Figure 36.

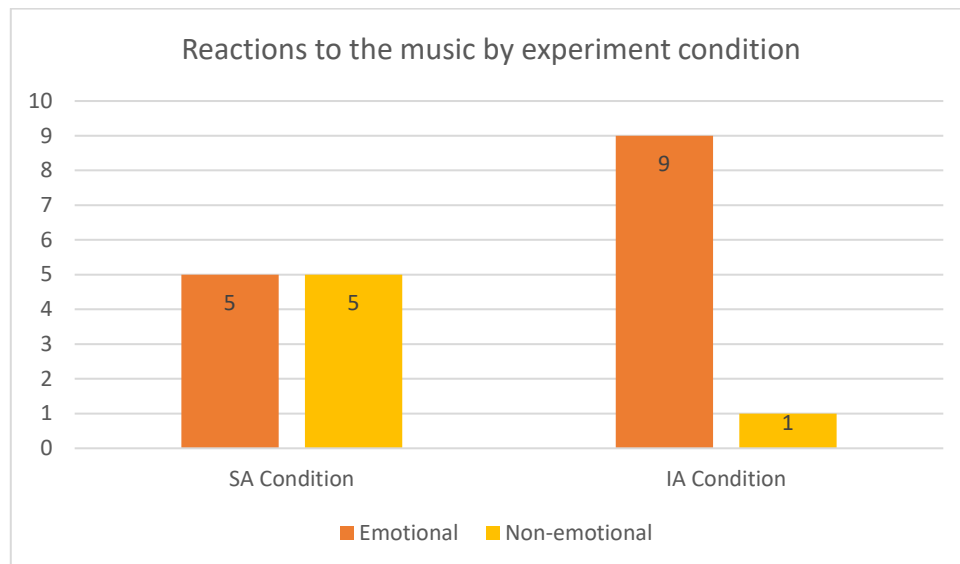


Figure 36: Reactions to the music by experiment condition

#### 6.3.2.1 Emotional

As mentioned previously, users' answers classified as emotional were characterized for being delivered at a slower pace and in a solemn tone. Some gave longer descriptions of the memories the song brought to them such as subject 6, whereas others linked the narrative and the song as a unit communicating how it made them feel such as subject 10.

Subject 5, female 26, expressed her opinion about the music.

*"The song is great. I didn't hear many English songs before, but this one I'm familiar with".*

Subject 6, male 30, said.

*"It's actually quite a bit... bit memorable to me because it's also the song that played when Kobe Bryant died. So, it's actually, I remember that song a lot, so, it...it brought about some memories".*

Subject 10, female 32, makes a direct link between the narrative and the song.

*"it made me quite emotional with the situation and the song"*

#### 6.3.2.2 Non-emotional

Generally, users who gave non-emotional answers to the music used short statements or expressed their opinion on the relevance of the song to the narrative in the simulation. Only one participant, subject 13, directly expressed not having a particular feeling towards the music.

Subject 7, male 58.

*“That was a good song”.*

Subject 8, male 27.

*“ It was an appropriate song”.*

Subject 13, male 42.

*“I don’t have any particular feelings towards the song”.*

#### 6.3.2.3 Associations

By in large, the song was associated with death. Three themes were found in users’ descriptions: the film Fast and Furious, Kobe Bryant and death at a young age.

Most users who made associations mention the film “Fast and Furious” accounting for six (6) instances compared to one (1) for “Kobe Bryant” and one (1) for “death at a young age”. See Figure 37.

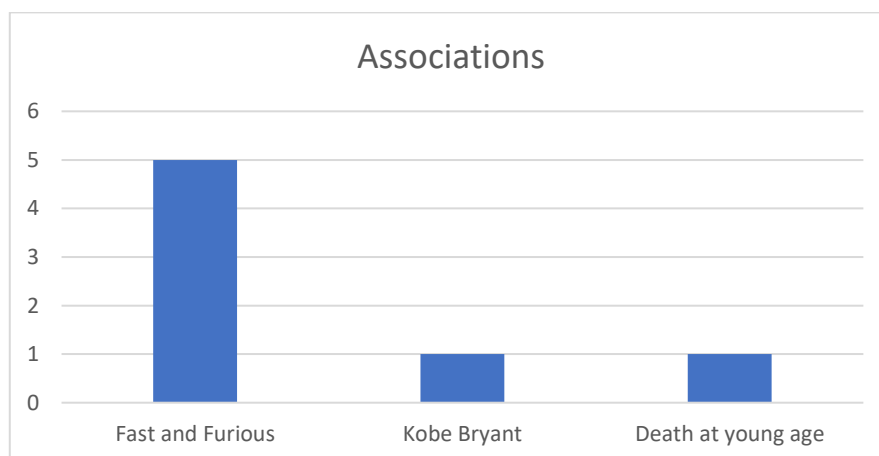


Figure 37: Themes associated with the song “see you again”.

#### 6.3.2.4 Assessments

All participants thought the song was relevant to the subject regardless of the experimental condition.

Subject 16, male 28.

*"It's not my favourite song, but I think it fitted the scene certainly".*

Subject 11, male 30.

*"It's one of my favourites. I really enjoyed it. It's a perfect match".*

#### 6.3.3 Appraisals of brotherhood

With the purpose of evoking emotion, a series of floating displays showed photographs of the brothers at different stages of their lives. During the interview, one question was asked in relation to such images:

Q8 "What do you think of the photographs of X-ABC and his brother?", "did they evoke any feelings or memory in you?"

And one related to the experience:

Q9 "Do you think your previous experiences influenced what you felt during the experiment? any close story?".

It was found that some participants described the photographs in terms of personal connection, while others factored the photographs and the narrative construct an answer to Q9. Therefore, the user's descriptions were condensed into two themes which relate to either a personal connection or the absence of it (Examples of participants responses will be show in the following sub-sections). Consequently, the two themes derived were personal connection and non-personal connection.

The first group, personal connection, contains expressions where the users mention the photographs and communicate a personal connection with the story or the main character at any time during the interview.

The second group includes those who did not express a personal connection with the narrative or the main character.

On the other hand, it was found that users noted some photographs more than others. Eleven (11) users mentioned specific photos where "childhood" and "brothers" were the most common themes.

From the eleven descriptions, ten (10) referred to the pictures showing the children hugging in Figure 38, and the photos in black and white, where the brothers are younger in Figure 39 and Figure 40. The only mention of an image showing the characters as adults was the photo in Figure 41.



