INTERACTIVE CULTURAL STORY-TELLING VIRTUAL ENVIRONMENTS USING SAN STORIES

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Abstract

Story-telling is being used for the preservation of culture, and interactive story-telling in particular, is attractive for its ability to provide the user with a hands-on experience.

We explored the feasibility of interactive story-telling in relation to the San culture of South Africa, by investigating the effect of interactivity on users' perceived levels of presence. Presence refers to the feeling of 'being there' in a virtual environment (VE presence). We also investigated the level of presence in the story (story presence). Priming as a contributor to presence, and the relationship between VE presence, story presence, and enjoyment were also investigated. These investigations were made based on two virtual environments (one allowing interaction with the story and the other not interactive) and two priming materials (one relevant to San culture and the other not relevant).

Interactivity was found to reduce the users' levels of VE presence despite the fact that guidance was used to try to maintain the story plot. Of the two questionnaires that were used to measure VE presence (Igroup (IGPQ) and Slater *et al's* (SUS)), a significant negative effect ($F = 4.983$, $p = 0.029$) was obtained from IGPQ, for the effect of interactivity on VE presence. The interaction effect of interactivity and priming was also found to have a significant negative effect ($F = 4.423$, $p = 0.04$) on VE presence according to SUS questionnaire. This result also showed that interactivity only decreased VE presence in the absence of relevant priming but once relevant priming was used an increase in VE presence, albeit not significant, was observed. The conclusion from this was that priming can contribute to increased VE presence. A significant positive correlation of 0.73 and 0.64 (according to IGPQ and SUS respectively) was obtained with VE presence and enjoyment. Story presence and enjoyment also correlated significantly at 0.43. This shows that participants enjoy more when they are present in the VE and/or the story and vice versa.

Low interface fidelity whereby input devices may have not sufficiently represented their real world counterparts, and possible disruption of the story plot were seen as reasons for a negative effect of interactivity on presence. In the case where expensive equipment is achievable we suggest the use of haptic props and devices which provide tracking to provide high interface fidelity.

We concluded that our study provided a feasibility for the use of interactive story-telling for culture and suggest that the use of guidance should be done along with restrictions on interactivity. While this may take away some of the attractiveness of interactivity we believe it would still give participants a hands-on experience while maintaining the plot.

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Chapter 1

Introduction

This research was carried out mainly to investigate the effect of interactivity and priming on presence, and the feasibility of interactive cultural story-telling virtual environments. Several studies were conducted and the obtained results are presented and discussed in Chapter 6.

1.1 Motivation of the Study

Virtual Reality (VR) has gained widespread use in a number of fields, such as psychotherapy, education, entertainment and story-telling. However, unlike other areas where the provision of interactivity characteristic of VR is highly desirable, interactivity gives rise to a number of challenges in story-telling. In this research, we investigated these challenges, while paying particular attention to the effect of interactivity on users' sense of presence, an important concept in the field of VR [67]. We also attempted to provide a way to overcome some of the challenges.

Presence can be defined as the extent to which the user feels they are engaged by a media. When applied to VR, presence refers to the feeling of 'being there' in a virtual environment (VE), rather than just watching images on a computer screen. The objective of most VR applications is to provide the user with the illusion that the mediated experience is real, reflected in high levels of presence. Several researchers contend that the effectiveness of a VR application is linked to this sense of presence [71, 67, 46]. We believe that manipulating factors that enhance presence should result in more effective VR applications.

Unfortunately, due to the lack of consensus regarding the definition of presence in the literature, no unified operational measure of presence exist [49, 22], neither does a clear outline of factors believed to contribute to presence. Several approaches of measuring presence have however been used, and these include:

1. Obtaining self-reported sense of presence from participants.

2. Comparing task performance in the real and virtual environment.

3. Observing users' behaviour when interacting with a VE.

4. Measuring physiological changes of the user.

Each of these measures have weaknesses and strengths as shall be seen in Chapter 2.

A number of factors of presence have also been investigated, however we believe that these factors have not been adequately researched when dealing with interactive cultural narratives. In order to create VR applications for culture and story-telling, it is important that these factors are sufficiently understood and for our research, we investigated these factors with regard to the San people of South Africa's stories.

The San people are widely known for their artistry, their extensive use of stories, and their hunting as a way of life [31, 19, 29]. For our purposes we chose a story on hunting. Here we looked at how VR can enable us to re-capture and present San culture, a culture that is fast becoming extinct. More so, we examined how this can be done in an interactive manner given that the chosen story is a 'hands-on' story about completing a certain task, i.e., making a hunting arrow.

We also explored the notion of priming, which is based on the construction perception thesis which states that participants are most likely to process perceptions of ambiguous stimuli more accurately if placed in an appropriate state of mind, or primed, than when they are not [36]. Therefore the belief is that participants will experience higher levels of presence when primed.

1.2 Objectives of the Study

The main objectives of this research are, to explore the feasibility of interactive cultural story-telling VEs by investigating the effect of interactivity on presence, and to test the effect of priming on presence. Two levels of presence are explored, namely:

- Presence in the VE: this refers to the presence in the overall virtual environment experience and not just the story.

- Presence in the story: this refers to the extent to which the user feels they are engaged in or are part of the story world and not necessarily presence in the overall VE in which the story is being narrated.

The combined effect of interactivity and priming on presence is also investigated. Lastly, the relationships between presence in the VE, presence in the story and enjoyment are investigated. These aims are discussed in details in the subsections which follow.

1.2.1 Feasibility of Interactive Cultural Story-telling VEs

As mentioned in Section 1.1 above, an effective VR application should result in high levels of presence. Our aim in relation to the feasibility of interactive cultural story-telling VEs is:

Aim 1: To investigate whether interactivity can have a positive effect on presence in the VE and in the story being narrated, if facilitation and guidance are used.

The following hypotheses with respect to this aim were hence developed:

1. *Enabling users to actively interact with a story in a story-telling VE can positively affect presence in that VE if facilitation and guidance are used.*

2. *A virtual story-telling environment which allows its users to actively interact with the events in the story being narrated, can positively affect the extent to which users feel they are part of that story.*

Although some researchers strongly oppose the idea of interactivity in story-telling VEs [18, 40, 17] due to the possibility that through interactivity the user can change the story-line intended for them by the author, we believe that facilitation and guidance can assist in the plot being maintained, hence enabling the user to actively participate in the story, especially a story such as the one used in this research where the user has to complete a certain task. We believe that this active involvement will lead to the user being more present in both the VE and the story. The idea of facilitation and guidance has been used in *'The Thing Growing'* [7] and the *'Cato Manor'* system [20] described in Subsection 3.4.4.

1.2.2 The Effect of Priming on Presence in Story-telling VEs

Research has shown that priming creates an awareness and readiness to experience a certain kind of event [36]. Therefore it is believed that giving participants a story that has something to do with the San culture before experiencing the story in the virtual environment, places them in an appropriate state of mind. Our aim in relation to this is:

Aim 2: To investigate whether priming users before they experience a VE will increase their sense of presence.

The hypotheses that were developed in relation to this aim are:

1. *Priming participants before they enter the virtual environment can have a positive effect on presence in the VE.*

2. *Priming participants before they enter the virtual environment can have a positive effect on presence in the story.*

   It is expected that participants who have been primed with relevant material will experience higher levels of VE and story presence than participants who have been primed with irrelevant material. This, as already discussed, is based on the construction perception thesis which says participants are more likely to process perceptions of ambiguous stimuli more accurately if placed in an appropriate state of mind.

Although relevant to the San culture, the relevant priming story was not similar to the one used for our story-telling VE (the Arrow-making story), instead, it was mostly about mythological characters, and it was made clear to participants that they were not expected to memorize it.

1.2.3 The Effect of Combined Interactivity and Priming on Presence

Aim 3: To investigate the effect of combined interactivity and priming on presence as compared to either one of these factors alone.

The following hypotheses in relation to this aim were developed:

1. *Combined interactivity and priming positively affects presence in the VE more than either one of these factors alone.*

2. *Combined interactivity and priming positively affects presence in the story world more than either one of these factors alone.*

1.2.4 Relationship between Presence in the VE, Presence in the Story and Enjoyment

Aim 4: Presence in the VE, presence in the story, and enjoyment are related.

The following hypothesis with respect to this aim was developed:

1. *It is believed that users are most likely to enjoy the overall experience in the VE, if they feel present in the VE and/or in the story world and vice versa.*

1.3 Methodology

To achieve our aims, we adopted the following methodology:

1. Hypotheses were identified from our aims as above.

2. The involved variables were then identified from the hypotheses. These were *interactivity*, *priming*, *VE presence*, *story presence* and *enjoyment*

3. A San story was chosen as the story to be narrated in the VE as it was in line with our aim of using an African culture. Also, due to the fact that it was a story about completing a task, it allowed us to test all our hypotheses.

4. Two environments that provided the different scenarios needed to test our hypotheses were then designed, and user-experiments based on these environments were carried out.

5. Appropriate measures for measuring the relevant variables were selected and the data that was obtained was then analyzed and conclusions were drawn.

The design of our experiments was as follows:

Experiments which ensured the testing of all combinations of our variables were run under the following four conditions:

Condition 1: This condition involved interaction with the story and reading relevant priming.

Condition 2: In this condition, interaction with the story was not allowed but relevant priming was still used.

Condition 3: This condition involved interaction with the story but with irrelevant priming.

Condition 4: In this condition, neither interaction with the story nor relevant priming were used.

Two different environments (interactive and non-interactive) were used for this, whereby interactivity was manipulated by assigning the value 1 to the interactive environment and 0 for the non-interactive one. Priming was manipulated by giving participants either one of two stories to read before their VE experience, whereby a story relevant to the San culture was used as the relevant priming material and a story about trains was used as the irrelevant priming material, with priming assuming the value 1 or 0 respectively. These stories have been included in Appendix B and C.

To test the correlation between presence in the VE, presence in the story, and enjoyment further analyses based on the data obtained from the experiments discussed above, were performed.

1.4 Outline of Dissertation

Chapter 2: This chapter reviews the background theory behind virtual reality (VR). We start off by presenting the different approaches used to define VR, followed by a discussion on the advantages and disadvantages of VR. An in-depth discussion on presence is also given along with the different factors thought to contribute to it. The manner in which users are represented in virtual environments is also described. Lastly, we discuss the different measures used for presence.

Chapter 3: In this chapter we discuss the theory pertaining to San culture, story-telling and VR's applicability for story-telling. Interactivity in cultural story-telling VEs is also reviewed. Here we look at the challenges one faces when designing such VEs whereby, a lot of conflicting limitations have to be taken into consideration. Lastly, we discuss some of the interactive story-telling VE applications which exist.

Chapter 4: This chapter outlines the approach that was taken (i.e., the strategy used to investigate our aims and the hypotheses involved, and the description of the virtual environments used). The considerations that had to be taken into account while developing our methodology are also presented.

Chapter 5: This chapter describes the experiments that were conducted to test the hypotheses put forth. The method that was taken, which explains how we went about recruiting subjects and what materials were used for our experiments, is also presented. We also describe the procedure that participants were expected to follow in the experiments. Finally, we end the chapter by outlining the way in which data was collected.

Chapter 6: In this chapter we present and discuss the results in relation to our different areas of interest. We found that some of the hypotheses were fully supported, or at least partially supported by the results, while other hypotheses were not in agreement with the results. Specifically, we found that the story presence variable did not behave as expected. Possible reasons as to why the results did not necessarily agree with some of the hypotheses are laid out. Briefly we found that:

- Interactivity negatively affects VE presence in story-telling environments. Low fidelity equipment and disruption of consistency in the story due to interactivity, were identified as the possible reasons for this.
- Relevant priming contributes to an increase in VE presence.
- Enjoyment and VE presence are highly related.
- Enjoyment and story presence are highly related.

Chapter 7: We conclude this dissertation with a summary of the major findings of the study and the contributions of those findings. We also present recommendations for future work.

Chapter 2

Virtual Reality and the Concept of Presence

Our research borrows from a number of disciplines, namely Virtual Reality, Psychology, Anthropology and Story-telling. This chapter reviews the background theory behind virtual reality (VR). Information on cultural and story-telling concepts is given in the next chapter. VR's potential for interactive story-telling is also examined there.

The first section (Section 2.1) presents the different approaches used to define VR, followed by a discussion on the advantages and disadvantages of VR (in Section 2.2). An in-depth discussion on *presence*, a concept deemed to play a crucial role in the success of VR systems, is given in Section 2.3. Here we look at the various ways in which different researchers define presence and the implications of those differences. Furthermore, the different levels of presence investigated in this research, namely, presence in the VE and presence in the story are presented. We also examine the importance of presence and outline the different factors thought to contribute to presence. Section 2.4 describes the manner in which users are represented in virtual environments, including the notion of *avatars*. The different measures of presence are discussed in Section 2.5. Lastly, we conclude the chapter with a summary of the important points discussed in the chapter, in Section 2.6.

2.1 Virtual Reality (VR)

Virtual Reality (VR) is a medium which enables its users to interact with three-dimensional objects presented in a computer-generated environment, known as a virtual environment (VE). This ability to interact allows users to actively participate in events going on in the virtual environment as opposed to passively watching/imagining the events, as is the case with conventional media like television and books. The intention of VR is that users will respond to events going on in the virtual environment in a similar way they would in reality. Steuer [59] defines virtual reality as a mediated

environment in which the user feels to a certain extent that they are present in the mediated environment. Different approaches have been used to describe VR. One of the prevailing definitions is to describe virtual reality in terms of technological hardware, not through the human experience.

In [60], Summit (1993) quotes Coates on defining virtual reality as a simulation of environments experienced via head mounted goggles and wired clothing enabling the user to interact with these environments. Greenbuam, (in [60]), also portrays VR as a world filled with images visited with equipment featuring "stereophonic video goggles and fiber-optic data gloves." This approach of defining virtual reality in a purely technological manner rather than experiential, can be inadequate as it suggests that the eminent feature of any virtual reality system is the presence or absence of certain hardware. The problem with this, as Steuer points out, is that a system is arbitrarily classified as VR or not-VR depending on whether a system includes certain hardware. This, makes it difficult to determine the quality of different virtual environments comprised of the same equipment, and therefore does not provide a clear unit for analysing virtual environments.

We believe that the idea of virtual reality goes much more than just technology. Some of the things that we believe set VR apart from other media are, the concept of presence, user-embodiment, and the ability to interact with the events going on in the VE. In the sections that follow, we look at each of these phenomena. However, before we do that, we discuss the advantages and disadvantages of VR while paying attention to cultural story-telling VEs.

2.2 Advantages and Disadvantages of VR

2.2.1 Advantages

- VR enables the simulation of situations which are otherwise impractical to construct in reality. For example, treating a person with a fear of heights might mean exposing the person to a real cliff which might be dangerous, or re-constructing an ancient social setting in which people used to live in, e.g., the San people cultural social setting which is now almost non-existent in southern Africa where they used to be found.

- Because VR is interactive, it allows hands-on experience in environments such as learning or story-telling VEs. It also enables architects to make alterations from designs with real-time response unlike in other representations where alterations normally mean starting the whole model from scratch, hence VR saves time.

- It saves cost. A good example is with the treatment of the fear of flying. A patient need not go on a real flight to be exposed to the feared stimulus. Another example can be that of re-constructing ancient social settings which no longer exist.

- It is also believed that people tend to respond more to events represented in a virtual environment as opposed to other kinds of media, due to its interactive nature.

2.2.2 Disadvantages

- Increasing fidelity (the extent to which the VE and the interaction with it resemble those in the real world) in VR can be very expensive [69].
- VR is known to be non-ergonomical; head-mounted displays can be heavy and users may trip on wires and harm themselves.

2.3 Presence

The notion of *presence* is a subject of primary focus in the science of VR [46]. Witmer and Singer [71] argue that the effectiveness of virtual environments is often linked to the sense of presence reported by users. They contend that manipulating factors which increase presence will increase learning and performance, they however state that they do not have direct evidence to support their contention. Slater *et al* report that previous research has suggested that presence in a virtual environment (VE) is important: "a highly present individual is more likely to behave in the VE in a manner similar to their behaviour in similar circumstances in everyday reality" [67]. Other researchers who support the importance of presence are Schuemie et al [46], who argue that although a thorough understanding of the reason why VR is effective maybe missing, most research on this subject is however related to the concept of presence.

