HIV/AIDS Quality of Life: Information and Awareness

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ABSTRACT

This paper details the most significant results of an exploratory investigation into the *potential* effectiveness of virtual reality (VR) as a therapeutic tool for improving the QOL of HIV-positive patients, whether presence affects the perceived therapeutic potential of the system. The investigation built on the demonstrated *therapeutic* usefulness for an HIV-positive individual of having a deeper understanding of his or her condition.

The VR educational experience was presented in a virtual human vein. This virtual environment (VE) provided a visual, audible and interactive simulation informing users about the actions of HIV in an HIV-positive individual's body, the responses of the immune system to the virus's behaviour and the effects of various stimuli on the activities of the virus. Exploratory qualitative experiments were performed with ten practised HIV/AIDS counsellors from several clinics around the Cape Town area.

In general the counsellors were very optimistic about the therapeutic potential of the system. The results of our tests provide an excellent grounding for future research into the therapeutic potential of the VE with *actual* HIV-positive individuals.

1. INTRODUCTION

Our research's principal objective was to test whether virtual reality (VR) could improve HIV-positive users' quality of life (QOL) or at least slow down their decline in QOL by empowering them with information about how the virus works in their bodies and how the immune system responds to it.. In order to pursue this objective, we modelled the early progression stages of the HI virus in a virtual human vein. The virtual vein showed what the virus does to an infected person's immune system and how the immune system responds to the actions of the virus.

Essentially, the purpose behind our virtual environment (VE) was to provide therapy through information. Specifically, we aimed to help the HIV-positive user develop an internal locus of control and to encourage an active coping style. Locus of control "is a construct which refers to an individual's beliefs about whether the outcomes of their actions are dependent on what they do (internal control orientation) or are determined by events outside their personal control (external control orientation)." [1]

Although the system was designed to provide therapy through information for HIV-positive users, our research was *exploratory* in that we tested this hypothesis with HIV/AIDS *counsellors* - many of whom were in fact HIV-positive themselves. The information gained from these counsellors in terms of whether or not the system would achieve its aims was a valuable initial step and laid the foundation for future research with *actual* HIV-positive patients.

Our research formed part of the broader CAVES research project, which attempts to create and test virtual reality tools that will be useful in a Southern African environment, where users have limited exposure to computers.

2. BACKGROUND AND MOTIVATION

The devastating world-wide intensification of the HIV/AIDS pandemic has been termed "a slow-wave disaster, leaving in its wake the devastation of individuals, families, communities and economies" [4]. HIV/AIDS represents a major life crisis with a unique set of stressful circumstances that impact negatively on both the affected individual's quality of life (QOL) and the community [4].

The success with which an individual manages to live with this persistent stressor impacts directly on their QOL [4, 5]. It follows that in coping with the stress of an HIV diagnosis, the individual's perception of the resources available in relation to the demands of the stressor will directly impact on subjective QOL [4]. There is increasing recognition that QOL is an important outcome in and of itself [9, 5]. Preserving a sense of personal well-being and purpose in life, whilst living with HIV/AIDS, is enormously challenging, but critical in ensuring optimal QOL during a restricted quantity of life [4].

There are numerous variables that have, to a greater or lesser extent, been shown to correlate with QOL [4]. In particular, research has shown that an active approach to dealing with the realities of being HIV-positive (an *active coping style*) together with a sense of having control over the events in one's life (an *internal locus of control*) promote the improvement in QOL for HIV-positive patients [example studies cited in 4].

The fundamental assumption in the VR literature is that VR will enhance learning as a function of the levels of presence achieved [18, 19, 20].

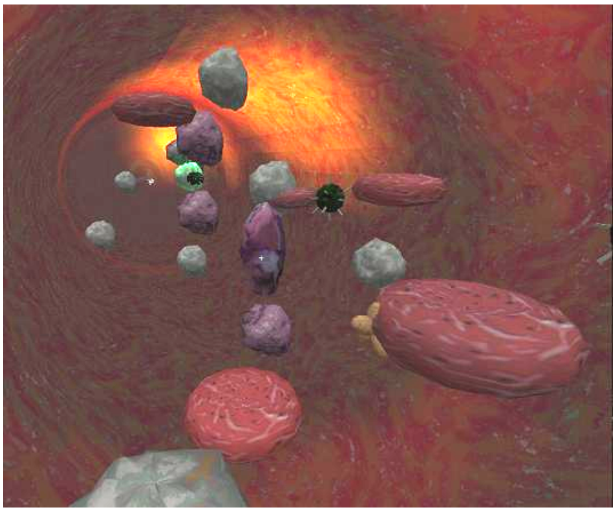

Figure 1: Screenshot depicting a scene from inside the vein

In the distance one can see the effect of a virus attached to a T4 cell: A bright green light has been placed above the T4 cell.