Figure 38: Childhood photos



Figure 39: Adolescence photo black and white 1

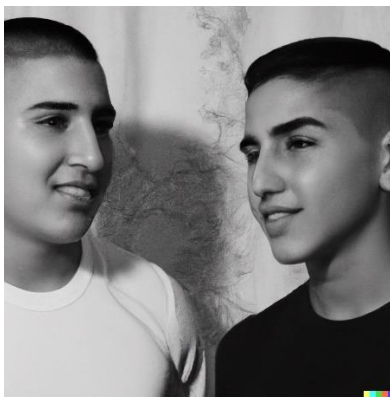


Figure 40: Adolescence photo black and white 2



Figure 41: Adulthood

#### 6.3.3.1 Personal connection

Under this theme, participants described how the photographs reminded them of their families or their friends. All these expressions could suggest that these subjects experienced a desire to reinforce or heal communal relationships, also refer as to the motivational component in kama muta theory [4], providing support to the KAMMUS two questionnaire on the same dimension.

Subject 2, female 37, explains which pictures she noted the most.

*“There were two pictures, one with their... their childhood”.*

Also, she indicates how she felt connected to them.

*“There was this particular picture that reminds me of my.... **me and my sister** having that moment”.*

Subject 6, male 30, provides an affirmative answer when he was asked if the photographs on the displays brought any feelings to him.

*"Yes, because they were showing pictures of the... the two brothers, right, when they when they were like kids and stuff".*

Then he elaborates on how he felt connected to the images

*"I kind of missed **my cousins** back at home in the Philippines".*

Subject 20, male 47

*"Yeah. So, they... they look like sort of that, that classic sort of, you know, young brotherly photos. And I've got photos like that... **with my brothers**".*

Subject 21, female 33, shares her personal experience when asked about her feelings.

*"I guess a little bit... sad because I have lost people before, so I can relate to how he was feeling. As someone I know went missing and they were never found so... I can relate to that".*

Then she indicated which photographs brought memories.

*"I think probably the one when they were younger".*

#### 6.3.3.2 No personal connection

The no personal connection theme collects the answers from participants who did not report any personal connection to neither the photographs nor the events in the narrative.

Subject 1, male 36, indicates that he does not feel connected personally,

*"I'm not sure like I connect personally with the drama of the plot, but, yeah, yeah, it, yeah... make me feel, maybe, empathetic to the person. To the main character that is going through... you know, hard time and having to deal with grief and things like that".*

Subject 17, male 27, explains how the photographs helped him connect with the narrative.

*"I guess the... they make me a bit more connected to the story that the character was telling. Yeah, since he was sharing some of his like photographs from his childhood with the audience".*

When asked about previous experiences, he mentions the memories evoked by the simulation, however, there is not a clear link to the photographs.

*"Yeah, I would say that I used to be quite close to one of my cousins who was a year older than me at school... and then when his parents split up, I never got to see him again. So, maybe in some way I could*

*relate to the situation that the...the singer was going through. So, to sort of bring up some of those memories for me”.*

#### 6.3.4 Analysing participant’s reaction to the virtual audience

There were three types of characters in the audience. First, the **realistic-static** set, which also had the largest number of characters as they did not only populate the south, west and east wings of the venue but also, they were right behind the participant’s seat.

The second group of characters was the **unrealistic-animated**, made up of copies of the same character with randomized cheerful reactions synchronized with the speech.

The third group consisted of only two **hyper-realistic** characters to the right and left sides of the subjects. Both played a breathing animation yet the character on the left sang along with X-ABC.

In the interview, participants were asked the question Q7 “What do you think of the characters in the surrounding? Did they affect you during the experience? In which way?”. Their answers were consolidated in Table 23 and Table 25.

To construct a list of themes, the content of the descriptions provided for all type of characters was analysed, what revealed that users referred to each type of character in terms of whether they saw them, if they thought the characters would perform some actions, or whether they thought the characters would interact with them. For example:

Subject 6, male 30, noted the existence of the characters and made a judgement on their attitude towards the music.

*“Yes, the ones that are in my that are sitting next to me... **it felt like** they are like real human beings **like they were connected to the song** they were listening”.*

This has been interpreted as INTEREST from the participant in the artificial audience since he looked around and took interest in their movements and actions.

Subject 1, male 37, took this interest somewhat further as he reported he wondered about the next movements or actions of the characters.

*“**I wasn't too sure what my reaction was**...was gonna create if they was going to have any. If I was going to have any feedback”.*

This type of wondering was interpreted as the participant being INTRIGUED.

Subject 10, female 32, went even further as expressed she tried to touch one of the characters.

*“I feel like those audiences give me, like, more sense of, you know like ..more sense like a feel in me like that... feeling in this scenery because I look around and **I try to touch the person actually**”*

The thought of executing a physical action towards the characters, or effectively executing it, has been marked as an active involvement. Therefore, these answers were classified in the INVOLVED theme.

On the other hand, there were participants who saw the artificial audience but did not have interest on their actions, for instance:

Subject 3, female 32, gave a simple yet clear statement.

*"I **don't mind** them."*

Or Subject 12, non-binary 18, who was more engaged with the events on stage.

*"I **actually didn't really**, take notice of them at all. I was, like, focused on the performance".*

The answers above fall under the UNINTERESTED theme. Below, Table 22 shows a summary of the themes and a description of their meaning.

Theme	Description
AWARE	Participants knew there was an audience since they saw it and/or heard it.
INTERESTED	Participants were AWARE of the audience and observed from time to time what they were doing
INTRIGUED	Participants were INTERESTED in the audience and <b>expected</b> them to perform an action
INVOLVED	Subjects were INTRIGUED by or INTERESTED in the audience and felt compelled to act upon their presence, i.e., touching them or clapping.
UNINTERESTED	Participants were AWARE of the audience but were not interested in anything they did
UNAWARE	The participant did not notice the audience at all
NOT-MENTIONED	This item was used to capture the fact that one user was not asked about the audience

Table 22 Themes used for analysing reactions to the virtual audience.

In summary, except for one (1) participant who was classified as NON-MENTIONED, most users were aware of the audience. However, the level of awareness varied between the two conditions as eight (6) participants classified as INTERESTED, INVOLVED, or INTRIGUED in the SA condition compared to four (4) INTRIGUED or INTERESTED in the IA condition.

Participants in the IA condition were more UNINTERESTED in the audience than participants in the SA condition with six (6) and four (4) users respectively. See Figure 42 and Figure 43 below.