It is quite clear from above that presence is of major importance in conceptualizing VR. Unfortunately, a concise and conclusive description of the concept does not exist. This, as we shall see later, presents problems such as lack of concrete measures of presence and lack of consensus on factors that are believed to affect presence. This section reviews some of the prevailing definitions of presence, and points out the similarities and differences between them. It also attempts to provide a common understanding of the notion of presence.

2.3.1 General Definition of Presence

Despite the conflicts that exist in the conceptualization of presence, researchers in the field seem to, to differing extents, agree on the following general definition of presence:

Presence is a subjective feeling of being in a virtual environment, that is the extent to which users feel they are 'there' in the world specified by the virtual environment [37, 38, 44, 49, 50, 55, 59, 71] as opposed to just watching images on a computer screen.

However, as argued by Witmer and Singer [71], this definition only provides a basic understanding of the concept but does not describe the nature of the feeling of being there, nor does it identify the factors which influence this feeling. In the subsections that follow we present a deeper analysis of the notion of presence and ultimately put, the definition of presence used for the purposes of this research, forward. We start off by describing a concept closely related to the notion of presence,

namely *immersion*, followed by the possible reasons which give rise to the diverse ways in which presence is defined, and thereafter discuss the various factors believed to influence presence.

2.3.2 Immersion

At least two different ways of describing immersion exist; some researchers describe immersion as a characteristic of a VR system hardware while others see it as a psychological construct. These dichotomous ideologies are discussed below.

Technological Aspects of Immersion

Immersion, as argued by Slater *et al* [53], is a quantifiable description of a technological hardware system. They thus describe immersion as the extent to which a computer display is "extensive, surrounding, inclusive, vivid and matching" [53], whereby by *extensive* they refer to those displays that can accommodate various sensory modalities; *surrounding* refers to the ability of a system to send sensory information in all directions; *inclusive* in that all sensory data from the physical surroundings is blocked out, but the only information that arrives to the user's senses is from the virtual world; *vividness* refers to the richness of the information content generated by the display, and *matching* refers to the match between the participant's anticipated feedback about body movements, and the information generated on the displays; for example, a turn in the head should result in a corresponding change in the visual display [53]. Therefore, according to this system of belief, immersion is an objective of a system and is not subjective to the user.

Similarly, Biocca & Delaney (1995) in [32] support the prior assertion of immersion being a technologically quantifiable construct, whereby they describe immersion as the degree to which inputs from the physical world are shut out and hence can be objectively measured by counting the "number of the users' senses that are provided with input" [32]. Schubert *et al* [44] also support this notion of immersion being an objective construct by stating that immersion can be described objectively.

Psychological Aspects of Immersion

In [71], Witmer and Singer firmly oppose the foregoing notion of immersion as follows:

> "Though the VE equipment configuration is instrumental in enabling immersion, we do not agree with Slater's view that immersion is an objective description of the VE technology. In our view, immersion, like involvement and presence, is something the individual experiences [71]."

In line with the above contention, they describe immersion as a psychological state whereby the user perceives themselves as enveloped, included and interacting with an environment that provides

a continuous stream of stimuli. Although Witmer and Singer define immersion in terms of the user's perception, they acknowledge that the type of technology used is instrumental to immersion and "a VE that effectively isolates users from their physical environment, thus depriving them of sensations provided by that environment, will increase the degree to which they feel immersed in the VE" [71]. They nonetheless maintain that immersion is an effect on the user's perception of feeling included in the VE.

Likewise, Manetta and Blade (1998) in [58] look at the psychological side of immersion. They qualify the user's emotional reaction to a VE as part of immersion and describe presence as the feeling of being immersed in an environment.

In response to Witmer and Singer, Slater [50] argues that he would include Witmer and Singer's definition of immersion as part of his definition of presence as he sees the individual's experience as presence, and immersion as a measurable characteristic of the system.

There seems to be no clear distinction between the concept of presence and the psychological concept of immersion as posited by Witmer and Singer, and Manetta and Blade above (e.g. *presence is a feeling of being immersed* - as stated by the latter twosome), and hence for the purposes of this research, we use Slater *et al*'s [53] definition of immersion being entirely technological in order to avoid any confusion.

2.3.3 Differences in the Theory of Presence

Below we list some of the reasons for the discord in the definition of presence:

- Conflicting opinions about what constitutes presence but not immersion. Thus the debate is whether the latter is entirely hardware-dependent or, just like presence, has a psychological component to it.
- Diverse views about how presence manifests itself, i.e., what exactly does a person do, or what precisely happens to them when they are present? This has led to different categories and measurements of presence.

We look at each of these different views in depth, and discuss how various definitions of presence have arisen due to the differences.

2.3.4 Immersion and Presence

Slater includes Witmer and Singer's notion of immersion in his description of presence, and hence states that presence includes the following three aspects [50]:

- The sense of 'being there' in the VE.
- The extent to which the VE becomes the dominant one in comparison to the real world.

- The extent to which participants, after the VE experience, remember it as a place visited rather than images on a computer.

Slater's preceding definition of presence, as we shall see later, determines the way in which he measures presence, which is also different to the way Witmer and Singer measure it. Witmer and Singer clarify that the perception of being enveloped (or immersion, according to Slater and others) may play a role in presence but should not be equated to presence. They define presence as the subjective experience of being in one environment while situated in another. However they are quick to point that one does not require a total attention shift from the real world in order to feel present in a VE.

We feel both Slater, and Witmer and Singer provide insight in what constitute presence and for our research we use the conception of presence being the extent to which users feel they are 'there' in a VE, and hence like Slater use this mental state of the user only for defining presence but not immersion as well. This, as already mentioned, is to avoid confusion between the two concepts.

In the subsection which follow, we look at how different researchers identify different kinds of presence and hence define it differently.

2.3.5 Categories of Presence

Another reason for the differences in the concept of presence, arises from the way different researchers believe presence manifests itself – leading to several kinds of presence being suggested.

Slater *et al* classify presence into the following two categories, which although related, are conceptually different [54]:

1. **Personal presence**: the sense of "being there" in a virtual environment.

2. **Shared presence (co-presence)**: the sense that other people are there in the virtual environment and the feeling of being part of a group.

The first manifestation of presence, which is personal, has been discussed by several other researchers. Held and Dularch [22], Loomis [34], and Sheridan [49] refer to this classification as *telepresence* and define it as a feeling of being physically present with the virtual objects at a remote location. Sheridan further distinguishes another type of presence, which he coins *virtual presence* and defines it as the sense of being physically present with displays generated by a computer. For our purposes we classify both telepresence and virtual presence as personal presence, as they clearly refer to an individual sense of being in an environment other than the one they are physically situated in.

In her paper, Heeter [21] talks about the three dimensions of presence: *personal presence, social presence* and *environmental presence*. Her definitions of personal and social presence are quite similar to Slater *et al's* [55] notions of personal and co-presence mentioned above. She defines personal presence as a measure of the extent to which users feel like they are in the virtual environment. She

argues that personal presence derives from feeling like you exist as a separate entity within the environment, and it may be enhanced if other users exist in the virtual environment and if they appear to recognize your existence, this she refers to as social presence. It is highly similar to Slater *et al*'s notion of co-presence. The third dimension of presence – environmental presence – refers to the extent to which the environment appears to know that we are there and seems to react to us. An example given here is that of lights turning on when the user enters a room. The argument made is similar to that of social presence, that if the environment seems to know we are there, that may help convince us that we are there. Heeter states that most virtual environments tend to be so totally unaware of the user's presence so much that one can get lost in a mountain, if illogical boundaries are not observed [21].

The argument which Heeter makes, is that users may doubt if they are really present if their actions seem to be ignored by either other people (in the case of social presence) or by their environment (in the case of environmental presence). We hence recognize the three classifications of presence she has put forth and argue that they sufficiently encompass other categories that have been suggested. This idea has been argued in details in [36] (a thesis done solely to investigate presence), and it is not our intention to go over it, at the same depth again. Here we only give a few examples of the other categories of presence that have been proposed to illustrate our point. Lombard and Ditton define presence as the "perceptual illusion of non-mediation" [32]. Non-mediation in this case refers to the failure of a participant to acknowledge the existence of the VE as a medium, and hence respond as they would if the medium was not present. This obviously ties in with the notion of feeling like you are 'there'. Lombard and Ditton argue that their definition encompasses six conceptualizations of the theory of presence. Below we briefly discuss each of their conceptualizations and show that they fall under the three categories identified by Heeter [32]:

1. *Presence as social richness* – the argument here is that, a medium that produces an illusion of non-mediation can provide a rich (non)verbal information for social interaction. This is the same notion of social presence discussed above, as the concern is social interaction in both cases.

2. *Presence as realism* – the extent to which objects appear vivid and real in such a medium. We believe realism is a factor of presence not a manifestation of it as shall be seen later.

3. *Presence as transportation* – the illusion that there is no medium means that there is no demarcation between users and the entities in the VE, so users can perceive that they have either moved to the entities in the VE, or the entities have moved to the user's immediate environment, meaning that the user can either think they are sharing their real world or the VE with the entities. This is equivalent to personal presence.

4. *Presence as immersion* – they use immersion as both a technological and psychological construct, hence refer to it as the user's feeling of being involved, absorbed, engaged and enveloped. Immersion, when used in this way, is categorized as presence (refer to Subsection

2.3.2) i.e., personal presence.

5. *Presence as social actor within medium* – if users encounter other users within a medium that provides the illusion of non-mediation, they are encouraged to respond to social cues in that medium as they would in non-mediated communication. This is similar to social presence.

6. *Presence as medium as social actor* – if the medium itself provides cues that replicate normal interaction, it is likely to be perceived as a social entity not a medium. This is similar to environmental presence.

2.3.6 Presence – the Illusion of Non-Mediation

So far, the different conceptualizations of presence seem to converge to a central definition of presence as the perceptual feeling of being in the virtual environment and being oblivious to the presence of the media – "illusion of non-mediation" [32]. However, Schuemie *et al* [46] present a different definition of presence which was discussed in *Presence-L Listserv*. Here the idea is that although part or all of the user's experience may be generated by the media, the user is aware of the media but overlooks it. Below is part of the quotation taken from Presence-L Listserv as it appears in [46]:

> *Except in the most extreme cases, the individual can indicate correctly that s/he is using the technology, but at some level and to some degree, her/his perception overlook that knowledge and objects, events, entities, and environments are perceived as if the technology was not involved in the experience.*

From the above quotation, we can see that emphasis is on the non-exclusive nature of presence, i.e., unlike most of the foregoing definitions where the impression given is that the user feels as if they are in the virtual and not the real environment, here the user is actually aware that the virtual world is mediated but chooses to overlook the media.

In [46], Schuemie *et al* corroborate with this definition and states that the user's acknowledgement of the experience being mediated by technology is rarely explicitly stated even though it is an essential aspect of the concept. They state that people always know that the experience is mediated and given the current state of technology, can always distinguish between real and mediated stimuli.

Like Schuemie *et al* [46], we also believe that given today's state of technology, users become aware of the medium to some extent.

To conclude this discussion of the definition of presence, we present the two conceptualizations of presence that were investigated in this research.

1. **VE Presence:** this was used to refer to the user's sense of being there in the VE. This is the same as personal presence. (Both social/co-presence and environmental presence were not investigated).

2. **Story Presence:** this was used to refer to the user's sense of feeling like they are part of the story being narrated in the VE. The distinction is that, here we are interested in the extent to which the user feels like they are part of a narration not necessarily the entire VE experience, as in story-telling VEs, the objective is not just involving the user in the VE but mainly in the story [14]. Making this distinction between these levels of presence may help us identify what factors are mostly important to what kind of presence and that knowledge can enable us to pay more attention to areas that are crucial to story-telling VEs. Aspects relating to effective narration are discussed in the next chapter.

In order to enhance the sense of presence in our virtual environments, we first considered factors that have been argued to influence it. An analysis of these factors is presented in the subsection that follows.

2.3.7 Factors Influencing Presence

Quite a number of factors are believed to contribute to the sense of presence. However, some of the factors may depend on the definition of presence used. Below we look at some of the most common factors that are found in the literature and are in accordance with the definition of presence used in this research. We found that most factors overlap and hence can be grouped into the following three major categories:

1. Characteristics of the VE display, i.e., the richness of the sensory stimuli generated by the VE.

2. The ability to interact with the environment.

3. The characteristics of the individual experiencing the VE.

Sheridan [49] identifies three determinants of presence, namely, *a) extent of sensory information* which refers to the richness of the information that is presented to the user's senses, *b) the ability of the user to modify their sensors in relation to the environment*, e.g., ability to perform haptic search or alter one's viewpoint, *c) the ability to change objects in the environment*, i.e., the ability to interact with the VE. Unfortunately, Sheridan does not say and neither does he present any empirical findings to suggest how these determinants can be manipulated to affect presence. Below we look at some of the more explicated arguments as to how various factors affect presence.

An important factor is that put forth by Waller *et al* [69]. They suggest that *fidelity of the interface* increases the user's perceived level of presence. We examine this phenomena in more detail.

Fidelity

Fidelity refers to the degree to which interactions with the VE resemble those of the real world, i.e., when performing a certain task, the user should be able to do it in a manner that they would in

reality. Waller *et al* [69] identify two types of fidelity; environmental and interface fidelity. Environmental fidelity refers to the extent to which the VE resembles the real world. Interface fidelity on the other hand, refers to the degree to which the input and output devices used for interacting with the VE resemble their real world counterparts. An example given is that of using the mouse for walking or riding. The question to ask here is whether this correspondence sufficiently represents the interaction, i.e., does the user really feel like they are riding when they move a mouse? Another example can be that of the devices used in this research, whereby participants had to press keyboard keys to pick objects. So the question here is whether they really feel like they are picking objects. Interface fidelity is normally increased by the use of sophisticated devices such as joysticks, data gloves and haptic props. These devices are however costly, and as firmly stated by Waller *et al* [69], a slight increase in fidelity can be very expensive, therefore a tradeoff has to be made between economic and technological variables. However other researchers such as Bliss *et al* (1997) in [69], have shown that primitive devices such as the mouse for navigation can be sufficient.

In a similar manner, Zeltzer [73] supports the concept of fidelity. He argues that presence is engendered by our ability to affect our world through touch, gesture and voice. He says presence is a lumped measure of the number and fidelity of available sensory modalities. The match between human perceptual and motor performance required for a task should be as close as possible. However this inevitably requires many tradeoffs among cost, performance and efficiency [73]. He also points out that this perfect presence represents a hypothetical future system.

Affordance

Closely related, but different to fidelity, is the notion of affordance. The term refers to opportunities an environment offers to the user [46]. Applying this phenomena to VR, one can conclude that users will perceive VR equipment in terms of what it can offer, or what kinds of interaction it can allow. Schuemie argues that in such cases the mediating technology becomes “ready-to-hand” (quoting Heidegger) invisible to the user [46]. According to Heidegger in [46], the notion of tools becoming “ready-to-hand” means the user is only aware of the usefulness of the tool in the task that they are performing, not the tool itself. The argument made is that VE’s ability to successfully support actions in a similar way to the real-world (i.e., good affordance), leads to high sense of presence. This ecological view seems to be suggesting that the tool used to carry out a certain task is not of high importance, “.. the user is no longer aware of the tool itself but only of the usefulness the tool has ...”. This concept contradicts with that of interface fidelity as importance is not placed on tools used, as is the case with the former idea.

Zeltzer also presents a related concept of *autonomy*. He suggests that autonomy can facilitate the engaging of our senses in the VE. Autonomy refers to the extent to which an object in a VE can react to simulated stimuli. We feel that objects in our VE were highly autonomous as they reacted to the stimuli they received. The same example of picking objects used above, can also be applied to the argument made here, i.e., our objects reacted to stimuli as they moved when picked.

In [59], Steuer refers to technological factors as two determinants of telepresence and labels them *vividness* and *interactivity*, respectively. Interactivity will be discussed with respect to storytelling VEs in Chapter 3.

Vividness

Vividness refers to the ability of the technology to produce a "sensorially rich mediated environment [59]." According to Steuer, rich mediation is dependent on the *breadth* and *depth* of the sensory information presented to the user's senses; breadth refers to the number of sensory modalities simultaneously evoked during the VE experience; depth refers to the richness of the sensory information conveyed by each of the sensory inputs. An example of good breadth is a VE that evokes the touch senses by enabling users to have haptic feedback; evokes the auditory system; the taste-smell and also the visual system, without any redundancy. Depth on the other hand, is described in terms of the quality of the stimuli: "an image with greater depth is generally perceived as being of higher quality than one of lesser depth; the same is true for auditory representation." Depth here refers to the amount of data encoded in the VE.