Figure 2: Screenshot showing the menu system in the VE

This screenshot shows the slide-out menu on the right and the screen information depicted when the user clicks the middle mouse button. In this case, the person has clicked on a virus

3. METHOD

In essence, our research built on the results of previous studies which illustrated that by empowering HIV-positive individuals with information about the disease, one encourages them to *change their behaviours* and *alter the way they perceive the disease*. Such changes promote an *internal locus of control* and an *active coping style* in the HIV-positive individual and thus improve his or her QOL (see section 2). We investigated whether, in the views of experienced HIV/AIDS counsellors, our VE might be able to change HIV-positive individuals' behaviours and alter their perceptions about the disease, thereby equipping them with information. We also examined the effects of user presence on the perceived therapeutic impact of the system. To describe it in another way, we analysed whether the users who felt high levels of presence in the VE learnt felt they more from it than those who felt less presence and in such a manner, were more positive about the potential therapeutic effects of the system.

In order to assess the feasibility of creating a VE for use in a southern African context, we constructed such an environment and tested it with volunteers who are typical of our target group. The VE simulated the spread of HIV in a way that could be easily identified by users, making sure the level of conceptual detail would not be too high for these users, while creating sufficient depth to ensure the simulation's credibility. We first describe the design and construction of the VE itself (Section 3.1) before detailing the method we followed for the actual experiment (Section 3.2).

3.1 System Design

The system comprised three sub-systems that worked together to create a complete experimental system. The virtual vein system provides relatively detailed information of the activities of the virus in the early stages of its progression in the blood and the response of the cells in the immune system. It also provides information relating to the effects of certain stimuli in the blood (for example the effects of drinking alcohol at various stages).

3.1.1 Simulation engine sub-system

The simulation sub system was created as a rule based engine. This means that it is based on a set of rules which was gathered by researching growth rates of the virus, and other important cells, as well as looking at cell counts at certain stages of the virus. Rules were also based on how the virus works. For example if a HIV cell comes into contact with a T4 cell, it attaches itself to it, and then begins to create new HIV cells.

The simulation engine was created to be as accurate as possible. However during the implementation phase it became clear that it would not be possible to model the virus entirely accurately. Several of the reasons for this will be explained below.

1. In order for the user to be able to see what was happening around them in the virtual vein, the number of cells had to be reduced. Similarly the distance between the cells had to be increased. As a result collisions between the cells did not occur frequently and they sometimes had to be forced. This required several changes in the system. One of these changes required the cells original natural motion to be abandoned for a motion algorithm that created more frequent contacts.

2. In order to better show the user which cells were important and which cells were not important, we decided to move the less important cells more slowly. This we felt would stop them from catching the user's eye. The more important cells continued to move at a faster speed. This again affected the realism of the simulation since the motion of the cells was affected. As a result the number of collisions was again affected. This also created a grouping affect between the slow moving cells, since the never moved very far apart.

3. Certain unimportant cells had to be limited to a certain number. As a result cell growth rates were affected which moved the simulation away from its desired level of realism.

3.1.2 Graphics sub-system

The graphics-engine system was designed to operationalise presence as a variable in the experiment. The following have been shown to encourage higher levels of presence in VEs: presenting information through both visual and audio means [3], displaying photo-realism and representing and showing the consequences of user actions in the real world. For these reasons, the VE was structured in the following ways:

- activities were illustrated visually and described using narratives and appropriate environmental sounds,
- dynamic entities and the static environment were created to approximate their real counterparts as closely as possible whilst still maintaining an acceptable frame rate,
- user mouse clicks paused activities and allowed users to select explanations or initiate new activities depending on where they clicked and
- natural user movement was approximated as closely as possible through the mouse.

The system incorporated ambient sound: gurgling, bubbling liquid and a constant heart-beat. These sounds help to create the sense of being submerged in liquid and of being inside the human body. The initial training phase, apart from giving the users an opportunity to practice moving in the vein, was crucial in helping the users form a conceptual overview of the complex process described by the simulation (by learning about the various functions of each type of cell in the immune system before actually experiencing the simulation). Narrative explanations in this phase therefore had to be clear, simple and presented slowly.

Taking into account the aims of our research (see Section 3), the decision was to provide control and interactivity above dynamism and realism in the VE.[1] When designing the system we had to take into account both the unique attributes of our targeted users and the frenzied nature of the real world phenomenon we modelled. For this reason, unlike in the real circulatory system, in the virtual vein many of the cells merely float slowly up and down in a fluid like motion and do not actually move through the vein. Only the cells crucial to the explanations being presented move through the vein, interacting with one another. Furthermore, to highlight different areas of interest, lights were placed above certain activities; for example a green light was placed above infected T4 cells.