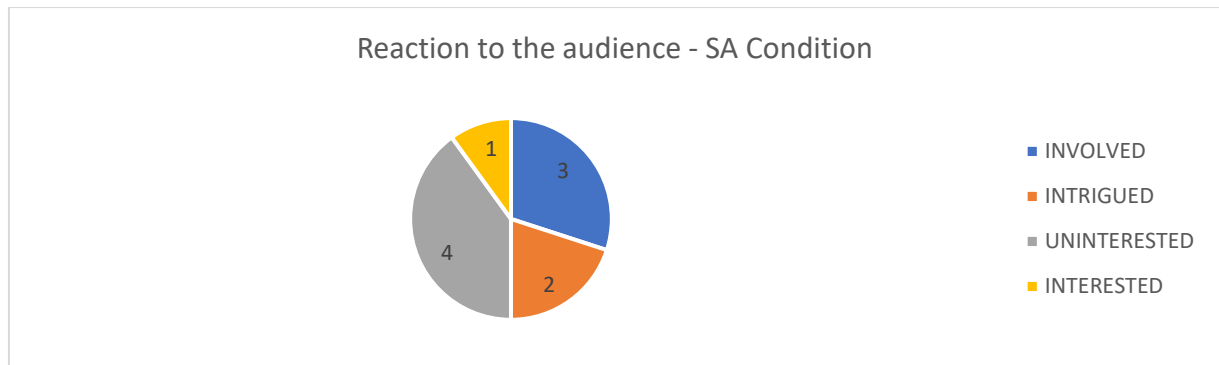


Figure 42 Reaction to audience - SA Condition

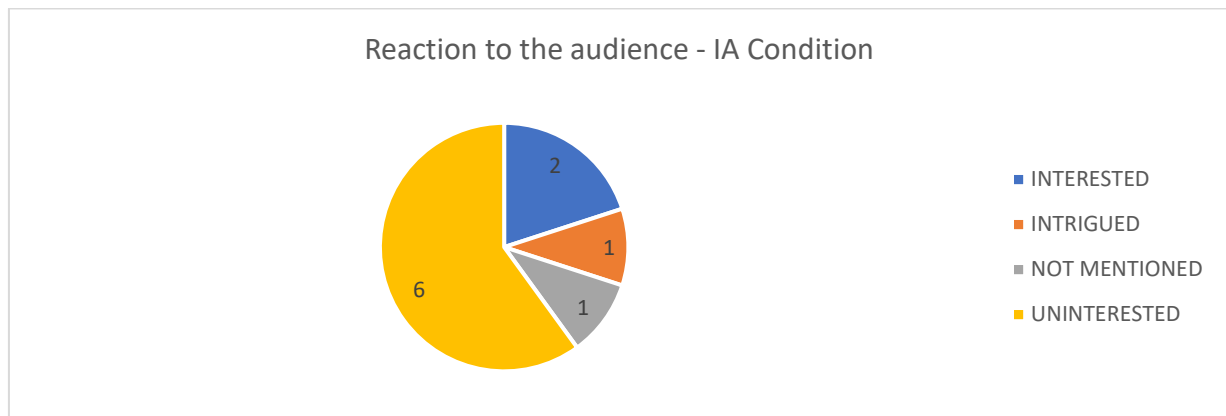


Figure 43 Reaction to the audience - IA Condition

Below, Table 23 shows the answers regarding the audience under the SA Condition. Themes were created by first writing the answer to Q7 in the column “awareness” and then copying the text to the column labelled after the specific type of character participants were referring to. The final assessment of which theme should be assigned was made using the statements in bold.

Subject	Awareness	Hyper-realistic	Unrealistic- animated	Realistic static	Theme
1	there were some people further away and felt that the people further away were more reactive than the people just next to me.	<b>I wasn't too sure what my reaction was...</b> was [sic]gonna create if they [sic]was going to have any. If I was going to have any feedback.			INTRIGUED
2	So, the people who are next to me, he looks quite real, and but there was one person in my left angle, in the dark, so it was a, felt a bit creepy. You look at him because he was in dark too	So, the people who are next to me, he looks quite real	I felt like I'm with people because of the...the cheering up. I <b>wanted to clap at some point</b>	Creepy	INVOLVED
3	<b>I don't mind</b> them				UNINTERESTED

Table 23: Reported reactions to the audience - SA condition - part 1



Subject	awareness	Hyper-realistic	Unrealistic- animated	Realistic static	Theme
5	<b>Just OK</b> , but, not like the actual person.				UNINTERESTED
6	Yes, the ones that are in my that are sitting next to me... <b>it felt like</b> they are like real human beings <b>like they were connected to the song</b> they were listening	the ones that are in my that are sitting next to me... it felt like they are like real human beings like they were connected to the song they were listening	Even the clapping felt... felt real,	Not mentioned	INTERESTED
7		I was <b>a little distracted, technically, by the audience</b> members around me, so.... every time I looked at the guy to the right, he's like breathing deeply, and the woman to the left seemed to be trying to sing along. <b>and then I wondered I wondered if they were like going to do something</b> or... Interact with me or.... so I was kind of distracted by the audience			INTRIGUED
8	<b>I didn't pay them much attention.</b> I liked when they clapped.		I enjoyed when they clapped, it was kind of like, oh yeah, it feels added to the environment.		UNINTERESTED
9	Yeah, they were <b>like an audience.</b>	Yeah, they were more natural.			UNINTERESTED
10	I feel like those audiences give me, like, more sense of, you know like ...more sense like a feel in me like that... feeling in this scenery because I look around and <b>I try to touch the person actually</b>	There and then like they had it like... like human looked and feel like, oh, yeah, they are audiences	and then also like the surroundings, there are people around and then, yeah, like it was like, oh, it looks like a real concert	and then also like the surroundings, there are people around and then, yeah, like it was like, oh, it looks like a real concert	INVOLVED
11	like from my left-hand side and right-hand side. They were so realistic, and they were like moving as well	like from my left-hand side and right-hand side. They were so realistic, and they were like moving as well	When some when I hear background noise like clapping and stuff, I was watching whether they are clapping and if they were clapping, <b>I might also clap</b>	The other characters, they were more static, but, but it's so nice to have them	INVOLVED

Table 24 (Continued): Reported reactions to the audience - SA condition - part 2

In Table 25, the same approach is followed as in Table 23 for the IA condition. The statements in bold were used to make the decision as to which theme would be used for a given answer. There is a caveat that in this section regarding to subject 14, who despite having reported not paying attention to the audience, he noticed one character was on their phone all the time; This may look like a contradiction, however, it has been interpreted that if the subject checked on the state of the character enough times to say “the entire time”, he was interested in whatever actions this specific character was doing. Therefore, this participant was labelled as INTERESTED.