This notion of depth has been highly investigated by a range of researchers. Some of the most significant investigations include visual properties effects, auditory effects, and tactile effects. Hendrix and Barfield [23] investigated *the effect of visual display parameters* by manipulating head tracking, stereoscopic cues, and field of view (FOV). They found that levels of presence were higher when head tracking and stereoscopic cues were provided, and that more presence was associated with wider fields of view. Ruddle *et al* [42] also found that using helmet mounted display (HMD) as opposed to desktop monitor display, significantly increases the effectiveness of VEs. They attribute their findings to the tracking abilities provided by the HMD and suggest that participants using desktop displays sometimes developed a "tunnel vision" [42]. With respect to pictorial realism, delay of visual feedback, and observer interactivity, Welch *et al* [70] found that realism and interactivity increase presence while delay feedback diminished it. A similar result was also found by Barfield and Hendrix [9] with respect to update rate. They found that higher update rates resulted in higher levels of presence. However, they found that increasing update rates above 15Hz did not make any difference.

Another interesting study is that done by Slater *et al* [55] whereby the aim was to determine the influence of dynamic shadows on presence. They found that for visually dominant subjects, presence increased with the extent of shadow phenomena. They also assert that, from perceptual studies, it is obvious that shadows enhance depth.

In light of the sundry factors of presence, we ensured that our implementation incorporates most of these factors when possible. For example, we ensured that the fire used in both of our VEs (a description of the VEs is given in Chapter 4) cast shadows, to increase realism and enhance depth. Our rendered VE also updated at rates above 15Hz . We also tried to increase pictorial realism by using human-like agents, texturing objects and animating our fire and making it to look 3D by using

billboards. However, we were not able to provide tactile feedback nor tracking due to the expensive nature of the equipment needed for these.

Another factor which can be categorized under vividness is that of user embodiment. The notion of user embodiment is explored further in the next section.

2.4 Users Representation in Virtual Environments

Users' representation in a virtual environment is very important, especially if users have to interact with the VE. Representation of participants is normally via a virtual embodiment called *avatar*.

Benford *et al* [11] argues that an embodiment can indicate which data a user is accessing and the kind of activity the user is engaged in, and that this can be critical in supporting interaction. Heeter [21] also gives an example of a participant who described the experience of watching her self-representation hand within a virtual environment as convincing evidence that she was there. In this research, avatars have been used to represent users' hands as shall be seen in Chapter 4.

2.5 Measurement of Presence

Providing a well-defined measure of presence seems to be a problem in the science of VR. The literature does not seem to offer a unified operational measure [49, 22]. Lombard and Ditton [33] argue that the lack of consensus regarding the definition of presence is one of the reasons that no standard measure of presence exists. This normally ends in many single measures which unfortunately, maybe tailored to particular studies. However, several approaches of measuring presence which are relatively well used still exist. These are:

1. Obtaining self-reported sense of presence from participants:

   This involves asking participants about their experience in the VE normally via questionnaires. This is normally done in one of two ways, i.e., either by asking participants directly about their perceived level of presence, or measuring their perception of attributes believed to cause presence. For example, in the latter case, instead of inquiring about the extent to which they felt present, they may be asked about their level of control, hence assuming that control directly affects presence. The strengths and weaknesses of these two approaches are discussed further in Subsection 2.5.1. In general, however, this class of measurements present several problems as we rely on the participants' ability to remember and this may result in useful information being omitted. Also, because of the subjective nature of these measurements, results may not be consistent across participants whereby different participants may gauge the same feeling differently. The good thing about this class of measures though, is the fact that they obtain the users' mental state and perception of a given stimuli from the user not through inference from some secondary source. Also, it does not disrupt the user's

experience in the VE (a likely destruction to the level of experienced presence) as it is done after the user has finished experiencing the VE.

2. Comparing task performance in the real and virtual environment:

   Here we assume that if a participant performs a task in a virtual environment as s/he does in a real world then her/his level of presence is high in the VE. This measurement is done objectively as compared to the preceding subjective self-report and this may be desirable in that it may be consistent across users. Unfortunately, as pointed out by Slater *et al* [53], the assumption that task performance is directly related to presence may not be necessarily correct as a user's task performance in either the VE or the real world may decrease due to the interface of a device even though the user maybe fully present in what they are doing.

3. Observing users' behaviour when interacting with a VE:

   In this case, measurement is done by noting users' reaction to the virtual world with reference to the real world, whereby the stimuli in the latter is different to the one in the former world. An example similar to the ones given in [50, 49] is that of a bee flying near the user in the real-world while s/he is exposed to a visual cliff in the VE. Will s/he duck away from the bee or is s/he going to avoid falling over the visual cliff? The disadvantage of this approach is that it needs a VE which contain events that invoke strong reactions and hence may not be applicable to VEs without such events. Another problem is that it yields the level of presence as observed by the experimenter as opposed to the perception of the subject as they experience it. The good thing about it is that it measures presence during the VE experience hence eliminating any memory problems. It is also non-intrusive and is not subjective depending on different users.

4. Measuring physiological changes of the user:

   Physiological measurements include the measurement of changes in muscle tension, cardio-vascular responses, blood pressure, respiration rate and so on. These measures as argued by Prothero *et al* [38] are very attractive as they can be administered unobtrusively. Also, because they are objective, they are taken to be more valid [49]. Unfortunately there does not seem to be enough evidence to support the correlation between physiological changes and presence [38]. Another major shortcoming of this class of measurement is that, it is only applicable to those VEs that contain stimuli which elicit physiological changes.

Presence measurement is normally done subjectively by the use of questionnaires given to participants after the experiment. However, as Sheridan [49] points out, objective measures are desirable as well. Unfortunately as discussed above (in user behaviour, task performance and physiological measures), such measures have major flaws and can be limited to certain types of applications. For our investigation, they were found to be unsuitable as our VE did not contain events that needed

extreme reflex actions and neither did it evoke any strong physiological changes. We hence used self-report questionnaires.

2.5.1 Self-report Questionnaires

Although questionnaires are generally used to measure presence, no one standard questionnaire exists. However, a few have gained widespread use and three such questionnaires worth mentioning are *Witmer & Singer (W&S) questionnaire, Slater, Usoh & Steed (SUS) questionnaire* and *Igroup questionnaire*.

Witmer & Singer (W&S) Questionnaire

This questionnaire has been criticized for measuring variables thought to cause presence not presence itself [50]. Subjects give self-report about these factors and a measure of presence is inferred from this. The questionnaire consists of 30 items, each with a differential scale of 1 to 7. The items are grouped into four groups based on control, sensory, distraction and realism factors. Unfortunately, measuring factors of a construct not the construct itself can introduce a lot of noise to the measurement. Furthermore, a total relationship between the factors and presence itself has not been sufficiently established. Also, the operational definition of presence employed by the authors is that it is a function of its factors [50]. This questionnaire hence depends on the definition of presence used, as is the case with most measures of presence. We felt that this questionnaire has many flaws and since we did not use W&S's definition of presence, we did not use this questionnaire.

Slater, Usoh & Steed (SUS) Questionnaire

This questionnaire consists of 6 items (each with a differential scale of 1 to 7) whereby the items introspectively ask the user about their sense of being in the VE and regarding the VE as a place visited as opposed to images seen. The authors of this questionnaire use the same definition of presence employed in this research, which is the sense of 'being there' in the VE. This questionnaire has, however, not been submitted for a formal reliability test by its authors [36]. However it has been shown to measure what it says it measures (construct validity) by several studies, such as those done by Slater *et al* [56] and Usoh *et al* [68].

Igroup Presence Questionnaire (IPQ)

Schuemie *et al* [46] identifies 2 questionnaires which have been shown to be valid (the extent to which a scale measures the construct it aims to measure) and reliable (consistency across different equivalent samples). These are the Igroup Presence Questionnaire (IPQ) and the ITC Sense of

Presence Inventory (ITC-SOPI), whereby the IPQ is specifically designed for VR whereas the ITC-SOPI is for a range of media including VR, cinema and television.

The Igroup questionnaire was constructed from items drawn from various presence and immersion scales, "including almost all possible presence items from the last years" by Schubert, Regenbrecht, and Friedmann [44]. It originally consisted of 75 items which were tested on 246 users. It was then analysed and factored resulting in a smaller scale which was re-tested on 296 users. Further factoring of this latter scale resulted in 8 factors emerging, with 3 describing components of presence, namely:

1. Spatial Presence: the relationship between the user and the VE.
2. Involvement: awareness devoted to the VE.
3. Reality: the realism of the VE.

The authors argue that the first factor describes what is commonly included in the definition of presence; the sense of being in a place. They also state that it is actually the factor with the highest loading. This definition of presence agrees with ours. For our research we used both the Igroup presence questionnaire and Slater, Usoh and Steed questionnaire.

2.6 Summary

In this chapter we have explored the relevant background theory in the literature of virtual reality (VR) which guided the choices made in this research. We presented the various approaches of describing VR, which are either in terms of the technology used or the user's experience, with the latter ideology being used in this research. We hence defined VR as a medium that enables its users to interact with three-dimensional objects in a VE with the intention that users will feel like they are 'there' in the VE and therefore respond to events in the VE in a similar way they would in reality. The notion of presence was discussed along with the conflicting ways in which presence is conceptualized and categorized. The various factors thought to influence presence as found in the literature were reviewed. The importance of user-representation was also explored.

Lastly, the different ways of measuring presence were examined. These include self-report measures, task performance, observing users' behaviour when interacting with the VE, and measuring physiological changes of the user. The strengths and weaknesses of each of these measures were also discussed.

In the following chapter, we review the literature pertaining to San Culture, story-telling and interactivity, and VR potential for story-telling.

Chapter 3

San Culture, Story-telling, and Interactive VEs

In this chapter we discuss the background theory pertaining to San culture, story-telling and VR's applicability for story-telling. A critical evaluation of interactivity (a feature regarded to distinguish VR from other media) in cultural story-telling VEs is also given. Here we look at the challenges one faces when designing such VEs where conflicting limitations have to be taken into consideration. To close the chapter, we look at some of the applications of interactive story-telling.

3.1 Culture

Human beings are cultural beings who experience culture as a dynamic process which is not timeless, but is affected by social changes [28]. Due to these social changes, cultures may disappear. One such culture, in South Africa, is that of the San people [31, 19], hence preserving and presenting this culture is desirable. As mentioned in Chapter 1, the San people are well-known for their widespread use of stories, hence in this project, we have chosen to present their culture via story-telling in a VE.

In the following section we give an in-depth discussion of some of the important features of story-telling, while paying particular attention to San story-telling.

3.2 Story-telling

Stories are a rich heritage of human civilizations and form an important part of our lives [20]. At present, story-telling is being revived in an effort to preserve art and culture, and is gaining popularity [64]. Various kinds of stories exist and the following categories of stories can be identified [65]:

- Folk Stories - stories which normally contain supernatural elements and are usually about real or imagined ancestors.
- Historical Stories - stories about cultural and social history of a given society and its contacts with the rest of the world.
- Mythology - stories which explain origins, natural phenomena, social or religious practices. This type of stories often involves supernatural acts.
- Personal Experiences - these stories often tell us about acts of a significant event in the lives of a certain community or the narrator, and hence depict the way of life of a particular community. For this research, we employed a story from this category whereby, a story on hunting based on personal observation was used.

3.2.1 Importance of Story-telling

Since ancient times, stories have been used as a means of communication and sharing experiences. Some of the benefits of stories as discussed in [64] are:

- Stories were used to explain the world that people live in.
- Stories were ways to honour or appease religious beliefs and other supernatural forces.
- Stories were used as a method of communication and of sharing experiences.
- Stories helped to understand others and helped groups to become compassionate and capable of appreciating other people's way of life.
- Story-telling were used as a form of entertainment.
- Stories present an aesthetic of beauty, language and rhythm of a culture.

The importance of story-telling is similarly echoed by several other researchers. In their paper, Umaschi *et al* [63] state that narrative is the primary form through which we give meaning to our experiences. At the individual level, a narrative of our own lives enables us to understand our role in the world, and at a cultural level narratives give consistency on shared beliefs and cultural values. Umaschi *et al* argue that narratives serve at least three vital functions [63]:

1. A cognitive function: Personal stories are the main constituents of human memory and provide intuitive understanding.
2. A social function: Stories define a social group or the culture that one belongs to and provide continuity between generations.
3. An emotional function: Story-telling is normally used in psychotherapy and hypnotherapy, also, it has been shown that children not only find recreation but also find self-cure in stories.

Mazalek *et al* [35] also emphasize the importance of story-telling to human culture both in education and entertainment by arguing that story-telling enables us to learn about our society and history – whereby creating stories, structures our perception of the world in a form that can be passed to other people.

In [12], Berthelot emphasizes the importance of stories by stating that since the most primitive campfires and throughout history, stories have helped educate, influence and bind people together. She argues that stories have helped in the understanding of others, of self, and of life, which is fundamental to progress. She however points out that story-telling is dying out and is now becoming limited to commercial productions and personal stories are now confined to the psychoanalysts couch.

3.2.2 Story-telling and San Culture

The San people distinguish two types of stories; true stories and 'stories that are not true'. True stories are comprised of hunting stories, plant stories and healing stories. These stories are didactic in nature and among other things "*advise men on how to hunt*" [29]. *Yeu*–songs, a particular sub-type of true stories serve to invoke the ancestors for help to treat diseases. True stories are normally told by experienced hunters, women that are used to gathering food, and healers [29]. Conversely, 'stories that are not true' are narrations that fall under the term folktale. *Yuceregu* a term used for 'stories that are not true' in some San groups, include the following three genre [29]:

1. Fables: Most fables are about animals, but in some stories there are also human beings involved. Generally, fables deal with social behaviour, i.e., they instruct people on how to behave with other people or in dangerous situations. Fables are not only didactic in the European sense but are also explanations for the necessity of the creation and the existence of social laws which did not exist in earlier times [29].

2. Legends: In these stories, known as *Karakarani*, the Kxoe hero stands for the most clever of human beings, and in almost all the stories he demonstrates how to survive dangerous situations.

3. Creation myths: These type of tales explain the creation of all living beings, humans, clans, the different tribes, but particularly the creation of animals from human beings [29].

From the different categories of stories, it is clear that the San used story-telling a lot [1] hence it makes sense to convey their culture in the form of story-telling even in the present day. However, the old way of conveying stories by word of mouth around the fire is no longer practical. This is where VR can have a place.

[1] Although most of the mentioned characteristics of San stories are from the Kxoe San group, it was found that similar stories also exist with other San groups such as the —Xam group and the Nama/Damara group [29].

3.3 VR and Story-telling

VR enables the re-construction of scenes that no longer exist, making it ideal for presenting a culture such as the San's, which is fast becoming extinct, as the traditional social setting can now be re-captured. However, a number of considerations have to be taken into account when using VR.

According to Roussou [40], VR has been mostly focusing on the technical aspects of creating objects and spaces in the VE, rather than on the stories that tie them together. She adds that this may be due to the fact that VR is still uncharted territory and its use as an artistic and cultural medium is still largely unexplored. In [14], Brooks suggests that when designing computer based story-telling systems, answering the following questions can help guide the research:

1. How do computational processes assist in the presentation of the stories?
2. What computational processes can affect different presentations and experiences of a story?
3. How does the user's input affect these processes?

We look at these questions and present the insights they provide.

3.3.1 Presentation of Narratives

Telling a story involves what to tell and how to tell it [14]. The choice of which medium to use is hence imperative, as different media offer both the author and the listener distinctive ways in which to create and affect a story. Herein lies the definitions of narrative and narration, whereby narrative refers to the organization of information, while narration refers to the manner in which that organization is expressed. Eco in [61] states that a narrative mostly contains unsaid things and the user is in charge of constructing the story from the pieces s/he is given. Through the evolution of story-telling, we have evidenced additional factors to the content of the story, being used to enhance narrations. Since the time when stories were told around the fire by old people up to present, sounds and music are now used to complement speech, theatrical sets are now used to enhance the story and actors in the story are now being used to replace the "lone story-teller" [8]. Instead of just being passed on by word of mouth, stories are now being realized in books, theatre, movies and television, and the advancement of technology has led to new ways of story-telling, such as using virtual environments [8].