The virtual vein was created using GenEdit Classic – one of the 3D games engine Genesis3D's interactive environment editors. Genesis3D, apart from being freely available, uses fairly recent 3D technology and offers certain advanced features [21]. The structure of the vein was designed to be fairly simple (a long cylinder) so as to afford more rendering time to the interactions of the cells with one another.

Cellular activities were highlighted by defining certain action sequences for each type of activity. For example, when any cell died, it would first begin to rotate and would then start shrinking and turning brown. This repetition presented some structure to the system, enabling the users to recognise activities they had previously learnt and thus could potentially improve the educational-capability of the system.

3.1.3 User requirements sub-system

Before implementing the user interface and orientation, it was important to keep in mind the kind of users likely to be testing the system. We expected that the volunteers would have little computer experience, and that they would at least have a basic grasp of the English language. We were not sure at the outset how much knowledge the users would have of the make-up of the blood or of the spread of HIV in the blood. We decided to lay some basic foundations in these two areas during an orientation session and we planned the user interface around users who had no computer experience.

The orientation session consisted firstly of a brief discussion with the users, describing to them the purpose and style of the experiment and their role as volunteers. In the second part of the orientation, the users were individually seated in front of a computer and given a set of Microsoft PowerPoint slides to study. These slides consisted of information on how the immune system functions to fight off disease, how HIV successfully bypasses this system and how the simulation and its controls worked. The PowerPoint system of using left and right arrows to move between slides worked very well with first time users.

The user interface within the virtual environment was built entirely around the mouse. We felt that the mouse provided the best means of moving the head around, and, rather than having the user trying to manage two implements (keyboard and mouse), we transferred the usual keyboard functionality to the mouse. This included the ability to move forward and backward, done with the left and right mouse buttons, and the option of clicking on an object in the simulation and opening a menu of options, done by pressing down the mouse wheel.

The virtual environment was effectively partitioned into two periods of activity. At first the user entered a training mode, where they could take time to become familiar with the system, adapt to the controls and be introduced to the standard objects to be found in the simulation of the blood (red blood cells, macrophages, etc). Thereafter they were able to see the actual HIV simulation. The controls for each session were similar, except for a change in menu options.

Menus were needed to provide extra functionality for the simulation, such as getting help, controlling narration, initiating new scenarios and exiting the program. Using the menu was a three-step process of pressing down the mouse wheel, rolling it to highlight the chosen option and pressing down again to select the option.

We provided a means for the user to enquire about what they were looking at by pointing a central crosshair at an object while opening the menu. This displayed an information box that described the object, its role and its current state. We also implemented a narration system for two reasons: firstly because some people learn better by listening than by reading, and secondly, because the current state of the simulation was not always clear and narration provided a real-time description of the state.

[1] 'Dynamism' here refers to VR's ability to provide dynamic explanation of concepts – allowing users to understand by seeing the objects in action.

3.2 Experiment Design

3.2.1 Test subjects

The volunteers for the experiment were HIV counsellors, who had very little if any computer experience and who, for the most part, had no knowledge of how the HIV spread in the blood, apart from contact between body fluids. These counsellors were good candidates for volunteers in that their limited knowledge would make them typical of our target users, while their experience with working with HIV patients could give them a better idea of how useful our simulation might be for those patients.

3.2.2 Experiment procedure

The volunteers were transported to the venue and were involved together in a brief discussion, describing their roles in the experiment. One user at a time was put through the computer experiment, while the others waited in a common room.

The computer experiment consisted of three phases. Firstly, the volunteers were asked to read through a set of Microsoft PowerPoint information slides which gave them a theoretical grounding. Then they entered the virtual environment and experienced a familiarisation phase. Finally, they watched the simulation of the HIV spread. Here, they were put through one run of the simulation where they were left to watch the simulation independently without help. A second run was then initiated where the facilitator pointed out parts of the simulation that the user may have missed. This was done because the test subjects were also evaluators and needed full exposure to the system in order to evaluate it effectively.

The final phase of the experiment was the evaluation period. First the volunteers had a one-on-one interview with the above-mentioned clinical psychologist [17]. This interview comprised of open-ended questions which gave a qualitative assessment of their experience, with the interview being recorded for further analysis. They were then asked to complete three questionnaires, which provided a quantitative analysis of the experience, measuring their presence in the VE and their success in handling the user interface.

3.2.3 Questionnaires used after experiment

Three questionnaires were used to evaluate the users' experience and provide a numerical return, upon which some statistical analysis could be done.

The IGroup presence questionnaire composed of fourteen questions that asked the participant questions about the level of presence they felt and how real the VE seemed to them. This questionnaire was adapted slightly by rephrasing the questions in simpler English, without changing the intended message.