user	awareness	Hyper-realistic	Unrealistic- animated	Realistic static	Theme
12	<b>I actually didn't really</b> , take notice of them at all. I was, like, focused on the performance.				UNINTERESTED
13	they are very static props when you look at them. When they are in the periphery, they... they give this feeling that you're in the crowd as soon as you look at them, it's obvious they're just static puppets. <b>As long as you're not looking at them directly</b> , they actually give this illusion that you are in a crowd.		they are very static props when you look at them.	When they are in the periphery, they... they give this feeling that you're in the crowd as soon as you look at them, it's obvious they're just static puppets	UNINTERESTED
14	I didn't see much change in them in what was happening, <i>but I wasn't paying much attention</i>  There was no, real audible reaction or visible reaction of anything			I did notice that <b>one of them was just on their phone the entire time</b>	INTERESTED
15	I look at them while I was listening and <b>I was looking at them... few times. They are pretty real but didn't move.</b>			They are pretty real but didn't move.	INTERESTED
16	<b>I didn't think too much of them.</b> I mean, I had... I had a bit of a look around at the start. I think maybe later on there was a bit of noise, but I didn't notice much, sort of, I guess sound coming from the people around me,				UNINTERESTED
17	I mainly just looked at them at the start of the concert. Yeah, <b>I didn't really pay too much attention to them</b> during the concert or afterwards.				UNINTERESTED

Table 25: Reported reactions to the audience - IA condition - part 1

user	awareness	Hyper-realistic	Unrealistic- animated	Realistic static	Theme
18	I mean cause most attention was mostly at the front, so that's where I was staring most of the time. But at the beginning, you know, looking around, you know, you could tell they weren't real, but you also didn't just constantly in your mind be going ohh their fake. They just felt. What's the word? It made it feel like. You were just sitting on the front row somewhere, you. Know by yourself. You you could you. You thought there were people around you yes				UNINTERESTED
19	They were unemotional except for like a little bit of cheering towards the end. So, <b>I feel like maybe I would have been a bit more moved if they were also moved</b>				UNINTERESTED
20	Audience <b>they were quite distracting, didn't know the guy on the right was breathing</b> , which is kind of nice, but without them having any reaction to what was happening, I think yeah, you get a lot of your social energy of the people around you, so, with them sitting without them reacting, you know, I don't think you're, it's easier not to...to react to the entire scene	Audience they were quite distracting, didn't know the guy on the right was breathing, which is kind of nice			INTRIGUED
21					NOT MENTIONED

Table 26 (continued): Reported reactions to the audience - IA condition - part 2

## 7 Discussion

This research explores the user experience design elements necessary to evoke the emotion called kama muta, commonly known as the feeling of “being moved” or “being touched”, in a virtual reality concert, looking to answer the research question:

How to design a game or experience capable of evoking kama muta in Virtual Reality?

As discussed across this document, kama muta theory posits that it occurs when there is an intensification of communal sharing relationships [18]. Therefore, allowing participants to appraise communal sharing relationships in the virtual environment was the main driver to make four major design decisions, which were implemented in the VR prototype:

- First, the simulation would revolve around a narrative involving the loss of a loved one.
- Second, for the users to observe the emotions of the singer, big on-stage screens would be placed showing close-ups of the artist.
- Third, the main character would be as realistic as possible to display high fidelity human facial expressions.
- Fourth, the music should be aligned with the narrative yet familiar so that the users would understand it more easily.
- Finally, an artificial audience reacting to the events on stage would be placed in the virtual environment.

Each one of the elements mentioned above accounts for an experimental variable, however, this study only aimed to measure the impact the artificial audience had on participants’ experience of kama muta. Accordingly, two conditions were set, the **SA condition** (Supportive Audience) under which participants are exposed to an artificial audience which reacted to the events in the virtual environment by cheering, standing, and applauding at specific points in time.

The second condition is the **IA condition**, where participants were put in a virtual environment with an artificial audience who did not react to any event, in other words, they remained static.

During the simulation a virtual artist named X-ABC addressed the audience with a speech talking about his grief in relation to his brother being missing, and later he performs a song, (see section 5.1.4 for details on the simulation phases).

After participants went through the simulation, kama muta was measured with one take of the KAMMUS Two [4] questionnaire followed by the Bailenson et al [33] and a semi-structured interview.

KAMMUS Two is a tool designed to measure the intensity of the five components of emotion: bodily sensations, appraisals, motivations to commit to a communal sharing relationship, valence, and labels of being moved. **It was hypothesized that the intensity of each measurement for each component would be higher in the SA condition when compared with the IA condition (H1).**

During the data analysis, the means and the medians were calculated for each measurement in KAMMUS Two, in addition to the Shapiro-Wilk normality test to decide on the type of hypothesis test that should be conducted. Accordingly, as not all measurements passed the test (see Table 5, Table 6, Table 7, [Table 9](#)~~Table 9~~, Table 11, Table 13, Table 15) a non-parametric method was employed, more specifically, the Mann-Whitney U test.

Considering the measurements that characterize kama muta [17], whose means were calculated and explained in section 6.2, they suggest that the design was capable of eliciting kama muta. Thus, by observing the different means for bodily sensations, appraisals, motivations to attend to communal sharing relationships, valence and labels, it was found that all twenty three (23) measurements taken through KAMMUS Two [4] presented values greater than zero in either one or both conditions (SA and IA Condition). Ultimately, the meaning of this technicality is that the prototype was able to evoke kama muta regardless of the experimental condition.

Figure 44 below illustrates that the means of the twelve (12) measurements comprising the bodily sensations component of kama muta, are greater than zero in both conditions, except for “Difficulty speaking” which had zero (0) in the SA condition. This exception, does not invalidate the claim that kama muta occurred, since as mentioned in section 2.2, not all bodily sensations have to be present in every instance of kama muta [17].