The use of VR in this project enabled us to present our narrative - steps in arrow-making (see Appendix G for full account of the story) - in a richer manner via various complementary techniques: the traditional setting of telling stories around the fire was constructed; traditional San music was used in the background to increase authenticity; an appropriate social setting of a desert, which is where most of the remaining San people are found, was modelled; users had the chance to carry out actions depicted in the story if they so wished, as the story used was a hands-on story of completing a certain task. Some of these features could also be achieved via other media such as

video but sometimes with a great deal of cost, e.g., using an appropriate social setting could mean actual construction of scenes that no longer exist, hence VR assisted in the easier development and presentation of the story. Also, interactivity could only be realized through the use of VR.

3.4 Interactivity and Narrative in VR

Roussou [40] states that interactivity is the raison d'etre of VR, and suggests that interactivity promises an experience of something you do rather than are given. As Wright [72] argues, virtual reality is fundamentally different from other media because of interactivity, hence the viewer is not passive but pro-active and able to change the course of events. The combination of interaction and immersion provided by virtual reality makes it a good medium for cultural productions, and although it provides new challenges it also provides new opportunities [7]. Besides providing designers with absolute freedom for designing three-dimensional objects which one can interact with, VR also has limitations; on one hand designers are presented with an almost limitless canvas in which they can produce a visual effect and offer interactivity, while on the other we have a computer that can only render so many polygons and textures with a limited speed [7]. Moreover, when dealing with story-telling environments, the challenges are amplified by the fact that interactivity presents the user with an undesirable flexibility to change the story-line, hence may alter the story intended for them by the author.

A deeper review of the literature seems to suggest that there is a threshold level up to which interaction is advantageous, and beyond which it may be detrimental. In light of this, several researchers [20, 28] have suggested guiding and facilitation of the user in interactive story-telling VEs, to ensure that while the user interacts with the VE, the original message intended by the author can still be communicated.

3.4.1 Facilitation and Guidance in Interactive Story-telling VEs

The ability to interact with and feel present in an environment, provided by virtual reality, is a good opportunity for presenting culture to people who might not necessarily be of the same culture. However, as Jackson *et al* [28] argue, guidance is required in such environments. According to Jackson *et al*, "sophisticated facilitation for guiding and engaging the user in experiencing the environment is taking form of *interactive story-telling*". The importance of virtual reality and the need for guidance is also further emphasized in [20]. Here Greeff *et al* state that virtual environments are much richer both in terms of navigation and interaction, "however guidance is also needed in these environments in order to support the user during the exploration and facilitate the understanding of the purpose and the intention of the particular virtual environment" [20]. The idea of facilitation seems promising and was employed in this research.

Jackson *et al* indicate that facilitation can be achieved by the use of real life interaction metaphors

to guide the user on how to use and interact with the environment in an intuitive way. The example given here is that of a VE modelling a traditional Zulu [2] court whereby taboos and societal rules prohibited young boys from doing certain things, such as stabbing with an ikwla [3]. In that environment, unless provided with other cues and content, the boy would not be able to experiment with the role of a Zulu warrior who can stab with an ikwla [28]. In this research, facilitation was done by telling the story in parts, whereby the user could only hear the latter parts of the narration after they were done with the previous ones. The user was also prompted by the story-teller to perform the actions they had just listened to in the part that had just been narrated to them. However it was still possible for the user to choose to not follow the prompts (which were given both in audio and text) and any of the cues given to them. In that case the environment was made to behave realistically (details of the VEs which we used have been given in the next chapter), however regardless of the facilitation measures taken, the possibility that the story-line could be broken could not be totally guarded against.

3.4.2 Problems of Interactivity in Story-telling VEs

Despite the many advocates of interactivity [7, 72, 28], several researchers such as Glassner [18], Roussou [40], Clarke and Mitchell [17], do not support the idea of interactivity in story-telling systems.

Roussou argues that realistic simulation together with a fascinating story seem to be all that is needed to elicit the illusion of meaningful experience in a story-telling VE. She argues that interactivity can yield an experience that is disorienting, unnatural and difficult to become part of, even if the technology used is relatively simple. Glassner claims that people typically enjoy stories passively. Although we think that this statement is too encompassing and hence not necessarily true for every story which exists, Glassner gives some insightful reasons for this strong assertion. He argues that the author should be responsible for the sequencing and timing of major plot events and the example he gives is that of a kidnapping story. He shows that in such a story, it is important that the victim is kidnapped before the police go searching for them.

Greeff *et al* summarize these problems into four categories as follows [20]:

1. **Character's Knowledge of the Story-world:** this refers to the user's lack of knowledge about the events of the story-world. The knowledge can be incorporated in the story so that we acquire it through facilitation.

2. **Internal Consistency:** at any point in the story, the events of that specific point must be in line with whatever events happened before. However, the core of interactivity is freedom and hence this gives rise to conflict as the user desires to do as he chooses and the author tries to

[2] one of the prominent cultures of South Africa.

[3] a bladed weapon invented by the legendary leader of the Zulu - Shaka.

impose a given characterization on the user. The challenge is hence to ensure that the user's high degree of freedom is combined with the story in a consistent way at every stage.

3. **Narrative Flow:** This refers to the difficulty of ensuring that when a dramatic climax occurs in the story, the user is ready for it and not busy interacting with other unrelated parts of the story. This problem is normally solved by limiting the interactivity such that the user cannot stray away from the plot. This solution obviously takes away some of the power of interactivity but may solve the problem. Sometimes the problem is solved by advancing the plot along the user's advances. However, as Greeff *et al* [20] point out, this solution is mechanistic and implies that the story will only progress when the user performs the right actions.

4. **Ease of Creation:** here Greeff *et al* argue that one of the main problems of using interactive story-telling VEs is the difficulty in creating an interactive story.

3.4.3 Challenges with VR as a Whole

Some of the problems of VR as applied to interactive story-telling virtual environments as identified by Alborzi *et al* [6] are as follows:

1. Costly haptic props are normally needed to develop interactive virtual environments.

2. There might be limited access to technologies presenting these virtual story environments.

3. It is complicated to program or author interactive story environments.

Also, as applied specifically to African art and cultural systems, most of the models needed for a realistic and convincing representation are not geometric as may be the case with western artefacts, but involve complex difficult-to-model structures. For example, the huts the San people used to live in or the fire setting which is representative of their social setting.

3.4.4 Interactive Narratives Applications

Because interactive narratives are still largely unexplored, most of the systems that have been developed are still in the research stages and empirical findings pertaining to these systems rarely exist. Below we look at some of these systems, namely *'The Thing Growing'* described in [7] and the *'Cato Manor'* system described in [20].

The Thing Growing [7] is an interactive narrative whose authors declare that it could only be fully realized in VR. The narrative consists of three acts whereby in each act, the user is involved in an interactive activity. The narrative progresses to the subsequent acts either as a result of the user's choices or by time. The user is prompted to perform certain actions, like opening a box in the

first part, by voice. The following parts involve 'the Thing' teaching the user to dance and the user is asked to perform the dances by the Thing. The Thing always tells the user what to do and this guides the user along the plot. At the end there are two endings according to what the user chooses to do, however each of these alternatives allows a meaningful end to the story.

The Cato Manor [20] story world is a shebeen (township tavern) in Cato Manor (a place which was destroyed during apartheid in South Africa). The authors created three identities, namely a shebeen owner, a Zulu man, and a Zulu boy and the user was allowed certain interactions according to the identity they chose to explore as. For example, while assuming the identity of a Zulu boy, the user's view would be lowered. Also the boy could click on things and move cups around, but was not allowed to drink from them, whereas the Zulu man could drink from the cups.

Unfortunately both of these applications do not present any empirical findings. The authors of *Cato Manor* state that they have demonstrated this application with promising results. The authors of *the Thing Growing* state that feedback from users lead them to believe that users do become involved.

3.5 Summary

In this chapter we have examined issues surrounding culture, the importance of story-telling specifically to the San Culture, and the role of VR in story-telling. Along with VR, we explored the notion of interactivity (arguably the crux of VR in comparison to other conventional media such as books, video and so on). We looked at the weaknesses and strengths of interactivity in relation to narratives. We also discussed some of the tactics that are being used to solve the problems presented by interactivity. To conclude the chapter, we discussed some of the examples of interactive narratives that exist. In the next chapter we describe the approach that was taken in this research. We also present the considerations that had to be made in light of the literature that was outlined in this chapter and the preceding one. The design of the virtual environments used for our studies is also described in the next chapter.

Chapter 4

Hypotheses, Methodology And VE Design

The main aims of this research as described in Chapter 1 were: first, to explore the feasibility of interactive cultural narratives by testing the effect of interactivity on users' presence in the story-telling VE, and on their presence in the story being narrated; second to test if priming has an effect on presence in the VE and on presence in the story; third to test if combined interactivity and priming has more effect on presence in the VE and on presence in the story, as compared to either one of these factors alone; and fourth to investigate the relationships between presence in interactive story-telling VE, presence in the story, and enjoyment. To investigate these areas of interest, various studies were carried out. This chapter outlines the approach that was taken (i.e., the strategy used to investigate our aims and the hypotheses involved and the description of the virtual environments used). The considerations that had to be made while developing our methodology are also presented.

4.1 Hypotheses

In order to test our first aim, as discussed in Chapter 1, the following hypotheses were developed:

1. *Enabling users to interact with a story in a story-telling VE can positively affect presence in that VE if facilitation and guidance are used.* Interaction is in the form of carrying out actions depicted in the story, by pressing keys on the keyboard. The user is expected to carry out the actions after they have been prompted to do so by the narrator. However, with the flexibility offered by interaction, it is possible that they could perform actions different from the ones they have been prompted to do. This idea has been discussed in Chapter 1 and the possible solutions will be discussed later in this chapter.

2. *A virtual story-telling environment that allows its users to interact with the events in the story being narrated, can positively affect the extent to which users feel they are part of that story*

(i.e., their presence in the story).

In order to test our second aim, the following hypotheses were developed:

1. *Priming participants before they enter the virtual environment can have a positive effect on presence in the VE.*
2. *Priming participants before they enter the virtual environment can have a positive effect on presence in the story.*

To test our third aim, the following hypotheses were developed:

1. *Combined interactivity and priming positively affects presence in the VE more than either one of these factors alone.*
2. *Combined interactivity and priming positively affects presence in the story world more than either one of these factors alone.*

In order to test our fourth aim, the following hypothesis was developed:

1. *Users are more likely to enjoy the overall experience in the VE, if they feel present in the VE and/or in the story world and vice versa.*

4.2 Methodology

To achieve our aims, the following methodology was used:

1. The San culture was chosen as the African culture to be used for our cultural story-telling VE, as discussed in Chapter 3.
2. A San story (titled *Arrow-Making*) to be narrated in the VE was then selected. The story is discussed further in Section 4.2.1.
3. Hypotheses were identified from our aims and these have been discussed in Section 4.1 above. The variables involved (described in Chapter 5) were identified from these hypotheses.
4. Two environments (described in Sections 4.3, 4.4 and 4.5) to provide the different scenarios needed to test the possible combinations of the identified variables were story-boarded and developed.
    (a) To investigate interactivity, it was decided that one environment would not involve interactivity with the story world and the other environment would allow interaction with the story world. In the sections that follow, when we talk of interactivity we are referring to the ability to carry out actions involved in the story. We refer to the ability to move through the virtual environment as navigation not interactivity.

(b) To investigate priming, it was decided that before experiencing the virtual environment, some subjects would read a story related to the San culture (relevant priming material) while others would read a story which is unrelated to the San culture (irrelevant priming material).

5. Experiments (described in Chapter 5) based on these environments were then conducted.

Issues relating to the methodology used, are detailed in the subsections that follow, after which the actual implementation of the virtual environments is discussed.

4.2.1 Considerations

When developing our methodology, certain considerations had to be taken into account. These included selecting a suitable story to be told. For this, a story on arrow-making was chosen. Also, due to the high prices of sophisticated devices needed for high fidelity, a low fidelity interface was used. However, affordance was ensured by successfully supporting actions in a similar way to the real world, e.g., when the user picks an object the object's position is changed to where the user is picking it to. Also, the story was narrated in an appropriate social setting, i.e., the desert, which is where most San people are found. Figure 1 shows the different views of the modelled desert and the surroundings.

Figure 1: The above figures show the different views of the desert and the surrounding scenario used in our VEs.

The Story: *Arrow-Making*

The Arrow-making story (compiled in March 1879) was taken from the book *Stories that Float from Afar* [31], pg 103. *Stories that Float from Afar* is a collection of San stories as narrated by the San people then translated to English. The chosen story reflects the San people's way of life as it details the steps involved in making the arrows they used for hunting. In the story, the narrator explains that

they would fetch and cut up the reeds used for arrow-making. They would then remove the extra pieces from the reed and then straighten it using a hot stone. Then the reed would be warmed by placing near the fire and would afterwards be poisoned with !kuai juice. A feather was then attached to the reed and left to dry. Then they would warm an arrow-head near the fire and thereafter poison it with !kuai juice. The arrow-head would then be left to dry and afterwards be attached to the shaft. This story was highly suitable for our purposes as it a 'hands-on' story which involved actions which the user could perform and hence interact with the story.

The next sections describe the two virtual environments that were used for our experiments.

4.3 Virtual Environments Design

The layout of our environments was based on the events depicted in the story and the San people social setting. Ideas concerning interactivity and priming were discussed with some of the researchers in the field of Virtual Reality and Psychology. Cultural content was decided on, in consultation with Contemporary Arts and Music Archives (CAMA) [2].

The events that had to be done in each of the environments were dictated by the Arrow-Making story and the hypotheses. Story-boards were used for determining the exact sequence of events in each environment.

4.3.1 Non-Interactive VE Design

In the non-interactive environment, the events were straight-forward as the user sat and passively listened to the story without carrying out any of the actions mentioned in the story. In this environment, the user was greeted by the narrator and was asked to follow the narrator to the fire, as shown in Figure 2.

When they got near the fire, the user could hear traditional music playing in the background. They were then asked to sit down and were introduced to other agents already sitting around the fire (see Figure 3).

These agents would then respond accordingly, and the narrator would then sit down and start the narration. Figure 4 shows the view of the user as the narrator tells the story.

Once the narration started, the agents and the narrator would do actions like nodding and shuffling to make the experience look realistic. From this point onwards, the user did not do much besides listening to the story. Upon completing the narration, the narrator then notified the user they had finished.

4.3.2 Interactive VE Design

Events in the interactive environment were quite complex, as the user had to be able to interact with the story. The events involved from the beginning up to the stage where the user is introduced were similar to the ones in the non-interactive environment. However, after the user had been introduced

Figure 2: The narrator greets the user and asks him/her to follow him to the fire.

to other agents around the fire, s/he had to be able to perform actions mentioned in the story. Hence in this environment the narration was given in parts as opposed to the continuous narration used in the non-interactive environment. After each part was narrated, the user would be prompted to carry out the actions involved in that part in order to ensure internal consistency. The following example illustrates a typical part which was narrated to the user and the prompt (given both in audio and text) that told the user what they could do (this excerpt was taken from the first part of the narration together with the subsequent prompt).

The first part of the story:

We go fetch reeds, to cut reeds. We bring the reeds and bind them up with cord. We put them in the net and take them to the hut. We go and divide up the reeds at the hut. We straighten the reeds. When the arrow is like this, we are accustomed to scrape them and remove the reed's [extra pieces]. We take the reed and put it near the fire.

The prompt that followed:

To put reed near the fire press the letter K on the keyboard.

It is very important to highlight at this point that the user could choose to not carry out the prompted action and perform a different action instead. Therefore designing the sequence of events in this environment was fairly complex, as the story-line was not entirely linear but depended on the

Figure 3: This figure shows the narrator introducing other agents already sitting around the fire.

actions that the user chose to carry out. To solve this problem, we used a state flow diagram (see Figure 5) to list the possible actions which the user could perform after each prompt, and ensured that the environment would still behave in a natural way even in the case where the user did not do what they were prompted to do. For example, if instead of performing the following actions in the order given below, the user were to perform them in a different order, the environment was such that, that would be handled appropriately and convincingly.

The order as dictated by the story was as follows:

1. pick the shaft and place it near the fire.
2. pick the feather and attach it to the shaft.
3. pick the arrow-head and attach it to the shaft.