The Participant Workload Questionnaire used ten questions to measure the level of cognitive load experienced by the user while they carried out tasks in the VE. These tasks consisted of activities such as moving around and using the menu. Once again, this questionnaire was adapted slightly by simplifying the language while trying to preserve the original message.

The final questionnaire was constructed by the group to receive input about other parts of the experiment not covered in the other two questionnaires. The questionnaire was split into categories covering: arrival at the experiment, the information slides, the experience of being in the vein, adapting to the environment and watching the simulation.

3.2.4 Equipment and location

We used a standard desktop computer for the experiment, keeping in mind that we were trying to develop a system that could be placed around HIV clinics in a cost-effective manner. The computer was a Pentium 4 2.4 gigahertz, with 512 megabytes RAM, a GeForce4 64 megabyte graphics card, an optical mouse, a standard Microsoft Windows keyboard and a 21-inch colour monitor. Sound was provided through earphones that did not cut out surrounding sound, so that an instructor could still talk to the user during the simulation.

The location for the experiment was Room 300 of the Computer Science Building at the University of Cape Town. The computer part of the experiment was done in a partly closed off area with the light turned off to prevent glare on the monitor, but with light filtering in behind the user. The interviews were conducted in a closed room, with recording done on a portable tape deck.

3.2.5 Supervision

The supervisor throughout the actual experiment was a clinical psychologist from the UCT Department of Psychology, who had previous experience in supervising a virtual reality experiment of this kind and in counselling HIV positive patients. She made contact with the volunteers, supervised the experiment and conducted the interviews. Her experience ensured that counsel would be available for any volunteer who became traumatised by the experiment.

4. RESULTS

This section is divided into two parts. The first part provides a description of the most significant results and observations made, and the second presents general conclusions from the experiment and describes how well each of the expectations were met.

4.1 Results at computer-testing time

The following significant observations were made during the time that the users sat in front of the computer and attempted to navigate through the information slides and the VE.

Regarding the orientation slides, it was found that users seemed very comfortable with using the left and right arrow keys and with managing the level of detail in the slides. However, users were confused by instructions on the controls for the VE and tried the mouse controls, which had intended results in Microsoft PowerPoint.

With using the mouse, we found that users adapted better than anticipated. There was a lot of confusion over which of the three buttons to use for which tasks, and the users seldom became comfortable with moving backwards and forward or opening and using the menu. Rather, the users spent a lot of time looking at the walls during the simulation, partly because they were carefully listening to the narration and partly because they often got stuck and struggled to turn around inside the vein.

One particularly interesting result was that while most were comfortable with the concept of moving the mouse in the same direction as they wished to turn, for about half the users, when they were trying to point the crosshair at an object, they inverted all their mouse movements. While most users successfully clicked on objects within the simulation, nobody did so within the main simulation. In general, users found the menus difficult to use and frequently asked for help. Nobody used the menu of options during the main simulation, although it aroused interest and queries when we used the menu to exit the program at the end.

The narration seemed quite popular, especially in the training mode, where users wanted to listen to it a second time. Some users also seemed to enjoy listening to the ambient liquid sounds.

Lag became a key influence in the running time of the demonstration. For instance, when a user was staring at the cell walls during the simulation, it completed very quickly, but the simulation was very slow when the user was looking at a large section of the objects in the vein.

4.2 Interview results

In analysing the qualitative data extracted from the interviews, the participants' answers to the questions relating to the following concepts were grouped:

- Whether the system would help change the behaviour of HIV-positive patients (coded as *ChBhv*)
- Whether the system altered the way the participant perceives the virus (coded as *AltThk*)
- Whether the participant gained information from the system (coded as *InfGnd*)
- Whether the system is a more effective information delivery tool than other informative mediums (coded as *BettOth*)
- Whether the system is upsetting (coded as *Scry*)
- What, if anything, should be changed about the system to enhance its therapeutic potential (coded as *WhtCh*)

The participants' sentiments about each concept were categorised on a scale of 1-3 with the following representations (see Table 1):

- 1 = 'No, I do not feel that'
- 2 = 'I am not sure about that'
- 3 = 'Yes, I do feel that'

Table 1: Interview Results Categorised According to the Experiment Themes

Subj	*Ch Bhv*	*Alt Thk*	*Inf Gnd*	*Bett Oth*	*Scry*	*Use*	*Int*	*EOU*
1	3	3	3	3	3	3	3	1
2	3	2	3	3	2	3	3	3
4	3	3	3	-	3	3	3	2
5	3	3	3	3	2	3	3	1
6	2	3	3	3	1	3	3	3
7	-	-	-	3	1	-	-	-
8	3	-	3	3	2	3	3	3
9	-	3	3	3	1	3	3	2
Avg	*2.83*	*2.83*	*3*	*3*	*1.88*	*3*	*3*	*2.14*

ChBhv = ChangeBehaviour; AltThk = AlterThink; InfGnd = InfoGained; BettOth = BetterOther; Scary = Scariness; Useful = Perceived usefulness of the information; Interest = Whether the information was interesting; EOU = EaseOfUse. 1 = No, I do not feel that; 2 = I am not sure about that; 3 = Yes, I do feel that; – = not recorded.