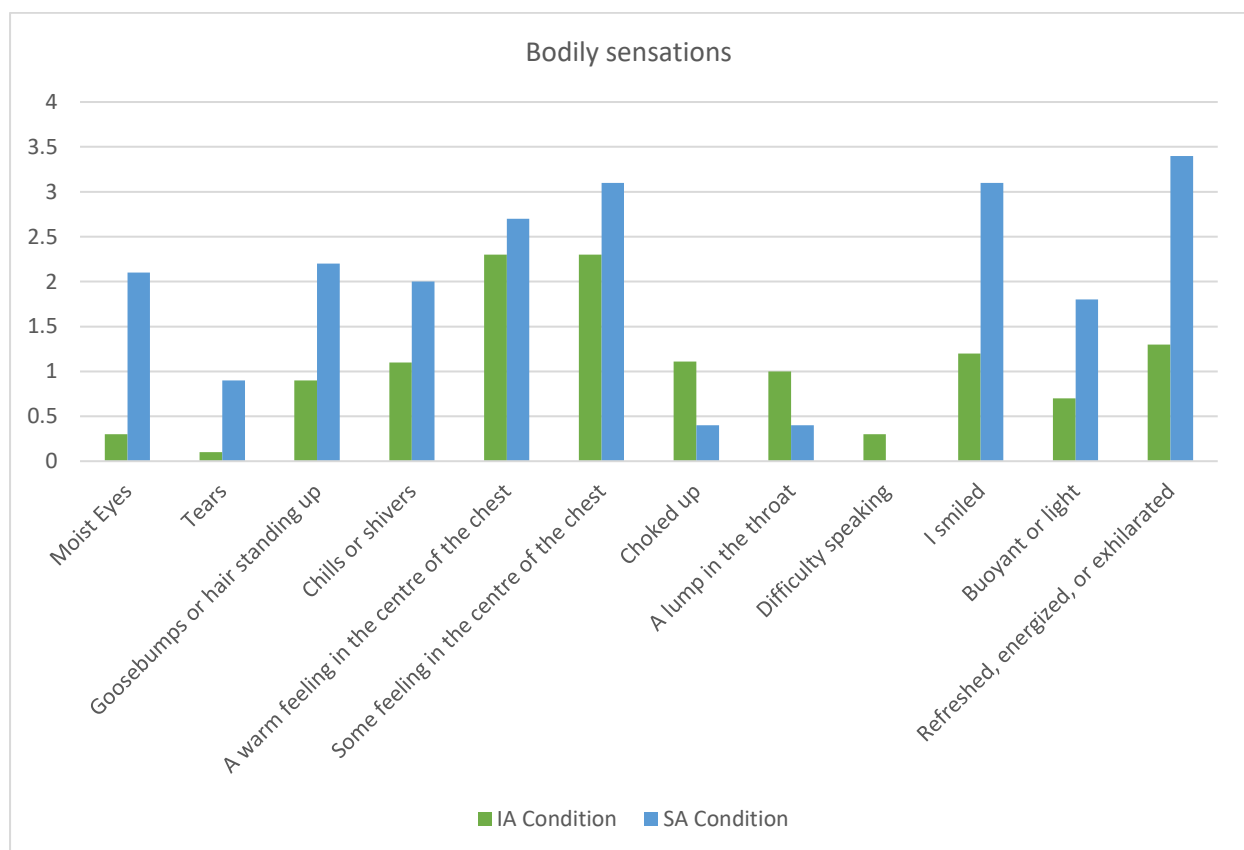


Figure 44: Bodily sensations

One additional reflection on the “Moist eyes” item, which stems from the fact that participants were not asked whether this event was caused by the HMD (Head Mounted Display) rather than by an emotional response. Consequently, this specific measurement is not reliable.

Figure 45 shows that the means of appraisals indicate that, regardless of the experimental condition, participants perceived relations of closeness. Here, the highest measurement was “an incredible bond” which on the scale from zero (0) six (6), the values in the kama muta scale [4] , could be considered of mid intensity.

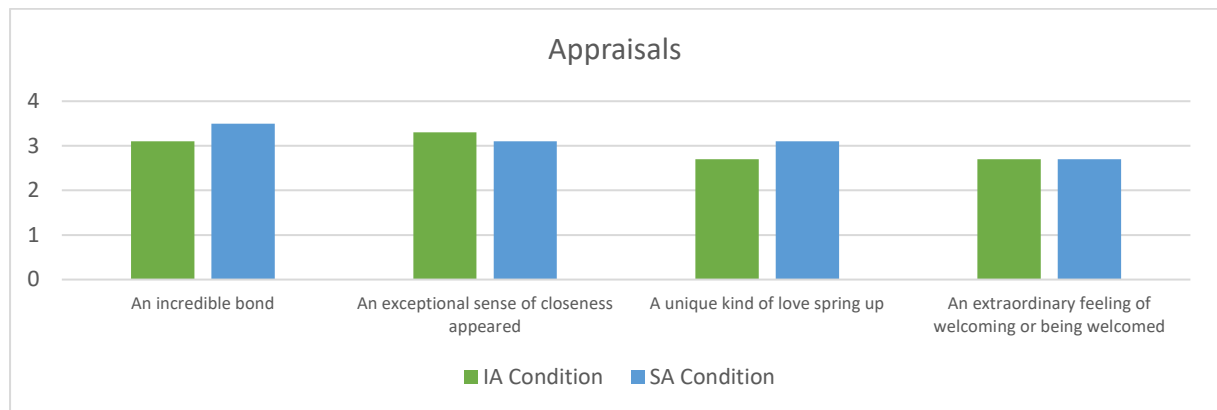


Figure 45: Appraisals of closeness

On the component of motivations, Figure 46 shows that participants were compelled to commit a communal sharing relationship. In particular, through the interpretation of the value for “I wanted to do something extra-nice for someone” which is greater than 3.00.

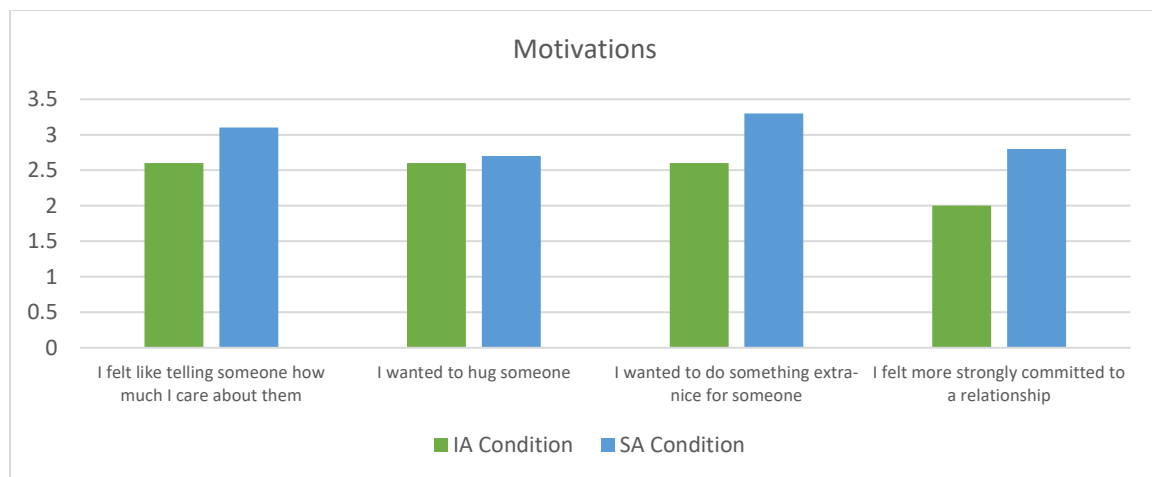


Figure 46: Motivations

Finally, on the measurements “Positive feelings” and “It was heart-warming”, the data suggest participants experienced them at a mid-high intensity, with the former at 4.70 in the SA condition and 3.40 in the IA condition; and the latter at 4.80 in the SA condition and 3.70 IA condition. On the scale from zero (0) six (6), the values in the kama muta scale [4] , these values can consider mid-high as they are over 3.00.