All the possible actions which the user could perform based on the above-required actions are shown in the state diagram. The shaded areas show the states which were crucial if the user did not follow the prompt; for example the user needed not place the feather near the fire before placing the reed. Failing to do so resulted in the feather shrinking.

The above design was quite robust as even if the user did not complete the task of making an arrow, they could still see the results of their chosen actions being reflected properly.

Figure 4: This figure shows the view of the user as the narration is given.

In the actual VE, if the user did not do the desired action, the narrator would give the user another cue to do it, after which case if the user had still not performed the action, the narrator would continue to the next part. However, if the user performed a different action instead, a text message informing them that they were ought to perform that action at a later stage was given.

Figures 6, 7 and 8 show the different steps as the user makes an arrow: Figure 6 shows the user's hand as the user moves the shaft closer to the fire; Figure 7 shows the user as they attach the feather with one hand while supporting the shaft with the other; Figure 8 shows the completed arrow, on the white stone.

4.3.3 The Sound Used

The sound used for the narration was recorded as one file for both environments. This was to ensure that the sound used in both environments was identical hence no extraneous variables were introduced. For the interactive environment however, this sound had to be broken into parts, as the narration was given in parts. Additional sound files were also used in the interactive environment for the prompts. To make the virtual environment more authentic, ambient sounds in the form of San traditional music were also used.

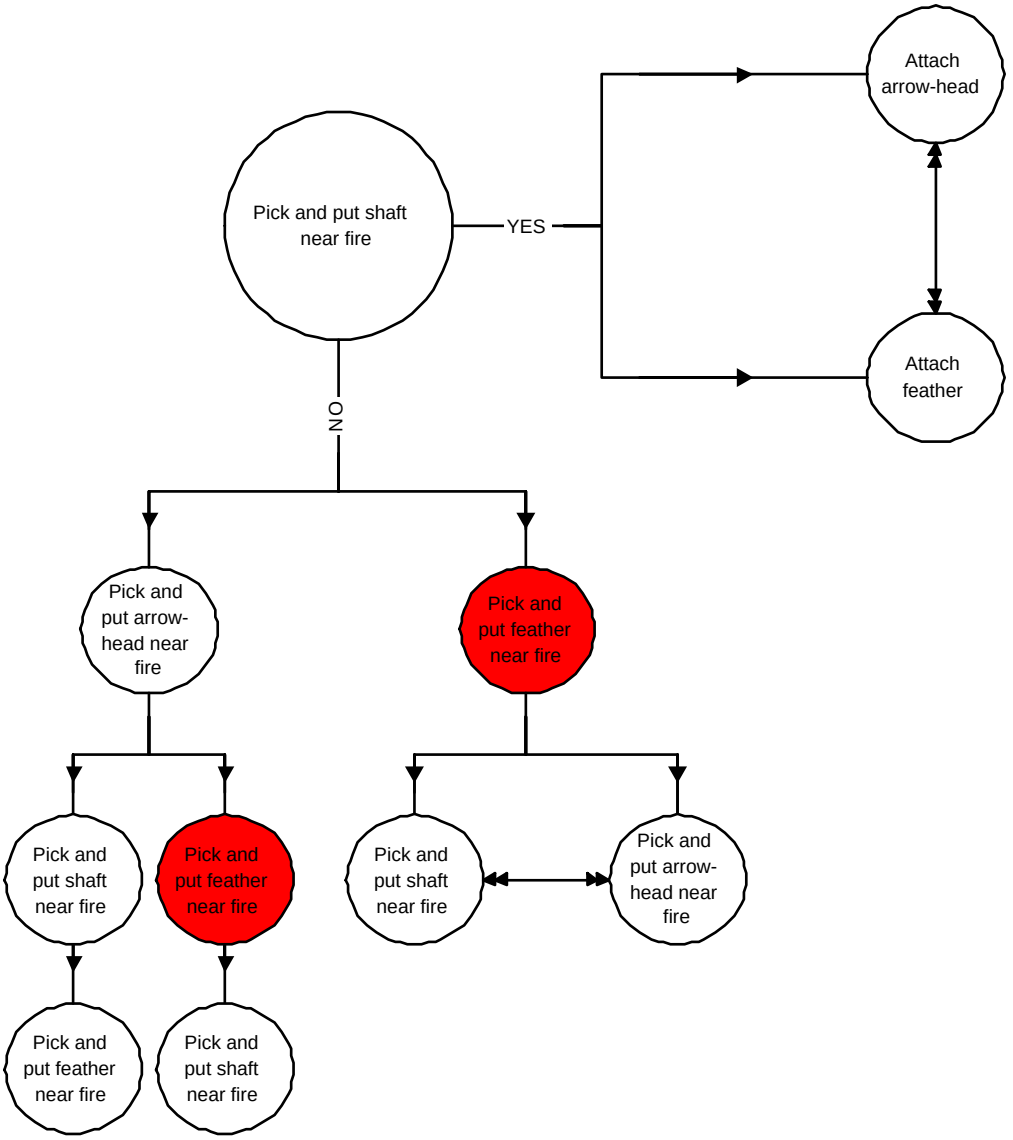


Figure 5: A state diagram showing the different events that could take place in the interactive VE. The shaded areas show the states which were crucial if the user did not follow the prompt.

4.4 Creating Entities in the Virtual Environments

The virtual environments described in the preceding section were created using Genesis3D engine. Genesis3D is a game engine which enables the creation of a map containing 3D objects, rooms, sky boxes, textures, lights, a camera and actors. Once the entities have been created, the functionality of these entities is implemented using methods provided by Genesis3D engine and Visual C++.

Figure 6: This figure shows the user's hand as the user moves the shaft closer to the fire.

Figure 7: This figure shows the user as they attach the feather with one hand and supporting the shaft with the other.

Figure 8: This figure shows the completed arrow.

4.4.1 Creating the Basic Layout of the Environments

GenEdit Classic [1] was used to create a skybox which formed the world (basic layout) of the virtual environment. A skybox is basically used to define the terrain and the landscape of the virtual environment. Since our environment was based outdoors, the skybox modelled the sky, the desert and the mountains, as shown in Figure 1. Skyboxes use a texturing algorithm which prevents parallax and give illusion of great distance. Once the skybox was created, logs for the fire, the hut and stones for agents to sit on, were created, also using the GenEdit Classic editor. These objects were then textured accordingly with some wood and stone textures to increase realism. These entities formed the basis of our virtual environment without the fire, the agents and the objects used for making the arrow.

4.4.2 Creating other Objects

Apart from GenEdit Classic, Genesis allows the creation of objects using 3D modelling software such as 3D Studio Max and Milkshape, making it very robust. Hence for the shaft, the arrowhead, the feather and the musical instrument, which could not be created realistically in GenEdit, 3D Studio Max was used and these objects were then exported to Milkshape in *.3ds* format and

[1] GenEdit Classic is an editor provided by Genesis3D.

exported as *.bdy* files which could be used to create actors (*.act* files) which are read by Genesis. Once the objects were read, they were textured using Genesis functions.

4.4.3 Creating the Agents

Agents plus their motions and poses were created in Character Studio and exported into ActorStudio, which in turn outputs .act files to be read by Genesis. Character Studio is a specialized 3D Studio Max plug-in designed for creation of human-like figures with accompanying realistic motions and poses. Character Studio allows free-form animations providing the designer with the flexibility of creating desired motions (e.g., walking, nodding, etc). Although the internet offers freely available models, these could not be used as most of them are game-like models and even those which are human-like do not resemble the San people. Once the agents and their motions were created, they were then textured with images of faces which resemble the San people as can be seen in the preceding figures (e.g., Figure 2).

4.4.4 Creating the Hands Avatar

The objects used in the two environments were similar except the user's hands (hand avatars) used in the interactive environment. To make sure that the hands were at the right position, an avatar representing the user was used (this was later removed as the user was not supposed to see his/her representation). This avatar gave us the exact position of the user in the environment, so that whenever the user needed to pick objects, we could know where to place the hands avatar.

4.4.5 Making the Fire

Modelling realistic fire meant the fire had to have animated flames, an accompanying fire sound and flickering shadows. This can be quite complex to do in virtual environments. However, for our environments, it was very important that the fire was realistic as the whole story-telling scenario was based on people gathered around the fire (see Figures 4 and 6). To make the flames look realistic and three-dimensional, we used animated billboards of fire images, and made the flames slightly transparent. We then placed a 3D fire sound in the centre of the fire source and ensured that this sound attenuated with increasing distance. A dynamic light (moving around quickly) was used and the objects around the fire cast shadows, hence making the flickering more visible.

4.5 Implementing Functionality in the Virtual Environments

Once all entities had been created, the events presented in the design section (Section 4.3) were then translated into the virtual environment. This meant that the user had to be able to carry out the desired actions, and the agents and the objects had to have a certain degree of autonomous behaviour, i.e., they had to have the ability to act and react to simulated events and stimuli as opposed to being

passive geometric models. The behaviour could depend on the user input or be automated. The functionality and behaviour of the entities were coded in Visual C++.

This section describes the basic structure of the functionality involved in our environments.

4.5.1 The Basic Structure

The overall logic followed is outlined below. While our program had not exited, the following steps were continually repeated:

- The user's input was obtained where applicable.
- Any other changes involving the entities in our VE, between the previous frame and the current frame were then calculated.
- The dynamic entities were then updated with the changes.
- The VE, reflecting all the changes, was rendered.

4.5.2 User Input and Automation of Events

The user's mode of input was only through the keyboard and mouse. To begin, the user had to press the keyboard and this changed the mode of the narrator to a talking mode in which case, the narrator greeted and asked the user to follow him to the fire. The narrator's mode then changed to walking, in which he followed pre-calculated waypoints and stopped when he was close enough to the fire. Navigation keys could be used by the user to follow the narrator. Updating the user's position meant updating the camera position relative to the camera view direction. To change the view (i.e., yaw and pitch), the user could use the mouse.

Once at the fire, the narrator's mode changed such that he could instruct, with the appropriate sound and gesture, the user to sit down (see Figure 3). The user's view was then lowered after sitting. Continually, the narrator checked the user's state so that once the user had sat down he could introduce other agents. From this point onwards, in the case of the non-interactive environment, the agents around the fire and the narrator performed pre-determined actions like sitting, nodding, shuffling and so on. In the interactive VE however, the narrator was made aware of the user's input so that he could determine whether he should move to the next part of the narration or give more cues. He also informed other agents about when to nod or shuffle. Also, the objects used in the making of the arrow had to react to simulated events like being picked or moved. To ensure that the user did not go through objects and agents, collision detection was used.

This chapter presented the hypotheses involved in our study. It also described the overall strategy used in trying to investigate these hypotheses. This included the considerations and decisions that had to be made to ensure that all our areas of interest were investigated. Challenges that were faced

when designing the virtual environments were also examined and the details of the modelling of the virtual environments were presented.

In the next chapter we describe the design of the experiments that were carried out. These experiments were based on the virtual environments described in this chapter.

Chapter 5

Experimental Design

This chapter describes the experiments that were conducted to test the hypotheses put forth. In this chapter we revisit these hypotheses and re-state them in terms of the constituent variables. The first section (Section 5.1) gives a concise description of the variables, distinguishing between the independent and dependent variables and re-states the hypotheses in terms of these variables. The design of the experiments is given in Section 5.2 and the pilot runs that were performed are described in the Section 5.3. The method that was used, which explains how we went about recruiting subjects and what materials were used for our experiments, is described in Sections 5.4 and 5.5. Section 5.6 describes the experimental procedure. Here we present the procedure which participants were expected to follow in the experiments. Section 5.7 outlines the way in which data was collected and lastly, Section 5.8 gives the summary of the chapter.

5.1 Description of variables

Five variables were identified from our research questions; two independent and three dependent. The independent variables are *interactivity* and *priming*, while the dependent ones are *VE presence*, *story presence* and *enjoyment*.

A short description of each of the variables is given below. The corresponding codes used in the analysis of the results (presented in the next chapter), are given in brackets.

- *Interactivity* (INT): This independent variable refers to the ability to carry out events depicted in the narration being given in the virtual environment.
- *Priming* (PRIM): This independent variable refers to creating a certain awareness and readiness to experience a certain kind of event.
- *VE Presence*: This dependent variable (dependent on interactivity and priming) refers to the extent to which a participant feels they are part of the virtual environment. Two separate measures were used to yield the presence score, namely:

  - Igroup questionnaire (IGTOTAL) (included in Appendix D).
  - Slater *et al* questionnaire (SLATOTAL) (included in Appendix E).

- *Story Presence* (STORYPTOTAL): This dependent variable refers to the extent to which the user feels they are part of the story world. Story Presence also depends on interactivity and priming.
- *Enjoyment* (ENJTOTAL): This dependent variable refers to the level of enjoyment experienced by the participants. It may not necessarily be directly dependent on our two independent variables (priming and interactivity) but can be related to VE Presence and Story Presence.

5.1.1 Hypotheses

Below are the hypotheses expressed in terms of the variables presented above:

1. Interactivity in cultural story-telling virtual environments, can positively affect VE presence if facilitation and guidance are used.
2. Interactivity in cultural story-telling virtual environments, can positively affect story presence if facilitation and guidance are used.
3. Priming positively affects VE presence.
4. Priming positively affects story presence.
5. Combined interactivity and priming in virtual environments, positively affects VE presence.
6. Combined interactivity and priming in virtual environments, positively affects story presence.
7. Enjoyment is co-related to VE presence.
8. Enjoyment is co-related to story presence.

5.2 Study Design

Our experiments were run under the conditions explained in Chapter 1. A 2x2 factorial design was used, and Table 1 presents this design.

When designing the experiments, certain issues arose. The design considerations that were taken into account are as follows:

	PRIMING	
INTERACTIVITY	*Priming Present*	*Priming Absent*
Interactivity Present	Both	Interactivity and No Priming
Interactivity Absent	Priming and No Interactivity	None

Table 1: Factorial Design of the variables involved.

- Each participant experienced only one of the four conditions outlined above to ensure that extraneous variables like the learning effect, which might have unforeseen effects on the results, could be eliminated.
- Also, to reduce reactivity effects (participants trying to guess what was being tested and hence reacting in a certain way), participants were not made aware of any conditions apart from their own.
- To ensure that participants gave their honest opinion about the experience, it was explained to them that their information was not going to be used in any personal way and that they should not fill in their names when filling in the questionnaires.
- A preliminary practice environment was designed and this was used to familiarize participants with the technology being used. Participants had to explore this environment before they could go through with either one of the virtual environments designed for our research.

5.3 Pilot Runs

To ensure that experiments ran smoothly, pilot runs were carried out. Here several students were used (their data was not used in the final analyses) and their comments resulted in the following changes being made:

- Pressing the keyboard to start the virtual environment was incorporated. This, as suggested from the pilot runs, was to make sure that the environment only started when the participant was ready.
- More animations like shuffling and nodding were added to the agents. It was suggested that once the narration had started, the scene looked pretty static so more animations could be added as the few which were present made the VE look more realistic.
- Bugs were also identified and were fixed.

5.4 Method: Participants

The participants were paid volunteer students from the University of Cape Town. A total of 67 students from various courses were used. The participants were broken down into four groups; 3 groups of 17 participants per group and 1 group of 16 participants. The participants were recruited by visiting lectures and putting posters around campus. Timesheets were passed around in the lectures, and participants filled a time that was appropriate for them and their contact details. The same timesheets were also placed outside the experiment room to allow other volunteer student to fill in their details. On completion of the experiment, participants were paid R20 to thank them for their time.

5.5 Method: Materials

5.5.1 Experimental Setting

Experiments were conducted in a quiet partitioned room allowing two experiments to run concurrently. The experimenter was available at all times to provide assistance if needed.

5.5.2 Hardware

The hardware specification of the computers that were used are as follows (where two options are given it means the specifications of the machines differed):

- Processor: Intel Xeon 1700MHz
- Memory (RAM): 1.2GB/2.25GB
- Graphics Card: GeForce4 Ti 4600
- Hard drive: 17GB/(2*17GB)
- Size of Monitor: 21 inches
- Sound Card: SoundMax Integrated Digital Audio/Creative AudioPCI (ES1371, ES1373) (WDM)

5.5.3 Priming Material

Two stories, of approximately the same length (one was 432 words long and the other 445 words long) were used as our relevant and irrelevant priming material. The priming materials have been discussed in Chapter 1.

5.6 Experimental Procedure

This section describes the procedure that participants had to follow in the experiments depending on the condition that was allocated to them.