Most of the participants were optimistic about the system's ability to help change HIV-positive patients' behaviours (see 'ChBhv' Table 1). Although several counsellors felt that the reality of the information provided in the VE would be quite "scary", most thought that it would be better for patients to be more conscious of the realities of being HIV-positive. Specifically, the system would be like "a wake-up call" and it would facilitate a greater understanding of the virus as one can see "what's going on" and one "can see how it does destroy the body". An interesting observation was that the participants generally felt that the VE would be particularly effective in helping to change HIV-positive patients' behaviours because of the manner in which it delivers the information. This observation will be revisited in the ensuing paragraphs.

With regards to the ability of the system to alter perceptions about the virus, the counsellors' feelings were much the same as their feelings with regard to its ability to instigate a change in behaviours. The majority felt that their opinions of the virus definitely changed however there was one participant who was unsure of her feelings (see 'AltThk' Table 1).

One counsellor described that she found the system helpful because it helped her to understand more about what is actually happening to her patients – it helped her to "know what is going on to the person who has got the virus". Another expressed that the reality of the VE was particularly effective in altering her perceptions about the virus - her perceptions "changed a lot … because when [she] [saw] the computer and [saw] the viruses getting in the body and how your body works, to [her] it's real". In a similar comment another participant contrasted the learning experience she had in the VE with being taught by someone about the virus. She expressed her preference for the former describing that with the latter, unlike in the VE, "it's not the real thing".

Considering these and other similar comments, it would seem that the reality of the VR experience prompted a more effective change in perceptions about the virus and might thus also instigate a more successful change in behaviours than would other mediums presenting similar information.

All participants felt they gained useful information from the VE (see 'InfGnd' Table 1). Our experiments did not, however, analyse the quality of this gained information even though this would indeed be something of interest.

The participants were split 50/50 when asked whether they felt the simulation was scary. It seemed as though people who had witnessed the effects of the virus a lot were more scared.

All participants felt that the information that they gained was very useful. Several of the participants did however have several other questions after using the software which would indicate that the software helped the participants to become more questioning about the virus. It also shows that more information can be built into the simulation.

All the participants also felt that the information gained was interesting. This would indicate that the participants are being taught things which they were previously un-aware of. It also shows that the correct information was targeted in our simulation in a balanced form.

Lastly the participants were mixed when it came to ease of use. Most of the participants had no previous computer experience and they all tended to battle initially. However several of the participants did learn very quickly indicating that the user interface was fairly good and easy to become accustomed to.

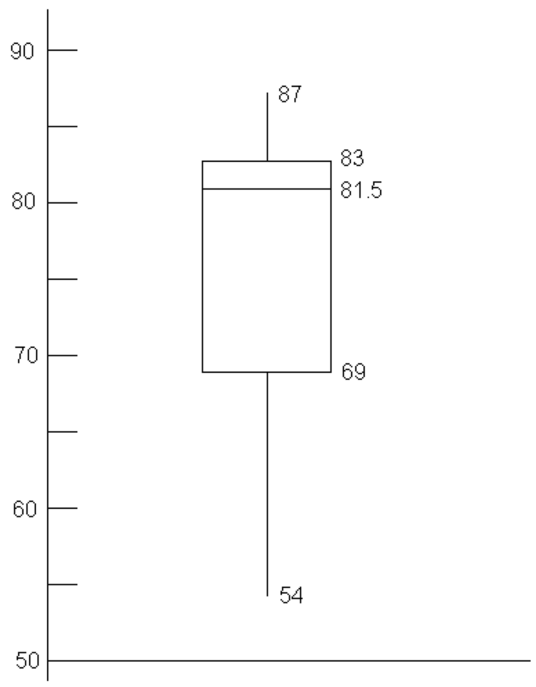

Figure 3: Box-and-Whisker Plot of Presence Scores

The Above Plot shows the spread of the measured Presence Scores. The median (middle value) was 81.5. The upper and lower quartiles were 83 and 69 respectively. The highest and lowest observations were 87 and 54 respectively. This figure clearly indicates that the Presence scores clustered in the 80's.