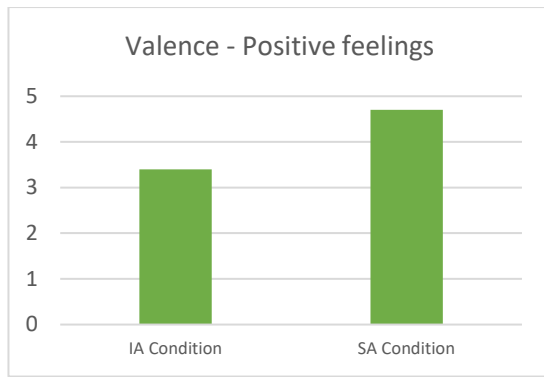


Figure 47: Positive feelings

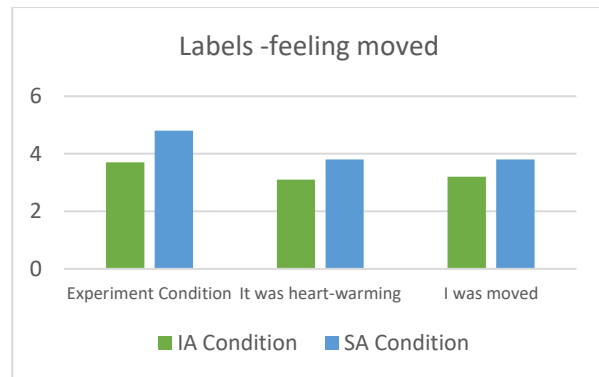


Figure 48: labels

Regarding to the hypothesis in this thesis, **H1**, the results summarized in Table 17 show that only six(6) (“Most eyes”, “Goosebumps or hair standing up”, “I smiled”, “Refreshed, energized, or exhilarated”, “I had positive feelings”, “It was heart-warming”) out of thirteen (13) measurements showed a difference that was statistically significant, which means the **null hypothesis (H0), which states that there is no difference in the intensity of all five components between the SA condition and the IA condition**, cannot be rejected. Therefore, this study concludes that there is no evidence to suggest that the presence of an artificial audience in a VR concert, who express support by making noises, applauding, or cheering influences the users’ experience of kama muta. This could be attributed to different factors, one of them being that users were more attentive to the events on stage as a consequence of them being purposely located in the front row to capture their attention (see section 5.1.1). In addition, the characters in the audience were not interactable and they were not put at the center of the narrative at any point in time. It could have been different if for example, some characters were given some camera time to appear on the floating screens.

Another reason as to why the audience did not have an effect on the elicitation of kama muta might be related to the fact that their sound, when cheering, did not contain intelligible words or sentences. Arguably, a different result could have been achieved if participants heard someone shouting phrases such as “we love you”, “we are with you” or “the same happened to me”.

On the other hand, it cannot be quantified to what extent the other elements in the virtual environment, such as the visual realism of X-ABC, the narrative, the song (music and lyrics), the realism of the venue, the acting of the speech, the floating screens, and the realism of the siblings in the photographs, affected participant’s experience of being moved. Nevertheless, the qualitative analysis in section 6.3 helps creating a picture of which virtual elements might have had the greatest input in the elicitation of kama muta.

Accordingly, participants emotional responses might have been created by connecting the narrative, which revolves around the protagonist’s anxiety and grief due to his brother being missing, with their perception of his humanness throughout the speech (see Appendix F for the content of the speech). The evidence for this can be found under the section of reported feelings 6.3.1.1, in which users whose answers were classified as emotional, equated X-ABC to a real human by using expressions such as “*I can feel the real feeling from a real human*”, “*the way he was saying was, like, literally makes me feel like touched*”, “*what he’s saying is translating for us like he was saying that he just... he can’t find his brother*” and “*But then so many people experience that similar, you know*”. This indicates that the selected narrative effectively portrayed a communal sharing relationship, however, it was

the emotional tone in the voice acting and the facial expressions of the character what afforded the emotion.

Another element in the virtual environment considered to be of critical importance were the floating screens with the sibling's photographs. Answers given by participants, mentioned in section 6.3.3, suggest they were an effective instrument to communicate the story of a relationship over time without breaking the illusion of being in a concert. Participants identified the characters in the sequence of photographs on both flanks, and they were able to make links to the distant and recent past times of the protagonists. This attest to the capability of the system to show communal sharing relationships (CSR's). However, the photographs showing the brothers when they were children, which were the most realistic as well, seemed to evoke a greater emotional reaction as participants not only could appraise a relation of closeness, but also felt a personal connection. The evidence of this can be seen in statements such as "there was this particular picture that reminds **me of my.... me and my sister** having that moment" or "*I kind of missed **my cousins** back at home in the Philippines*".

With respect to the music, valence seems to be the component impacted by it as most participants reported liking the song and being enthusiastic about it. In section 6.3.2 , which analyses the reactions to the music, reveals that there were fourteen (14) emotional reactions to the music in total. Such reactions had a valence, mainly positive, as twelve participants liked the song as opposed to two (2) who did not.

The song "See you again", in particular, might have played a role at activating participant's memories of episodes considered moving or touching (such as funerals as suggested by Menninghaus et al [16]), in particular, the deaths of Kobe Bryant and Paul Walker. However, as only seven users linked the song to these events, it is not clear that a song related to a known tragedy can add to the intensity of kama muta when it has already been elicited by other elements in an immersive environment.



## 8 Conclusion and future work

This research explores the user experience design elements necessary to evoke the emotion called *kama muta* [4] in a virtual reality concert. For such purpose a simulation was created following the findings from researchers in emotion psychology, in particular, Alan P Fiske, Janis H. Zickfeld, Thomas W. Schubert and Winfried Menninghaus, who have systematically profiled and measured this emotion, most commonly known as “being moved” or “being touched”.

Accordingly, a VR experience was created to simulate the performance of a fictional pop singer called X-ABC, who has been dealing with the grief of having his only brother missing and decides to share his feelings with the audience through motivational speech. The virtual environment hosts a full-size venue with four seat sections, an audience, a stage featuring big floating screens, musical instruments, and lighting, all in a night environment with moving clouds and stars. At the end of the simulation, the impact of all these elements in participant’s experience of *kama muta* was captured through the use of the questionnaire KAMMUS two [4], Bailenson et al [33] and a semi structured interview. The results derived from the analysis of the answers suggest that five of the previously mentioned elements played the most critical role at evoking *kama muta* in virtual reality:

- First, and the most important, the narrative developed throughout the simulation. This is a confirmation that the intensification of communal sharing relationships [15] evokes *kama muta*, hence, a design looking to evoke it should feature a narrative that facilitates such intensification, such as loss, separation, reunion, the reestablishment of a relationship in the context of hardship or difficulty, birth, extraordinary kindness from strangers, sacrifices for others or memories of love ones [4].
- Second, convincing voice acting. The emotional delivery of the speech, through a human voice, which was well aligned with the narrative, was able to trigger an equivalent emotional response in participants. It is recommendable to carefully craft the content of any spoken audio to obtain an emotional output from users.
- Third, realistic facial expressions. In the same way as the voice, facial expressions which are consistent with the mood of the characters and properly lip-synced, added to the perception of humanness of X-ABC and to the believability of the experience. Incorected lip-synced facial animations or constant glitches in facial expressions can potentially break the illusion of a human being behind emotion.
- Large screens. To evoke emotion, participants need to watch and internally assess what is happening with the protagonists of the narrative to experience an emotion. Hence, a VR experience needs afford these appraisals, for which large central screens are not only perfect devices for users to attend to, but also, allows the designers to control the pace, and focus points using different types of camera shots (close-shots, mid-shots, etc) that best serve the story.
- Realistic photographs of memories, in particular childhood. Photographs help telling stories, and in the case of the prototype in this thesis, they visually established the significance of brotherhood to the protagonist. They also evoked memories of the participants’ own childhoods which it is believed to have increased the intensity of their emotions.