5.6.1 Instructions

Upon arriving for their experimental session, participants were given an instructions sheet (included in Appendix A). This sheet explained the procedure that they had to follow. In this sheet it was explained that participants would explore two virtual environments; the first one used for familiarizing with the technology and the second being the actual story-telling environment used for our study. The sheet explained which keys and mouse positions the participants would need to use in the virtual environments.

5.6.2 Training

The environment used for familiarizing with the technology, consisted of rooms and an agent which asked the participant to follow him to a party. On arriving at the party, the participant met other agents already dancing to the music. In this environment, the participant familiarized himself/herself with keys used to start the VE , to navigate the VE, the K,L and I keys (on the keyboard) which in this case were used to change between the songs, but used for performing the actions explained in section 4.3 in the actual VE. They also accustomed themselves with the mouse and following instructions given in text and audio. A screenshot of this preliminary environment can be found in Appendix H.

5.6.3 Tasks

Once the participants had finished with the training stage, they were given priming material to read depending on the condition that was allocated to them. After priming, participants were then ready to experience one of the conditions allocated to them. The tasks that the participants had to perform in the virtual environments have been outlined in the previous chapter.

5.7 Data Collection

5.7.1 Questionnaires

At the end of the experiments, users were asked to fill in questionnaires about their experience in the virtual environment. Two questionnaires were used for measuring presence and additional questions were included for measuring story presence and enjoyment. The two questionnaires were combined into one and the users were not aware that they were filling in two questionnaires. The two questionnaires were, namely:

- The IGroup Presence questionnaire (see Appendix D).
- The Slater, Usoh and Steed (2000) scale (see Appendix E)

The following additional questions were included for testing story presence:

I became involved in the story being told in the virtual environment.						
1	2	3	4	5	6	7
COMPLETELY						NOT AT ALL
I felt present in the world of the San story, while it was being told.						
1	2	3	4	5	6	7
NOT AT ALL						COMPLETELY

Table 2: The above questions were used to test story presence.

For measuring enjoyment, we looked at the Differential Emotions Scale [27], which is a scale used to measure different emotions, and only one question was applicable to enjoyment. We also looked at [36, 15], whereby enjoyment was also investigated, but unfortunately found the same question. The question as it appeared in the questionnaire is given in the table below:

Characterize the extent to which you enjoyed yourself(i.e. how much fun you had) in the virtual environment by circling the appropriate number.						
1	2	3	4	5	6	7
DID NOT ENJOY AT ALL			MODERATELY ENJOYED			COMPLETELY ENJOYED

Table 3: The above question was used to test enjoyment.

All the questions used (for all questionnaires), were multiple questions with 7 possible answers. Participants were told to select only one answer. At the end of the combined questionnaire, a comments section was included to allow participants to give their comments if they had any.

5.7.2 Biographical Data

Biographical data was collected via a few questions presented at the beginning of the combined questionnaire, in case it influenced the virtual environment experience. The following biographical data was collected about each participant:

- Age

- Gender
- How many hours per week the participant spent playing computer games or interacting with virtual environment systems. Previous VR experience is thought to affect navigation ability [41].

5.8 Summary

This chapter described how we designed our experiments such that we could test all the possible combinations of our variables. Briefly, two independent and three dependent variables were identified, namely; Interactivity (an independent variable), Priming (independent), VE Presence (dependent), Story Presence (dependent) and Enjoyment (dependent). The materials that were used for our experiments along with the experimental procedure that participants had to follow were also discussed. Finally, we described the way in which we collected data. In the following chapter we present the analysis of this data and also make inferences based on the data.

Chapter 6

Results

This chapter presents the analysis of the results obtained from our experiments; first the descriptive analysis is presented, followed by the inferential analysis. The data was captured via questionnaires described in the previous chapter and was analyzed in Microsoft Excel 2000 and StaSoft Statistica 6.

We begin by describing the categorical data (i.e., the number of observations in each of the different categories that participants were placed under) in Section 6.1. Section 6.2 outlines the results and the various tests that were performed on them. We first outline the different effects of all possible combinations of our independent variables (*interactivity and priming*) on *VE Presence* as the dependent variable. We hence use a 2-way factorial ANOVA, as we are interested in the differences between multiple groups of independent samples. Secondly, we present the effects of interactivity and priming on *Story Presence* as the dependent variable, and thirdly, we present the correlations between the different variables involved, namely, *VE Presence, Story Presence,* and *Enjoyment,* and also examine the correlation between the measurement scales used.

We discuss the results in Section 6.3 in relation to our aims. We start by discussing the results regarding our first aim (*effect of interactivity on presence if facilitation and guidance used*) and make inferences based on the two kinds of presence that we have talked about, i.e., VE Presence and Story-Presence. We then discuss the results pertaining to our second aim (*effect of priming on presence*), and also examine the combined effect of Interactivity and Priming on Presence. We conclude the section by discussing the relationships between VE Presence, Story Presence, and Enjoyment. We also present other interesting findings in Section 6.4. Finally, Section 6.5 gives the summary of the chapter.

6.1 Categorization of Subjects into Conditions

Of the 67 participants that took part in the experiments, 3 participants' data was not considered as they did not fill in their questionnaires properly (two left out some questions and one filled in

two answers for one question). Unless otherwise specified, all the analyses were conducted on the remaining 64 participants.

Out of the 64 participants, 32 went through the interactive environment and the other 32 through the non-interactive environment. Each of these two groups consisted of two sub-groups of 16 participants who read either the relevant or irrelevant priming material. Categorizing participants in this manner enabled us to investigate our research questions according to the design discussed in Section 5.2. Table 4 summarizes each of these categories.

In the following section we present the results that were obtained from our experiments and these

	PRIMING		
INTERACTIVITY	*Relevant Priming*	*Irrelevant Priming*	*Row Totals*
Interactivity Present	16	16	32
Interactivity Absent	16	16	32
Column Totals	32	32	**64 (Grand Total)**

Table 4: Number of observations in each of the different categories which participants were placed under.

will be discussed in section 6.3.

6.2 Results

6.2.1 Factorial ANOVA with VE Presence as the Dependent Variable - All Effects

Two questionnaires, namely the Igroup Presence Questionnaire (IGPQ) and Slater, Usoh and Steed (2000) scale (SUS), yielded the VE Presence data [1]. Differences in VE Presence scores between the two levels of interactivity and two levels of priming were evaluated using a 2x2 factorial ANOVA at a confidence level p of 0.05, while treating Interactivity (INT) and Priming (PRIM) as between-subject independent variables, and VE Presence as a dependent variable.

Results Obtained with IGroup Presence Questionnaire (IGPQ)

Table 5 gives a summary of the effects of a 2x2 Factorial ANOVA with VE Presence measured by the Igroup Presence Questionnaire.

From Table 5, we can see that there is no significant main effect on priming ($p = 0.653$). No significant result was obtained with the interaction of priming and interactivity also ($p = 0.362$). However, the main effect on interactivity, on the other hand, was found to have a significant negative effect on VE Presence ($p = 0.029$). A means plot of this effect is given in Figure 9.

[1] The two questionnaires were analyzed separately.

	Degrees of freedom	MS Effect	F	*p*
Priming	1	28.8	.204	.653
Interactivity	**1**	**703.7**	**4.983**	**.029***
Priming*Interactivity	1	119.1	.843	.362

Table 5: Summary table of the effects of a 2x2 Factorial ANOVA with VE Presence (as measured by IGPQ) as the dependent variable. Effects marked in bold are significant at the 0.05 confidence level.

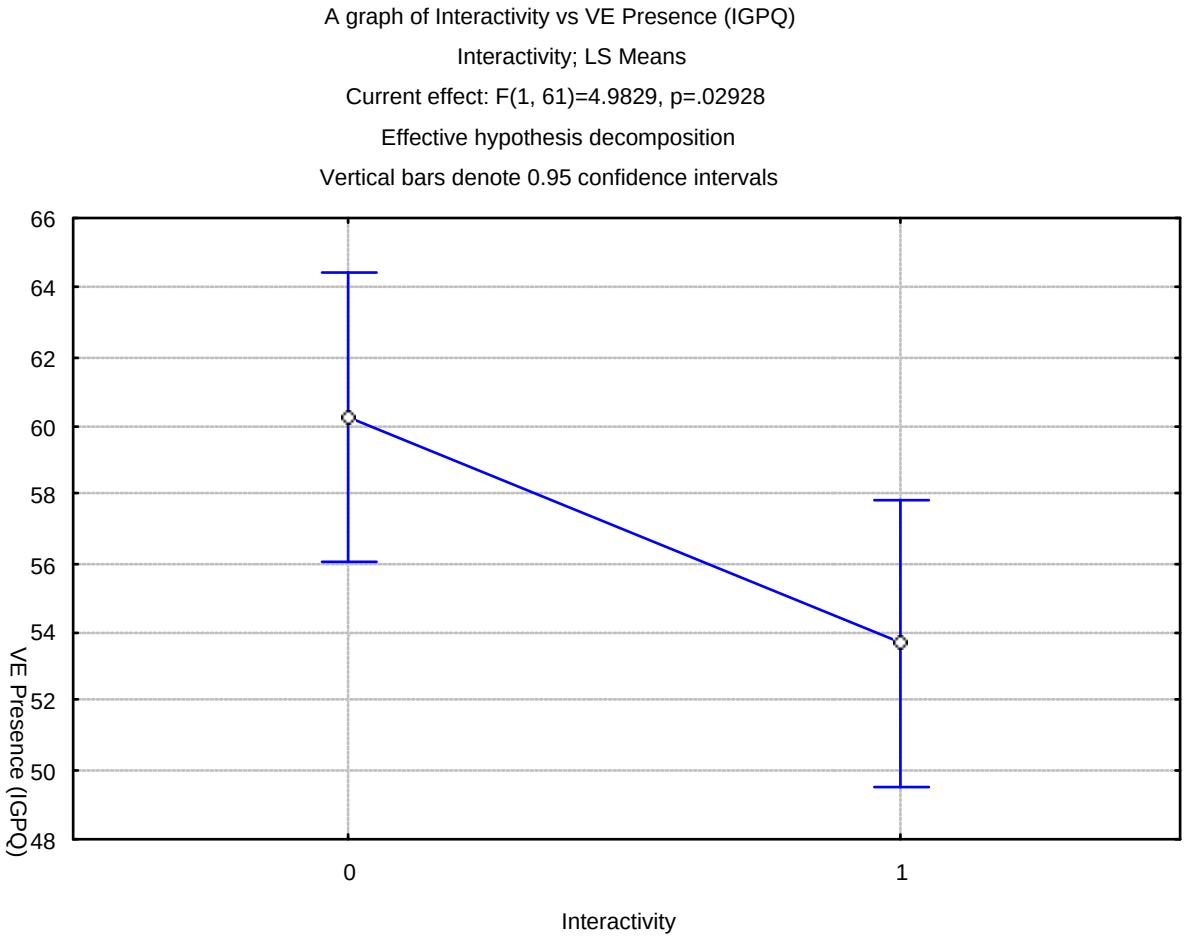


Figure 9: Means plot of Interactivity vs IGPQ

From the graph above it can be seen that the VE Presence means are higher when the value of interactivity is 0 (indicating the absence of interactivity), and decreases when interactivity equals 1.

Results Obtained with Slater, Usoh and Steed (2000) Scale (SUS)

Table 7 gives a summary of the effects of a 2x2 Factorial ANOVA with VE Presence as measured by the Slater, Usoh and Steed (2000) Scale.

	Degree of freedom	MS Effect	F	*p*
Priming	1	.0	.000	.996
Interactivity	1	91.0	2.451	.123
Priming*Interactivity	**1**	**164.2**	**4.423**	**.040***

Table 6: Summary table of the effects of a 2x2 Factorial ANOVA with VE Presence (as measured by SUS) as the Dependent Variable

From Table 7, it can be seen that neither the main effects of priming nor interaction have a significant effect on VE Presence ($p > 0.05$ in both cases, $p = 0.996$ for priming and $p = 0.123$ for interactivity) as measured by SUS. However, the interaction effect of the two independent variables yields a significant negative effect on VE Presence ($p = 0.04$). Means plots of this effect are given in Figures 10 and 11. Two graphs have been given for the same effect (the interaction of the two variables) to enable us to describe the results more clearly (i.e., in terms of either interactivity or priming).

From Figure 10, it can be seen that Interactivity significantly decreases VE Presence in the absence of Priming. However, once priming is introduced a slight positive effect can be observed.

The same graph can be interpreted in terms of priming (by swapping the axes) as shown in Figure 11.

We see that in the case of priming = 1 (i.e., relevant priming) the means of VE Presence are more or less the same regardless of whether interactivity is present or not. However, in the absence of relevant priming (priming = 0) there is a clear difference in the levels of VE Presence; higher when there is no interactivity and lower when there is interactivity.

6.2.2 Factorial ANOVA with Story-Presence as the Dependent Variable - All Effects

No significant result was obtained with the main effect of priming or interactivity on Story-Presence. Neither did the interaction of priming and interactivity yield a significant result. Table 7 gives the summary of the effects of a 2x2 Factorial ANOVA with Story-Presence as the Dependent Variable.

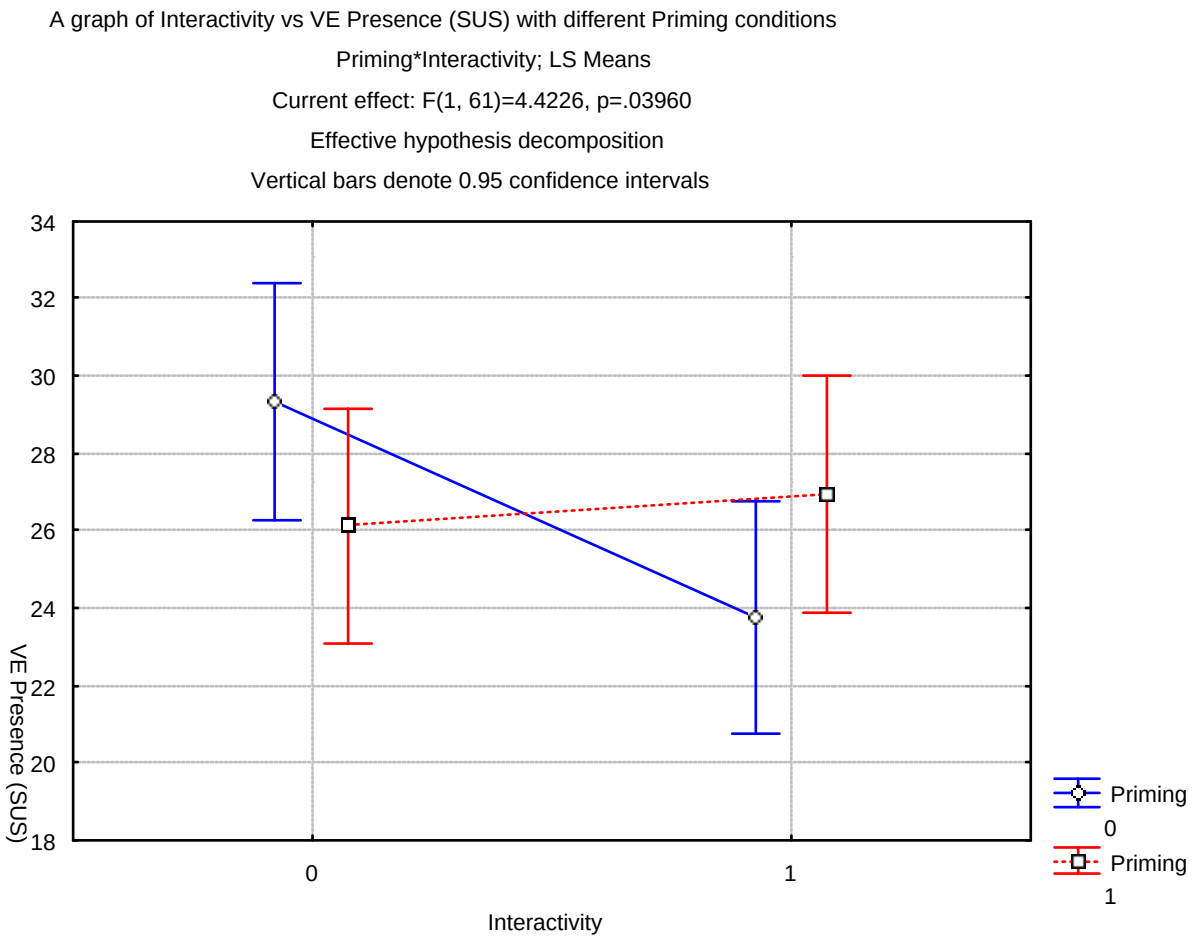


Figure 10: Means plot of Interactivity vs SUS with different Priming conditions

From the table, it can be seen that $p > 0.05$ in all cases.