Table 2 presents the Spearman's rank correlation results with *Presence* and the following variables:

- *GotInfo* (similar to *InfGnd* above but measured using the results from question 30 from the Ease-Of-Use questionnaire)
- *MoreVein* (whether the participant felt that she learnt more from the VE or from the PowerPoint slideshow presented during the orientation session – question 31 in the Ease-Of-Use questionnaire)

4.2.1 IGroup Presence Questionnaire results

Both the responses of the participants during the interview sessions and the results obtained from the IPQ Presence Questionnaires illustrate that most participants experienced high levels of presence in the VE. Indeed, one participant categorically stated that she "was seeing the real thing" and that it was as though she "was … in another world". The average presence score was 77.1 out of a possible 98. The spread of these scores is depicted in the box-and-whisker plot (Figure 3) below. These results suggest that the VE was effective in promoting high levels of presence amongst the users and thus in operationalising presence as a variable in the experiment.

- *MoreSound* (whether the user felt she learnt more from the audible descriptions in the VE or the text descriptions – question 32 in the Ease-Of-Use questionnaire)
- *Accurate* (the participant's sentiment towards the accuracy of the system – question 33 in the Ease-Of-Use questionnaire)
- *Scry* (defined above in section 5.1.2)
- *ChBhv* (defined above in section 5.1.2)
- *EOU* (defined above in section 5.1.2)
- *AltThk* (defined above in section 5.1.2)
- *ChBhvr + AltThk* (defined above in section 5.1.2)

The two most significant correlations were those between *Presence* and *GotInfo* and *Presence* and *MoreSound* (both with $P < 0.05$ in the one-tailed test). The implication of the former is that there is a significant relationship between the level of presence felt by the participants and whether they felt they gained more information from the VE than the slides in the orientation session. Due to the fact that the relationship is positive (with $R^2 = 0.639$) and the P-value is less than 0.05, one can state with 95% surety that the higher the levels of presence felt, the more inclined the participants were to prefer the VR medium than the slideshow medium (both of which displayed the same information). Similarly, the significance of the positive relationship between *Presence* and *MoreSound* implies that participants with higher presence levels tended to prefer the audible explanations over the written ones in the VE.

The relationships between *Presence* and *ChBhv* and *Presence* and *ChBhv+AltThk* were the next most significant (both with $P < 0.1$ for the one-tailed test). By and large, in order for a statistical relationship to be considered significant, the calculated P-value should be less than 0.05. Relationships with P-values greater than 0.1 are generally considered to be insignificant. The correlations between *Presence* and both *ChBhv* and *ChBhv+AltThk* lie in between these two values. Therefore, under these circumstances, one can neither say that these relationships are categorically significant nor that they are insignificant. We propose that were the sample size to have been larger, the determined relationships would indeed have been significant. As such, our suggestion is that in fact, *Presence* significantly correlates positively with *ChBhv* and also with *ChBhv+AltThk*; however, due to the limitations of a small sample size in this study, we are currently unable to provide convincing support for such a claim.

Should such support be provided for the significance of these relationships in the future, the implication would be that the higher the levels of presence felt by HIV/AIDS counsellors who use the system, the more favourable their attitudes would be to the potential therapeutic impact of the system (instigated through a change in behaviours and an alteration in perceptions as described in section 2). Such a claim would provide an excellent grounding upon which research relating to the therapeutic potential of the system with actual HIV-positive patients could be carried out.

Table 2: Correlations with Presence

Variable	R^2	*N*	*P-val 1-tail*	*P-val 2-tail*
GotInfo	0.639	10	0.05<>0.025	0.1<>0.05
MoreVein	0.427	10	0.25<>0.1	0.5<>0.2
MoreSound	0.611	10	0.05<>0.025	0.1<>0.05
Accurate	-0.233	10	>0.25	>0.5
Scry	0.137	8	>0.25	>0.5
ChBhv	0.714	6	0.1<>0.05	0.2<>0.1
EOU	-0.679	7	0.1<>0.05	0.2<>0.1
AltThk	0.543	6	0.25<>0.1	0.5<>0.2
ChBhv+AltThk	0.875	5	0.1<>0.05	0.2<>0.1

4.2.2 Participant Workload Questionnaire results

The Participant Workload Questionnaire (PWQ) is a way of measuring the amount of physical and cognitive work done by the user in order to carry out tasks through the user interface. The results are displayed in Table 3 and 4.

Table 3. Stem and leaf graph of results from PWQ

Rating	Question number				
	1	2	3	4	5
1		•	•	•••	••
2	•	•••••	•••••	•	•
3	••	•••	•••	•	••
4	•••		•	•	•
5	••••	•		••••	••••
Average	4	2.5	2.4	3.2	3.4

Table 4. Stem and leaf graph of results from PWQ

Rating	Question number				
	6	7	8	9	10
1	•••				•••
2	•••			••	•
3	••	••••	••	••	•
4	•	•••	•••	••	••••
5	•	•••	•••••	••••	•
Average	2.4	3.9	4.3	3.8	2.9

The results map quite closely to the observations made at computer-testing time. Those who struggled with the interface did in fact get a high score on the questionnaire, and the two users who coped best with the interface were the same two who got the lowest scores on the questionnaire.