All the aforementioned components were mentioned by users during the interview and during the qualitative analysis it was difficult to isolate each one. That is, the large screens showed X-ABC’s facial expressions while he was talking, moreover, additional screens showed the photographs of the children when the song is performed. Therefore, the impact that each element had in the elicitation of *kama muta* could not be quantified with the available data. Hence, additional research needs to be done using each component as an experimental variable to obtain a quantification.

In relation to the artificial audience, which was comprised of three different types of characters, hyper-realistic, static-realistic, and animated-unrealistic. Static-realistic and animated-unrealistic characters add to the environment and allow users to feel in presence of others, yet they may not add to the emotional response, whereas hyper-realistic ones may compel users to interact with them. This potential interaction was not explored in the settings of the experiment, mainly due to time and computing power restrictions. Therefore, more investigation needs to be done to explore the interactions between hyper-realistic characters and users in an environment that is inherently social such as a concert.

On the technical side, common sense used in video game development should be applied. There must be a balance between performance and realism which can be achieved by choosing high quality assets for the elements which are in focus and lower resolution for meshes that are distant. In addition, video casting a running simulation within itself is still prohibitively expensive in terms of computing power (for commercial grade personal computers), hence, casting pre-rendered video is the most advisable option.

## 9 Limitations

Some studies have conducted the measurement of kama muta by asking participants to complete the KAMMUS Two [4] questionnaire at different points in time while been exposed to video clips of different nature. In this study, it is assumed that the users were in a clear state of mind, therefore, their initial emotional state was not recorded to establish a base line to compare with the data obtained during the experiment.

In addition to the lack of a base line, the sample size was chosen by convenience and factoring the number of conditions in the experiment. Consequently, the distribution of the data seen in the results was not normal which led to the calculation of the p values of the Mann-Whitney U tests. Further research needs to be done with bigger samples to assess with greater confidence the statistical significance of results for a conclusion to be drawn from them.

In terms of the virtual atmosphere, most participants communicated been impressed by the realism of the experience and they were appreciative of the different qualities in it, such as the lighting and the clouds, this study does not isolate those elements to quantify their impact on the measurements of kama muta.

One of the main characteristics of *relational theory* is that it proposes a generic framework to describe social relations rather than a domain-specific one. For instance, it can be argued that there is an intersection between *communal sharing* and the concept of *relatedness*.

As per Martela et al definition:

“Relatedness is more about the interpersonal dimension, reflecting the extent to which a person feels that one is connected to others, has caring relationships, and belongs to a community” [58, p. 2]

However, this definition stems from Self-Determination Theory, which revolves around motivation and developmental pathways, one of the many domain-specific theories to explain a specific social phenomenon. This study uses relational theory as a foundation to understand social relations, therefore, the outcomes may not satisfy similar or overlapping theories.

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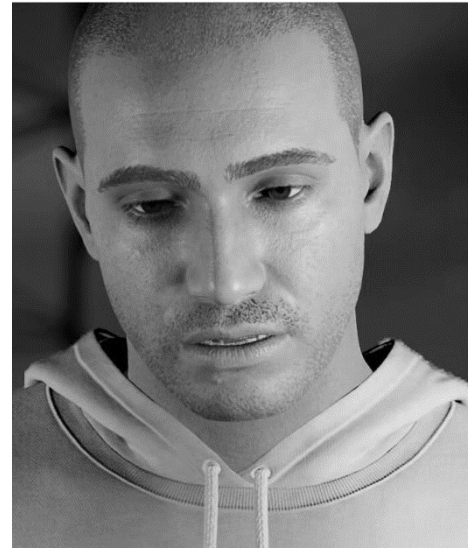
# Los Angeles Times

COVID-19 FOR SUBSCRIBERS FESTIVAL OF BOOKS FREE TAX FILING UCLA GYMNASTICS LAKERS L.A. GOES OUT

## X-ABC Tops charts around the globe!!

X-ABC's "do not falter" finds its way to the top 10 on Billboard.

"I am totally thrilled and very humbled. I think the people who help me on a daily basis, personally and artistically, are very happy too. So, a big part of this success can be credited to them"



Opinions War in Ukraine Investigations Climate Well•Being Tech Lifestyle World

# The Washington Post

*Democracy Dies in Darkness*

## X-ABC Touring New Zealand, tickets sold-out.

Everything is ready for X-ABC's "Waiving" Tour across Australia and New Zealand





## CULTURE

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## MUSIC



## X-ABC Reveals he grew up in an orphanage.

In a moving interview, X-ABC tells how he and his brother spent their teen years in the slums of Medellin. “My brother has always been my angel, he protected me and showed me why compassion makes you a decent human being”

X-ABC’s **brother Leo** on the left with X-ABC at the orphanage when they were 16 and 12 years old

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# Los Angeles Times

[COVID-19](#)[FOR SUBSCRIBERS](#)[FESTIVAL OF BOOKS](#)[FREE TAX FILING](#)[UCLA GYMNASTICS](#)[LAKERS](#)[L.A. GOES OUT](#)

## X-ABC’s brother, Leo, was reported missing after a monumental sandstorm in Mali.

Leo had been working as a volunteer for the UN when he was caught in a dust storm in the Saharan desert.





## X-ABC's brother, Leo still missing after 3 weeks

"I am sad and confused, but I still have hope, I am sure I'll have him here again" X-ABC said.



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Kia Ora, Aotearoa!


[Check your weather](#)




**newsable**  
 The story we couldn't ignore any longer



**the podium**  
 Moana would love to be based in Samoa



**the human race**  
 'No one says how to deal' with miscarriage



**the long read**  
 NZ's biggest aviation mystery



## X-ABC is in New Zealand

After weeks of speculation, the artist arrived in Auckland this morning.