	Degree of freedom	MS Effect	F	*p*
Priming	1	.47	.047	.829
Interactivity	1	2.09	.207	.651
Priming*Interactivity	1	10.29	1.019	.317

Table 7: Summary table of the effects of a 2x2 Factorial ANOVA with Story-Presence as the dependent variable.

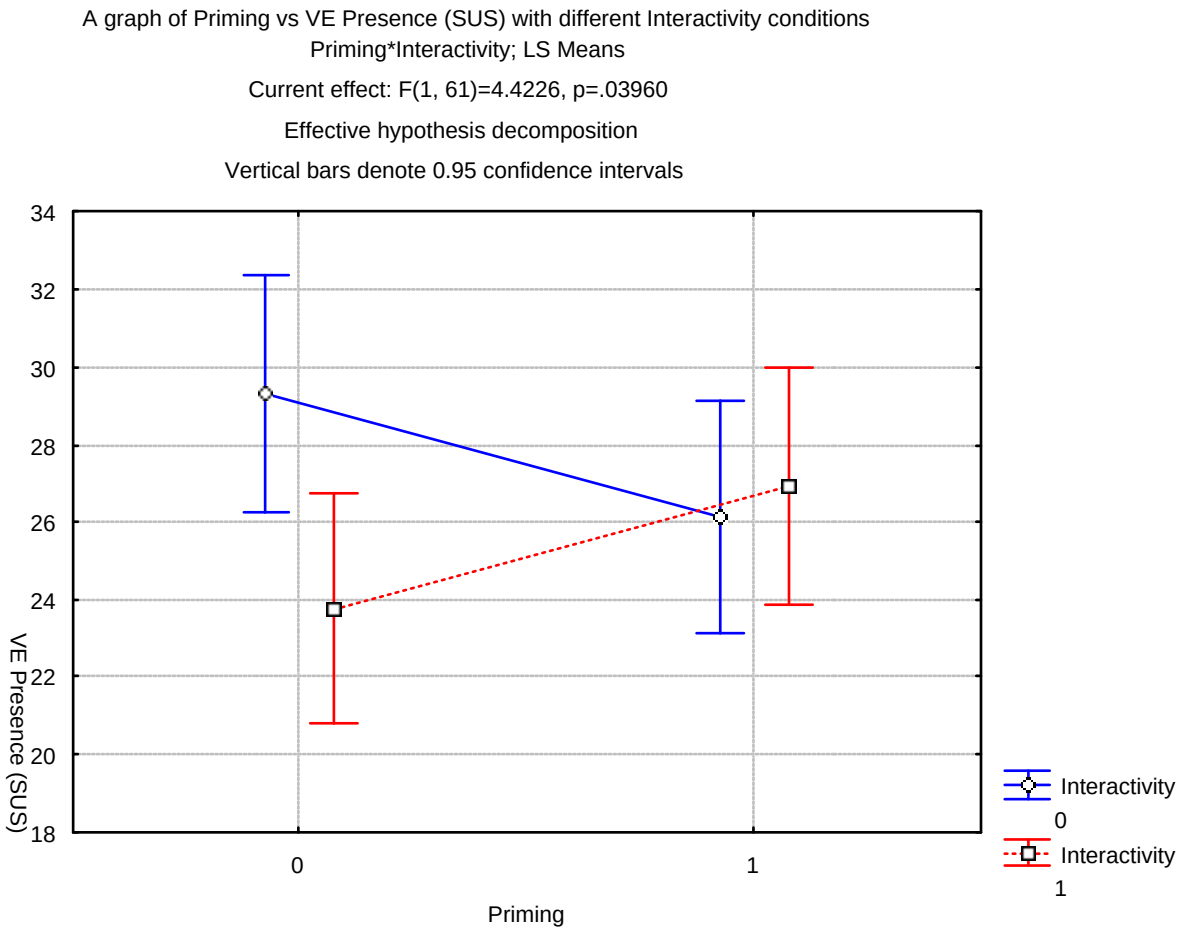


Figure 11: Means plot of Priming vs SUS with different Interactivity conditions

6.2.3 Correlations Between Variables

A series of correlations between VE Presence, Story-Presence and Enjoyment were performed to find out how these variables are related to each other. Table 8 below gives a summary of these correlations.

Also, to test if the two presence questionnaires that were used (IGPQ and SUS) are valid, we conducted correlations to see the concurrent validity of these measures. A significant correlation of 0.79 was obtained as can be seen from Table 8.

6.3 Discussion of Results

This section discusses the results outlined in the previous section in relation to our aims.

	IGPQ	SUS	ENJ	STORY PRES
IGPQ	**1.00**	**0.79**	**0.73**	**0.43**
SUS	**0.79**	**1.00**	**0.64**	**0.40**
ENJ	**0.73**	**0.64**	**1.00**	**0.44**
STORY PRES	**0.43**	**0.40**	**0.44**	**1.00**

Table 8: Summary table of correlations between VE Presence, Story-Presence, Enjoyment and Questionnaires.

6.3.1 Study 1: Interactivity vs. Presence

This study was done to investigate whether interactivity can have a positive effect on presence in the story-telling environment and in the story being narrated in that environment, if facilitation and guidance are used. It hence set out to answer the following questions:

1. How does interactivity in cultural story-telling virtual environments affect VE presence if facilitation and guidance are used?

2. How does interactivity in cultural story-telling virtual environments affect Story-Presence if facilitation and guidance are used?

As already discussed in Section 3.4, the two questions follow from the contradicting opinions about whether interactivity affects presence negatively or positively in story-telling environments, and the fact that facilitation and guidance can be used to solve some of the problems which interactivity give rise to.

6.3.2 Study 1: Effect of Interactivity on VE Presence

The results (according to Igroup questionnaire) show that there was a significant difference between the means of VE Presence scores, corresponding to the two different levels of interactivity. The scores of participants who went through the non-interactive environment were higher than those of participants who went through the interactive environment (as can be seen from Table 5 and Figure 9). Possible reasons as to why this is the case exist. One of the reasons could be that each time users had to perform certain tasks in the interactive VE, they may have been jolted back to reality, regardless of how engaged they may have been in the VE, due to the fact that the modal input did not match, as closely as possible, the human perceptual and the actual physical carrying out of the task at hand as in the real world i.e., the corresponding input device may have not sufficiently represented what they were supposed to. This concept of fidelity as discussed in [69] involves asking whether using a keyboard key to pick an object sufficiently represent picking objects in the real world? Equivalently, does the user feel like they are really picking an object by pressing a keyboard

key? We feel that this representation is not sufficient and that using more advanced equipment like data gloves to simulate actions like these, and the use of haptic props to provide tactile feedback would have been ideal. However as already mentioned, the state of today's technology is such that using such equipment even if to increase fidelity slightly can be quite costly. However, in contrast, other researchers such as Bliss *et al* (1997) in [69] have shown that the use of primitive devices such as the mouse, can be sufficient. Also related to this is the lack of tactile feedback, whereby participants could have expected some form of tactile feedback when picking objects. This was also not present in our VE for the same reason that the required equipment for this can be very expensive.

Furthermore, this finding is in agreement with the contention that allowing participants to interact with the story presents them with the opportunity to change the story-line hence missing the plot intended for them by the author. This is still possible even with facilitation and guidance, but we believe that just as the participants can be trusted to use the keyboard keys for navigation, they can also be trusted to use other keys for different tasks. We hence believe that this was not the main reason for this finding, however we do not rule out the possibility and hence believe further tests in relation to this should be performed.

No significant result with regard to interactivity and VE Presence as measured by SUS was obtained. We believe that the 6 questions used in this scale as opposed to 15 questions used in IGPQ may not have been enough to emphasize the difference between two different VEs. The efficacy of IGPQ has been discussed in Section 2.5.1.

6.3.3 Study 1: Effect of Interactivity on Story-Presence

Story-Presence was not affected by interactivity, i.e., no significant difference was found between participants who went through the interactive VE and those who went through the non-interactive VE. We believe that this was brought about by confusion on the part of participants, as the concept of story presence demanded them to remember their sense of presence which was specific to the narration and not to the overall VE experience (which we believe is easier to remember). Also, given the fact that the concept of presence, specifically story presence, is still not fully explored, we believe that the distinction between multiple levels of presence led to more confusion. We also did not find any established questionnaires for story presence (whereas several exist for VE Presence) and we hence believe that the two questions we used for obtaining story presence information may have been inaccurate.

6.3.4 Study 2: Priming vs. Presence

This study was done to investigate whether priming can have a positive effect on presence in the story-telling environment and in the story being narrated in that environment, if facilitation and guidance are used.

Priming on its own did not affect either of the two kinds of presence in any significant manner. However, it was found to affect VE presence scores by way of interaction with interactivity. Here we found that in the absence of relevant priming, interactivity decreases VE Presence in a similar way as in the preceding section, but once relevant priming was introduced, interactivity had a slight positive effect on VE Presence. This effect was however minimal and hence not conclusive (as shown in Fig 10). It however seems to suggest that relevant priming can contribute to increased presence. This agrees with the constructive perception thesis which, as mentioned in section 4.1, says that participants tend to process stimuli more accurately if they have been primed for that task.

Also, no significant result was obtained for either the effect of priming on its own or the interaction of priming and interactivity collectively, on story presence. Possible reasons for this are similar to the ones that have been discussed in the previous subsection.

6.3.5 Study 3: Enjoyment, VE Presence, and Story-Presence

A significant positive correlation was found between enjoyment and VE presence (according to both measurement scales of VE presence). This would be expected as one would expect participants who have a high sense of being in the VE to enjoy their overall experience in the VE more, and vice versa. A positive correlation, albeit smaller, was also found between enjoyment and story presence. This was also expected as one expects participants with a high sense of being in the story to enjoy the experience more, and vice versa.

6.4 Other Interesting Findings

The two measurement scales for VE presence were found to correlate significantly and positively. This indicates that the two scales were measuring the same construct despite the fact that the concept of presence is not clearly defined.

We also found that age and gender differences did not affect either presence scores or enjoyment. This finding may not be in line with Waller *et al* [69] study who found robust gender differences in training effectiveness of VEs.

Previous VR experience or number of hours spent playing computer games also did not seem to have any effect on participants presence scores.

6.5 Summary

In this chapter we presented and discussed the results in relation to our different areas of interest. The results pertaining to the effects of our independent variables (interactivity and priming) on VE Presence and Story Presence along with the different statistical tests that were performed were

outlined. The correlations of the different variables and the reliability of the measurement scales used were also described.

We found that some of the hypotheses were fully supported, or at least partially supported, by the results while other hypotheses were not in agreement with the results. Specifically, we found that the story presence variable did not behave as expected. Possible reasons as to why the results did not necessarily agree with some of the hypotheses were laid out. Briefly we found that:

- Interactivity negatively affects VE presence in story-telling environments. Low fidelity equipment and disruption of consistency in the story due to interactivity were identified as the possible reasons for this.
- Relevant priming contributes to an increase in VE presence.
- Enjoyment and VE presence are highly related.
- Enjoyment and story presence are highly related.

Chapter 7

Conclusions

This dissertation described a research whose main goals were to explore the feasibility of interactive cultural story-telling VEs by investigating the effect of interactivity on presence. The effect of priming on presence and the relationship between VE presence, story presence and enjoyment were also investigated. Two virtual environments (with one allowing the user to interact with the story and the other not allowing interaction with the story) were developed to help us investigate these areas of interest. Two priming materials (one relevant to the San culture and the other irrelevant) were also used to determine if relevant priming has a positive contribution on presence. The concept of presence was further broken down into two different levels of presence (VE presence and story presence) to help us distinguish between presence in the overall experience of the VE and presence in the story, with the hope that if we know exactly, the desirable conditions that enhance the feeling of being part of a narration and not just the VE, we can more clearly suggest a more effective, alternative way to story-telling using VR. The conclusions that were drawn from our findings are discussed in the next sections and lastly we present a way forward by making recommendations for future work

7.1 Major Findings of the Research

Concerning our first aim, we found that interactivity decreases the level of VE presence of participants in cultural story-telling VEs. This finding disproves the hypothesis we put forth in relation to this aim. Possible reasons as to why VE presence can decrease in interactive cultural story-telling VEs have been discussed. These include low fidelity, as the devices used to perform actions may not have mapped sufficiently to their real-world counterparts therefore leading users to feel that they are not really performing the actions. The lack of tactile feedback was also seen as another potential reason why interactivity affected VE presence negatively. The notion of internal consistency was also seen as another possibility, whereby the argument we made is that, although it may be attractive to allow participants to freely interact with the story, specifically in a hands-on story such as the one

used in this research, that unfortunately present them with the undesirable freedom to change the course of events hence can disrupt the intended story-line and hence negatively affecting the sense of presence.

We also showed that priming may contribute to an increased sense of presence. This result, although inconclusive, was observed from the combined interaction of priming and interactivity whereby in the absence of relevant priming, interactivity decreased VE presence but when relevant priming was introduced, a positive, albeit insignificant, increase of VE presence was observed.

With regard to enjoyment, a positive correlation between VE presence and enjoyment was found. As discussed in Section 6.3.5 this was to be expected. We also found a positive correlation between story presence and enjoyment and this has also been discussed in Section 6.3.5. This finding strengthens the notion that presence plays an important role in virtual environments and implies that participants are likely to enjoy themselves more when they feel present in the VE and/or feel more present when they enjoy their experience in the VE.

Unfortunately, no significant results were found with story presence. This, as discussed in Subsection 6.3.3, was probably due to the fact that the participants were confused by the concept of story presence as it demanded them to remember their sense of presence which was specific to the narration and not to the overall VE experience (which we believe is easier to remember). Another possible reason which was pointed out was that since no established questionnaires exist for story presence, the questions that were used may have been insufficient.

7.2 Contributions of the Findings

We believe that our findings make the following contributions to the area of interactive virtual environments:

- We provide a feasibility study for using interactive VEs in San culture, a culture that is fast becoming extinct.
- We provide empirical results with relation to the use of guidance in cultural interactive story-telling VEs, in which we show that interactivity in story-telling environments decreases VE presence.
- We further investigated the idea of priming in VEs, a notion which is still heavily unexplored (to the best of our knowledge it has only so far been investigated by Nunez [36]) and although our findings were not identical, we managed to show that priming can contribute to a positive effect in VEs as well.
- We also showed that presence in the VE, presence in the story, and enjoyment are correlated.

- We managed to show that there is a high correlation between Igroup presence questionnaire and Slater, Usoh and Steed scale.

7.3 Recommendations for Future Work

Our findings have provided several directions of further research. In this section we present different areas which we believe can be investigated more in the future.

INTERACTIVITY

With the insight gained about interactivity and VE presence, we make the following recommendations:

- *Facilitation and Guidance:* we suggest that facilitation or guidance in interactive story-telling VEs should be further investigated. We believe that giving participants cues of what they should do is not enough hence restrictions of what participants can do should be incorporated. Although this limits participants flexibility and creativity we believe it is a reasonable trade-off to make.

- *Fidelity and Use of Haptic Props:* understandably the use of more suitable equipment can be very costly, however when implementing environments where the user has to interact with the VE by performing certain actions, fidelity becomes an issue worth considering. Also in 'tactile' environments such as this one, the use of haptic props becomes imperative. In the experiment conducted by Strickland *et al* patients indicated that a sense of realism was further aided by the use of haptic props.

We therefore suggest that in the future a similar study to this one can be repeated but with the suggestions made above. We also believe that facilitation and guidance only become crucial when the interactive VEs are for story-telling but should not present much problems if such VEs are used for learning and exploration or in wayfinding.

STORY PRESENCE

We suggest story presence should be explored further in the future, as in story-telling VEs the interest can be mostly in the level of presence in the narration and not so much the overall VE. Making this distinction between these levels of presence may help us identify what factors are mostly important to what kind of presence and that knowledge can enable us to pay more attention to the areas that one feels are most crucial to their application.

PRIMING

The idea of priming seems to be very promising. An interesting study to follow in this direction would be to examine if priming can help improve presence on its own.