Looking at individual questions, users found that the tasks generally required a lot of thought but were not extremely difficult or physically demanding. Another interesting result was that the users felt like they had been very successful in achieving their tasks, and this could have resulted from the fact that they generally found the experience to be very interesting and educational, which may have fulfilled their original intention in coming to do the experiment. For the final question, the majority of users ranked their frustration as either one or four out of five.

4.2.3 Ease of Use questionnaire results

Matching up the answers with Eric's observations and noticing the patterns of the answers, it appears that the questions were given careful thought and accurately answered for the most part. The results are displayed in the following chart:

In the section about arriving at the experiment, the users generally seemed excited about the experiment, although they found the environment a bit strange. However, the majority felt more relaxed once the purpose of the experiment had been explained to them when they arrived. On the information slides, they found that the slides were easy to read, although not always easy to navigate (which did not correspond with observations). They felt that they learnt a lot of new material and remembered a lot of what they had seen.

On the experience of being inside the virtual vein, users generally felt that they were really inside the body and felt that the simulation of fluid motion was effective. They said that the objects floating in the vein were fairly easy to distinguish apart from each other and they matched up well with what they were shown in the orientation slides.

Referring to getting used to the environment, most users said they took a while to adapt, but became used to the mouse, and would prefer using a mouse to a keyboard, contrary to what we expected. They felt in control of their movement and felt comfortable to explore. The questions on using the mouse to open the menu produced more mixed results though.

Questions about learning from the simulation showed that most, but not all, felt that the components they saw were part of the blood. There was mixed opinion on whether there were too many objects to see what was happening, although most were quick to notice that viruses had become attached to cells and were replicating. There was an overwhelming response to suggest that they had learnt lots new, although there was a general feeling that the simulation was too short.

Finally, users generally learnt more from the VE than the orientation slides and learnt more from listening to sound than reading on-screen text. Another important result was that nearly all felt that the simulation was very accurate.

4.3 Analysis of Results

4.3.1 Effectiveness of virtual environment

As mentioned in section 5.1.3, the high levels of presence obtained from the IPQ questionnaires, when viewed in conjunction with the enthusiastic sentiments of most participants with regards to the reality of the VE, seem to indicate that the system was effective in promoting high levels of presence in the experiment.

Two particularly interesting results were the following:

- All counsellors who tested the system expressed their preference for the VE as an educational medium over other more traditionally informative media.
- There seems to be a significant positive relationship between the presence an HIV/AIDS counsellor feels and her attitude towards the potential therapeutic impact of the system (as achieved through a change in behaviours and an alteration in perceptions [*ChBhv*, *ChBhv+AltThk*]).

With regard to the former, when describing their reasons for stating such preferences, participants expressed that the *reality* of the experience of the VE was the overriding factor.

The latter may indicate that VR is effective as a therapeutic tool for HIV-positive patients. Such a claim cannot, however, be made without further research on the issue.

4.3.2 Effectiveness of user interface

Testing the user interface provided mixed results. On one hand, we found that users adapted more quickly to using the mouse than we expected and preferred the mouse to the keyboard. They also struggled with an inverted mouse problem when trying to point a crosshair at objects. They found the roles of the three buttons confusing and struggled to use the menus.

The controls for viewing the information slides worked very effectively and the information was well arranged. The information within the simulation usually provided good feedback to the user, and they responded well to the ambient sounds and the narration.

In general, the user interface was comfortably sufficient to provide basic movement within the environment and did significantly obstruct the users' participation in the simulation and viewing of the spread of HIV. More advanced features, however, remained elusive and would need improvements, especially if the system were intended for an independent user without supervisory help.

4.3.3 Educational effectiveness of simulation

Testing of the effectiveness of the simulation brought about several interesting results. Most importantly we discovered that everyone gained useful information from the simulation. People however learnt from the environment in different ways. Similarly people reacted to the simulation in different ways. For example some people were scared while others weren't.

One interesting discovery was that the participants seemed to learn a lot more from the environment when they were led around it, rather than when they controlled it themselves. This indicates that the software may be more effective as a demonstration tool than as a self-educational tool. This may however be since people were not accustomed to using the interface, and these results may differ with experienced users.

Another reason this may be more useful as a demonstration tool is that it would allow instructors to answer any questions that people may have. This would stop people from making assumptions that may be incorrect. It would also allow for instructors to watch people's reactions and make sure that they are not being traumatised.

4.3.4 Impact on locus of control and coping style

The ultimate aim of our project was to impact the users' quality of life by encouraging them towards an internal locus of control and active coping style. Primarily, these issues revolve around mindsets and knowledge, and users of our system did acknowledge both through the questionnaires and the interviews that they had learnt a significant amount about the virus.