## Appendix B



### Consent Form

HITLabNZ

Phone: +64 3 369 2226

Email: [info@hitlabnz.org](mailto:info@hitlabnz.org)

28/10/2022

HREC Ref: *[Provided by HREC when study approved]*

### Music and Emotion in Virtual RealityMusic and Emotion in Virtual RealityMusic and Emotion in Virtual RealityMusic and Emotion in Virtual Reality

#### Consent Form for Participants

- ☐ I have been given a full explanation of this project and have had the opportunity to ask questions.
- ☐ I understand what is required of me if I agree to take part in the research.
- ☐ I understand that participation is voluntary, and I may withdraw at any time without consequences. Withdrawal of participation will also include the withdrawal of any information I have provided should this remain possible.
- ☐ I understand that any information or opinions I provide will be kept confidential to the researcher. I understand that any published or reported results will not identify me.
- ☐ I understand that all data collected for the study will be kept in locked and secure facilities and/or in password-protected electronic form. I understand the data will be destroyed after five years after the conclusion of the study.
- ☐ I understand the risks associated with taking part and how they will be managed
- ☐ I understand that I can contact the researcher David Aguilar ([david.aguilarjaramillo@pg.canterbury.ac.nz](mailto:david.aguilarjaramillo@pg.canterbury.ac.nz)) or supervisor Heide Lukosch ([heide.lukosch@canterbury.ac.nz](mailto:heide.lukosch@canterbury.ac.nz)) for further information. If I have any complaints, I can contact the Chair of the University of Canterbury Human Research Ethics Committee, Private Bag 4800, Christchurch (email: [human-ethics@canterbury.ac.nz](mailto:human-ethics@canterbury.ac.nz)).
- ☐ I consent to my contact information being kept and used by researchers to contact me about future, related research opportunities
- ☐ By signing below, I agree to participate in this research project.

Name: \_\_\_\_\_ Signed: \_\_\_\_\_ Date: \_\_\_\_\_

Email address (for report of findings, if applicable):

---

*Please hand this form to the researcher.*

## Appendix C

### KAMMUS Two

[In all sections, Likert scales, 0 = “not at all” to 6 = “a lot”]

#### Section 1:

Please indicate whether you experienced any of the following sensations, feelings, or actions, and if so, to what extent:

- Moist eyes.
- Tears.
- Goosebumps or hair standing up.
- Chills or shivers.
- A warm feeling in the centre of the chest.
- Some feeling in the centre of the chest.
- Choked up.
- A lump in the throat.
- Difficulty speaking.
- I smiled.
- Buoyant or light.
- Refreshed, energized, or exhilarated.

#### Section 2:

Please rate to what extent each of the following statements are true:

I felt/I observed...

- An incredible bond
- An exceptional sense of closeness appeared
- A unique kind of love spring up
- An extraordinary feeling of welcoming or being welcomed

#### Section 3:

Please indicate whether you had each of the following feelings just afterwards, and if so, to what extent:

- I felt like telling someone how much I care about them.
- I wanted to hug someone.
- I wanted to do something extra-nice for someone.
- I felt more strongly committed to a relationship.

Section 4:

Please rate to what extent each of the following statements are true:

I had positive feelings.

Section 5:

Please indicate whether each of the following was true, and if so, to what extent:

- It was heart-warming.
- I was moved.
- I was touched

## Appendix D

### Bailenson Social presence Questionnaire

1. I perceive that I am in the presence of another person in the room with me.

	1	2	3	4	5	6	7	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

2. I feel that the person is watching me and is aware of my presence.

	1	2	3	4	5	6	7	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

3. The thought that the person is not a real person crosses my mind often.

	1	2	3	4	5	6	7	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

4. The person appears to be sentient (conscious and alive) to me

	1	2	3	4	5	6	7	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

5. I perceive the person as being only a computerized image, not as a real person

	1	2	3	4	5	6	7	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

## Appendix E

### Interview

#### Objective

This interview aims to capture the user's impressions of the experience not captured by the questionnaires.

- Know if the type of music played made the experience enjoyable for the user
- Establish if personal experiences affected the users' reactions
- Get the users' point of view on the ergonomics of the experience

The main questions to be asked are listed below, nevertheless, depending on the participants' answers others may be introduced.

1. Tell me how you feel right now?
2. What do you think of the song?
3. Do you think the experience portrays a real-life experience?
4. What do you think of the main character, do you think his attitude resembles a human being with real feelings?
5. Do you think that the character's appearance is scary, nice or did not make a difference?
6. There is a second character there what are your thoughts or feelings about him?
7. What do you think of the characters in the surrounding? Did they affect you during the experience? In which way?
8. What do you think of the photographs of X-ABC and his brother? did they evoke any feelings or memory in you (yes/no)?
9. Do you think your previous experiences influenced what you felt during the experiment? any close story?
10. What is your general opinion on the experience? Would you attend a VR concert like this again?
11. Did you experience any discomfort with the devices, headphones, head strap, or cables?

## Appendix F

### Main Character's speech

He starts playing the piano.

Thank you all. Thank you all!!  
thank you!!

It has been a great privilege to be on stage sharing with you all these years.

And although some of you might have thought, I wouldn't be showing up today, here I am.

This situation with mi brother Leo, is heart-breaking.  
You know in the face of loss; you have  
Anxiety,  
Denial,  
this horrible pain that makes you question everything in your life.

However, Leo, taught me not to despair and hold on to hope 'til the end. Specially during those days when you feel like walking the tightrope.

And if any of you my friends, here today are missing someone and are hurting or maybe feeling stuck and regretful. I want to tell you that

- there is always hope
- that even when some things are irreversible,
- you can still go forward
- you can still find yourself
- you can still be happy

To my brother, wherever he might be,  
thank you!! And I love you!!  
I'll go and find you.

To him, and all those you love, this song



## Appendix G

### Ethics Committee Approval



#### HUMAN RESEARCH ETHICS COMMITTEE

Secretary, Rebecca Robinson  
Telephone: +64 03 369 4588, Extn 94588  
Email: [human-ethics@canterbury.ac.nz](mailto:human-ethics@canterbury.ac.nz)

Ref: HREC 2022/101/LR

28 February 2023

David Jacobo Aguilar  
HIT Lab NZ  
UNIVERSITY OF CANTERBURY

Dear David

Thank you for submitting your low risk application to the Human Research Ethics Committee for the research proposal titled "Music and Emotion in Virtual Reality".

I am pleased to advise that this application has been reviewed and approved.

Please note that this approval is subject to the incorporation of the amendments you have provided in your email of 16<sup>th</sup> February 2023.

With best wishes for your project.

Yours sincerely

A handwritten signature in black ink, appearing to be 'DS' followed by a stylized flourish.

Dr Dean Sutherland  
*Chair, Human Research Ethics Committee*