Finally, for future research we suggest an area that has not been investigated in our research but deemed to be important, i.e., learning from interactive cultural VEs. Here we would suggest that an investigation about whether people learn more about a culture different from their own when interacting with a VE could be carried out. This can be done by performing studies similar to the ones presented in this research but with subjects who perhaps do not know about the culture in question, and then measuring whether there is a difference in learning between participants who underwent either the interactive or non-interactive VE.

Appendix A

Information Sheet

Thank you very much for participating in my experiments. This experiment should take 30-60 minutes to complete. Upon completion you will be expected to fill in a questionnaire about your experience in the virtual environment. This questionnaire is not a test and will not in any way be used against you. Please try to be as honest as you can while filling in the questionnaire. You should also fill in a receipt attached at the back of the questionnaire so that you can be given R20 to thank you for your time. Try to concentrate as much as possible while doing the experiment.

You will follow the following steps in the experiment:

1. Undergo a Practice Environment to familiarize yourself with the controls and navigation in virtual environments.

2. Read a story.

3. Undergo the real environment.

You will be given a practice environment where you will use keys on the keyboard to familiarize yourself with navigation, and to carry out actions in the virtual environment. Although some keys (used in the practice environment) might be identical to the ones which will be used in the real environment, they are not necessarily always the same. The instructions of actions you might be expected carrying out will be given both in text (written on the screen in the virtual environment) and/or in audio (a speaker will tell you what you can do). The keys that you will be using for navigation both in the practice environment and the real environment are as follows:

W - to move forward **S** - to move backwards **A** - to move to the left **D** - to move to the right

Paper arrows have been placed on these keys on the keyboard to help you. Look on the keyboard to confirm this. **Practice Environment**

Here you will have to press the letter B on the keyboard to start. Then you will be greeted by Mwelwa who will ask you to follow him to a party. Follow behind Mwelwa by using the W, S, A, D keys until you get to the party room. **Once you are in the party room you can perform the**

following actions, by pressing the following keys: (Note that these instructions will be written on the screen) **Q -** to stop a song **J, K and L -** play different songs. Remember to stop a song by pressing Q before changing to the next one. If you feel you are comfortable with the keys, call the experimenter so that you can move to next part. **Real Environment** To start press the letter B on the keyboard. The navigation keys (W, S, A, D) are also the same as in the Practice Environment. You will be greeted by a narrator who will lead you to the campfire. After you have been asked to sit down (to sit down press the letter J on the keyboard) you will be introduced to other people around the fire. Then the narrator will tell the story. Please listen to the narration carefully and perform any actions you are asked to.

NB: You have to follow the narrator to the fire at the beginning and you cannot walk through the narrator. At the end of the narration (text will be written on the screen indicating that you have successfully completed) please call the experimenter.

Appendix B

Relevant Priming Material - The San of Southern Africa

The San people were habitants in Southern Africa long before colonialism entered Africa. Their traditional culture has had to adapt to many different environments through the years and has ultimately survived only in the most remote areas of southern Africa. San men are instrumental in their survival as they take on the role of the hunter. For this reason, the San have been described in literature as the ”hunter-foragers of southern Africa”.

Southern Africa has one of the longest and richest rock-art traditions in the world. Rock art (including both paintings and engravings) is distributed widely over the southern African region. It has been suggested that painting increased association with ritual activities during times of social stress. The San are renowned for their beautiful rock paintings.

An important aspect of San culture is their use of storytelling. Unlike Western cultures where stories are stored as written documents, San use the word to ensure that their stories are remembered throughout the generations. Wilhelm Bleek and his family were pioneers in learning and documenting accounts of San culture. Kabbo was a San man who stayed with the Bleek family around this time. He told them that a story is ”like the wind, it comes from a far-off quarter, and we feel it.” They are consummate storytellers, and as such, have a rich store of myth and lore, with much interpersonal, inter-group and inter-regional variation. A couple of common themes within their stories can be isolated.

One is the notion of an earlier order of creation or existence in which spirit beings, humans and animals were not separate entities, but intermingled. They were generally amalgamated beings, e.g. human-animals. In the San myth, belief and culture the ambiguity in the make-up of mythological times and ritual states is embodied in the trickster.

The trickster character is a common figure in a large percentage of San stories. His traits and actions are multiple, ranging from that of a bad-mannered prankster to that of a divine creator, from goblin to god, human to jackal, incarnation of the lowest of animals (the jackal) to that of the highest

(the eland).

The basic trickster character is familiar in many cultures, e.g. the Tokoloshe in Africans cultures who is believed to be a gremlin or a goblin. The Tokoloshe is used by the unscrupulous to steal money. In accordance with other cultures and beliefs, the San trickster likes to play practical, spiteful and often obscene jokes on others, delighting in their misfortune. He goes by different names, such as Kaggen, Pate, Pisamboro and Jakkal. The trickster is in every way the ”embodiment of ambiguity” and a ”lord of disorder”.

*E*xtracts taken from ”The Bushmen of Southern Africa: A foraging society in transition” by Andy Smith, Candy Malherbe, Mat Guenther and Penny Berens. Published in 2000 by David Philip Publishers (Pty) Ltd.

Appendix C

Irrelevant Priming Material

The most spectacular part was climbing into the firebox of a Bulleid Pacific, two people at a time. The trick is to grasp a fairly high-up handle in each hand, swing both feet into the fire-door opening, transfer hand grip to lower handles, ease body further in, turn over and wriggle the remaining distance. Inside the firebox we could easily identify the components, including the enormous thermic siphons. Coming out of the firebox was a slight variation on the entry procedure: squeeze out, roll over and get two people to help you up. Clive did give us one warning: on these engines, there's a stub lever sticking up beside the firebox: it's used for rocking the grate. Make sure somebody is covering it because if you slip, you'll be like the engine itself: you'll have a tender behind! Another thing we had to learn was the name of each track and which signal controlled which road: which switch was controlled from the box in the station, and which could be accessed by throwing the point lever in the yard, adjacent to the switch. There were the two platform roads in the station, the Pump-house siding, the Newick road (which used to be the running line to Newick when the Bluebell was a "real" railway), the headshunt, and the six yard tracks. There were the starter signals, the two signals controlling entrance to the two station roads and their shorter counterparts allowing cautious entry even when the track was occupied, and "dummy" signals at ground level. During the second afternoon we were introduced to "our" locomotive, no. 263. It was an 0-4-4 tank engine built in about 1905 for the South-Eastern and Chatham Railway. From our point of view, it had two "interesting" characteristics: it used the regular train vacuum brake rather than steam brakes for the engine itself, and it had a steam-powered reverser. It was parked over the pit, so we could walk down the steps and look underneath at the points that would need lubrication and examine the reverser mechanism and dampers. At the end of the second day Clive handed us our exam papers, to be handed in by Friday. The cover sheet was a list of safety rules and regulations which we were to sign as "read and understood". Back at Wayside Cottage, I failed to obey the rule "Look out for metal obstructions above your head". I bent over to unlace my safety shoes in the porch, straightened up, hit my head on a metal flower basket, staggered back, and banged into and cracked a window pane.

Appendix D

IGroup Presence Questionnaire

Characterize your experience in the virtual environment by circling the appropriate number on the seven point scale. Please consider the entire scale when making your responses, as the intermediate levels may apply. Answer the questions independently in the order in which they appear. Do not skip questions or return to a previous question to change your answer. No right or wrong questions exist, only your opinion counts. You will notice that some questions are very similar to each other. This is necessary for statistical reasons. Please be honest as your personal experience is very important.

1. How aware were you of the real world surrounding while navigating in the virtual world? (i.e. sounds, room temperature, other people, etc.)

1	2	3	4	5	6	7
EXTREMELY AWARE			MODERATELY AWARE		AT ALL	NOT AWARE

2. How real did the virtual world seem to you?

1	2	3	4	5	6	7
COMPLETELY REAL					NOT REAL AT ALL	

3. I had a sense of acting in the virtual space, rather than operating something from outside.

1	2	3	4	5	6	7
FULLY DISAGREE						FULLY AGREE

4. How much did your experience in the virtual environment seem consistent with your real world experience?

1	2	3	4	5	6	7
NOT CONSISTENT			MODERATELY CONSISTENT			VERY CONSISTENT

5. How real did the virtual world seem to you?

1	2	3	4	5	6	7
ABOUT AS REAL AS AN IMAG-INED WORLD						INDISTINGUISHABLE FROM THE REAL WORLD

6. I did not feel present in the virtual space.

1	2	3	4	5	6	7
DID NOT FEEL PRESENT						FELT PRESENT

7. I was not aware of my real environment.

1	2	3	4	5	6	7
FULLY DISAGREE						FULLY AGREE

8. In the computer generated world I had a sense of ”being there”.

1	2	3	4	5	6	7
NOT AT ALL						VERY MUCH

9. Somehow I felt that the virtual world surrounded me.

1	2	3	4	5	6	7
FULLY DISAGREE						FULLY AGREE

10. I felt present in the virtual space.

1	2	3	4	5	6	7
FULLY DISAGREE						FULLY AGREE

11. I still paid attention to the real environment.

1	2	3	4	5	6	7
FULLY DISAGREE						FULLY AGREE

12. The virtual world seemed more realistic than the real world.

1	2	3	4	5	6	7
FULLY DISAGREE						FULLY AGREE

13. I felt like I was just perceiving pictures.

1	2	3	4	5	6	7
FULLY DISAGREE						FULLY AGREE

14. I was completely captivated by the virtual world.

1	2	3	4	5	6	7
FULLY DISAGREE						FULLY AGREE

Appendix E

Slater, Usoh and Steed (2000) scale

15. Please rate your sense of being in the virtual environment, on a scale of 1 to 7, where 7 represents your normal experience of being in a place.
I had a sense of "being there" in the virtual environment:

1	2	3	4	5	6	7
NOT AT ALL					VERY MUCH	

16. To what extent were there times during the experience when the virtual environment was the reality for you?
There were times during the experience when the virtual environment was the reality for me ...

1	2	3	4	5	6	7
AT NO TIME					ALMOST ALL THE TIME	

17. When you think back to the experience, do you think of the virtual environment more as images that you saw or more as somewhere that you visited?
The virtual environment seems to me to be more like ...

1	2	3	4	5	6	7
IMAGES THAT I SAW					SOMEWHERE THAT I VISITED	

18. During the time of the experience, which was the strongest on the whole, your sense of being in the virtual environment or of being elsewhere?
I had a stronger sense of ...

1	2	3	4	5	6	7
BEING ELSEWHERE					BEING IN THE VIRTUAL ENVIRONMENT	

19. Consider your memory of being in the virtual environment. How similar in terms of the structure of the memory is this to the structure of the memory of other places you have been today? By 'structure of the memory' consider things like the extent to which you have a visual memory of the virtual environment, whether that memory is in colour, the extent to which the memory seems vivid or realistic, its size, location in your imagination, the extent to which it is panoramic in your imagination, and other such structural elements.
I think of the virtual environment as a place in a way similar to other places that I've been today ...

1	2	3	4	5	6	7
NOT AT ALL						VERY MUCH SO

20. During the time of your experience, did you often think to yourself that you were actually in the virtual environment?
During the experience I often thought that I was really standing in the virtual environment ...

1	2	3	4	5	6	7
NOT VERY OFTEN						VERY MUCH SO

Appendix F

Additional Questions

The following question was used for testing enjoyment:

21. Characterize the extent to which you enjoyed yourself (i.e. how much fun you had) in the virtual environment by circling the appropriate number.

1	2	3	4	5	6	7
DID NOT ENJOY AT ALL			MODERATELY ENJOYED			COMPLETELY ENJOYED

The following questions were used for testing story-presence:

22. I became involved in the story being told in the virtual environment.

1	2	3	4	5	6	7
COMPLETELY						NOT AT ALL

23. I felt present in the world of the San story, while it was being told.

1	2	3	4	5	6	7
NOT AT ALL					COMPLETELY	

The following questions were also used:

24. To what extend did you feel you were concentrating during the session?

1	2	3	4	5	6	7
COMPLETELY						NOT AT ALL

25. Please write down any additional comments concerning the virtual environment you have just experienced or the experiment as a whole.

Appendix G

Arrow-Making Story

The story as it appears in the book Stories that Float from Afar [31].

We go fetch reeds, to cut reeds. We bring the reeds and bind them up with cord. We put them in the net and take them to the hut. We go and divide up the reeds at the hut.

We straighten the reeds. When the arrow is like this, we are accustomed to scrape them and remove the reed's excrescences. We take the !kui [furrowed stone] and put it into the fire. We take the !kui out. We straighten the part of the reed which was bent. We straighten it again. We do it in this manner. Holding the reed, we lay it in the !kui stone. We take the reed out.

We cut the upper end of the reed. We split it. We warm the reed on the fire. Then we put a feather along the reed and press it along the reed. We take an arrow-head poisoned with !kuai juice and warm it. We remove the arrow-head. We put the arrow-head to dry. After drying the arrow-head, we put it into the reed. Then we leave off working. We sit, while we feel that we have finished making them. We sit thinking of other work which we shall do. Therefore we exclaim, 'I shall first be quiet. Afterwards, I shall poison the arrows in the morning, when it is cold. For when it is warm, the poison's heat could cover my face. Therefore I'm first quiet. I will poison tomorrow morning so that I will not perspire while working.

The next morning we poison the whole arrow with snake's poison fang. We then hide the arrow so that a small child may not catch sight of it. We leave it to dry there.

Below is the story as it was in this research:

We go fetch reeds, to cut reeds. We bring the reeds and bind them up with cord. We put them in the net and take them to the hut. We go and divide up the reeds at the hut. We straighten the reeds. When the arrow is like this, we are accustomed to scrape them and remove the reed's extra pieces. We take the reed and put it near the fire.

Prompt 1: TO PUT REED NEAR THE FIRE PRESS THE LETTER K ON THE KEYBOARD.

Then we put a feather along the reed and press it along the reed.

Prompt 2: TO PUT FEATHER ALONG THE REED PRESS THE LETTER L ON THE KEYBOARD.

We take an arrow-head poisoned with !kuai juice and attach it to the reed and warm the whole arrow.

Prompt 3: TO ATTACH ARROW-HEAD PRESS THE LETTER I ON THE KEYBOARD.

Appendix H

Training

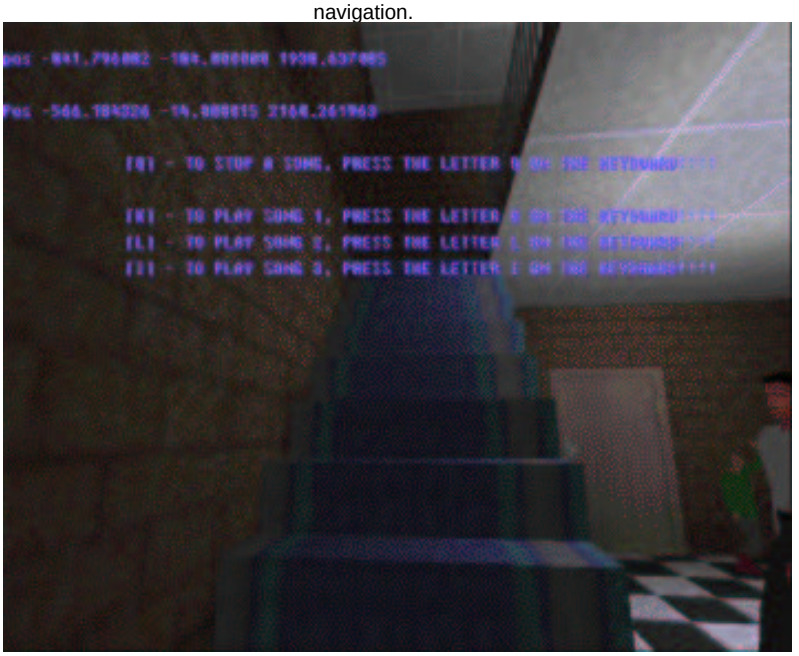
The screenshots on the next two pages were taken from the training environment, which was used for familiriazing users with the technology.

Stage 1: User view as s/he follows the person to the party room.

Stage 2: The user still following the person by navigating through the hallways of the building hence familiarizing themselves with VE navigation.

Stage 3: The user gets to the party and gets prompts in text about using the KLI keys to experiment things like changing between songs in the party.

Stage 4: User can go upstairs after the party. This further familiarizes them with navigation.



Stage 6: User navigates upstairs.

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