However, the interviews did also reveal that the demonstration had left the users in a state of surprise and possibly shock, which may be a useful motivator for a person to change their behaviour. The users seemed very impressed by how real the simulation seemed to be and how they felt immersed within the virtual world.

Regarding coping style, the testing did not sufficiently explore the area of a mental and physical response to fight the disease. While we intended to provide this capability through our addition of menu options to live a healthy or unhealthy lifestyle, the users were too pre-occupied with the virus spread to focus on these alternatives.

While the issue of locus of control relates to coping style, conclusions are a little bit trickier, given that a user may feel they have even less control of their lives after seeing how debilitating the HIV spread can be. Should we wish to create an internal locus of control, we would theoretically need to indicate through the simulation a way that a person can still stay in control of their lives by fighting the HIV spread. Simulating the impact of using anti-retroviral drugs could play a key role here.

Ignoring the impact on coping style and locus of control, we could reasonably conclude that viewing the simulation at least causes the user to reconsider their lifestyle. If they are not yet HIV positive, they would surely be more likely to revisit the consequences of living with HIV when they engage in sexual activity with an HIV positive person. For those who are HIV positive, viewing the simulation should in principle cause the person to take their disease far more seriously and search more earnestly for any available means to fight the HIV.

5. CONCLUSIONS

From the above research and experimentation the following conclusions can be drawn.

Firstly the system was educational and helped participants to learn more useful information about the virus. The participants agreed that this information would change the way they perceived the virus and felt that it would have a similar effect on HIV+ patients. They also felt that it may cause people to alter their lifestyles to be more favourable and healthy.

Secondly it can be concluded that the simulation may be scary, and perhaps even traumatising, for certain people. As a result it is best that the simulation be used as a demonstration tool rather than by individual people. This would allow instructors to answer any questions and to watch people's reactions to try to avoid people being traumatised. This would also help since many people found the simulation to be difficult since they were not used to using a computer. Instructors remove this obstacle. It also means that people do not have to concentrate as much. Many of the people found the simulation strenuous and felt it required a lot of thought.

In respect to simulating the HIV/AIDS virus in a VE, it was found that although it is possible, it may not be preferable. In effect, certain aspects of VR impose limitations on the feasible scenarios one can accurately represent in a VE.

Lastly we discovered that the participants initially battled with the user interface. This can be attributed to the fact that most of the users had no prior computer experience. However roughly half of the participants did learn to manoeuvre fairly quickly. As a result it can be concluded that the user interface is easy to both use and learn.

6. FUTURE WORK

Regarding the information slides, we felt that the instructions on the VE controls were misplaced within the slides and should only be handled within the training mode of the VE, where users could practice the actions while reading or hearing the instructions.

Our observation notes showed that users frequently look for reassurance that they should proceed with an action. Having a set of objectives in our training session could provide more structure to the session and help users feel like they are more successful within the environment.

Since users struggled to click on objects, there should either be improvements here, such as better feedback indicating when a crosshair is correctly positioned over an object. A pause mode could also be introduced during the simulation, where users would have a prescribed time to click on objects, rather than try to chase after the objects while they are moving.

In terms of the objects within the vein, the white membranous material floating in the vein was distracting and confusing and could be removed, as could the red blood cell, which served no function and could purely clog up the view and induce lag. The memory B cell did not appear in the simulation, despite being described in the orientation slides, and the killer T8 cells did not kill HIV.

Graphical changes could include making the textures of some similar cells (macrophage, T4 and T8) more visually distinguishable. Users are sometimes located inside cells, viewing broken polygons, and this could be corrected by moving their position to one side of the object when they are standing still. An improved method for turning around in the vein could be included, such as making the camera revolve faster when the user is viewing the walls. Also, the existence of an abrupt vein ending seemed to confuse users, so different means of ending the vein or preventing movement right to the end may help to reduce confusion.

A significant addition would be a simulation of how anti-retroviral drugs affect the HIV spread, as requested by several of our users. Also, the effect of choosing menu options like "Add HIV", "Drink alcohol" and "Eat healthily" had virtually no recognisable impact on the simulation, and their impact could be clarified. It may be of interest to include a simulation of how the immune system would eradicate a different virus, such as influenza.

Given that the system does not yet successfully manage an individual person without the help of an instructor, new mechanisms should be put in place to reduce the possibility of a user becoming stuck and not knowing where to look for help. Automatic demonstration tools should be included to point a user to an area of key interest so that they do not miss crucial activity, such as an automatic camera direction changer or arrows to point to activity out of the field of view. An improved menu system would be crucial to an independently operated simulation, and an inline FAQ section could prove helpful as well.

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