VReanimate - Non-Verbal Guidance and Learning in Virtual Reality

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***Abstract*—First aid saves lives and reanimation is an important part of it. We developed a virtual reality (VR) application, VReanimate, that teaches about this aspect of first aid in a controlled digital environment. In this paper we present its non-verbal approach to guiding as many people as possible through the VR experience. In the first part of this paper, we describe the conceptual and implementational details of this approach that is based on showing ghost controllers and headsets to convey the necessary interfacing information in the virtual environment. These projected controllers and headsets were augmented with pictographic user feedback to direct and reinforce the users' learnings. In the second part of this paper, we elaborate on our evaluation of the non-verbal approach to teaching first aid implemented by VReanimate. Conducting a qualitative study, we found that the non-verbal approach was able to impart knowledge to all testers. None of the participants had problems with the developed concepts and most of them understood the pictographic language without difficulties. Finally, the paper discusses the potential positive impact of the developed application *VReanimate* in real world first aid scenarios.**

I. Motivation

Reanimation is a crucial part of first aid. In Germany 100.000 people suffer from arrhythmia every year [1]. If affected, an immediate start of heart rhythm massage and defibrillation is essential to keep a patient alive until the ambulance arrives. However, many people are too afraid to give first aid [2]. First aid manikins and training defibrillators could mitigate this issue, but they incur great investment costs. A VR setup on the other hand is considerably cheaper and more versatile. Therefore, by using VR to deliver first-aid training, we hope to enable a greater number of people to cheaply and effectively practice it, whether at home, in schools, or at medical training centers. In this way, the number of trained first responders could be drastically increased [3]. To address as many potential first responders as possible, we decided against using text-based instructions in the simulation. Instead, we developed a non-verbal guidance and learning approach. Thereby, we hoped to overcome possible language barriers [4] that reach far beyond mere textual localization but include issues as multifaceted as dyslexia, illiteracy, or affection arising from inter-human communication in high-stress situations.

In this paper, we present *VReanimate*, a VR application where the user can learn about and train reanimation in a controlled digital environment. The remainder of the text is structured as follows. In section II, we introduce common means of training reanimation and present other training procedures that are realized by using interactive VR experiences. Afterwards, in Section III, we discuss *VReanimate* with special focus on its non-verbal user guidance and learning aspects. Finally, light is shed on the effectiveness and usability of our simulation in Section V, by discussing the findings of its the empirical evaluation. We conclude with a short summary and an outlook on future steps.

II. Related Work

In Germany first aid is usually taught by a voluntary expert in group sessions. For learning how to apply heart massage, a manikin is used [5]. However, this approach has several disadvantages: (1) One has to book and visit a course in a special facility such as a first aid centre. (2) The course can be considered rather time-consuming—it typically takes at least one full day. (3) Still, sometimes not all of the participants are given an opportunity to actively practice with the manikin. As a result, acquiring or refreshing one's first aid knowledge and skills is not very accessible. In order to overcome these potential obstacles and offer an easier way for learning and training, VReanimate provides the opportunity to practice such first aid skills in VR.

Using VR to teach medical-related procedures has already been suggested and evaluated in a number of different publications and studies. For example Zajtchuk et. al. [6] already recommended training first aid scenarios in VR. Furthermore, Mantovani et. al. [7] pointed out that there is a continuous stream of new medical procedures that could be trained almost instantly in VR [6]. Regarding the general use of VR in the medical field, the literature provides different examples for a successful application. In [8], lateroskopy is taught using VR. In addition to conveying the very foundational mechanisms of the operation procedure, the application exposes users to stressful scenarios in VR. An evaluation of according operation performances was recently presented in [9]. Multiple VR approaches have also been introduced in the dental health domain, where the operation can be narrowed down to a very specific environment and interaction activity, see for instance [10]. This limited scope renders this domain easily applicable to VR technology. Due to the need for gaining a spatial understanding of the subject matter, VR is deemed generally beneficial for learning about numerous medical training scenarios, see e.g. [11, 12].

The application of VR as an educational tool has recently become very popular, as, with its current state, it offers new and almost unique possibilities for teaching and learning and at the same time is reaching the mass market [13]: First, realistic immersive environments that can be manipulated by the user can lead to great advantages from the the perspective of learning theories, like the ones associated with situated learning or socio-constructivism. These define the process of learning as an active construction of knowledge in authentic situations [14, 15]. Second, todays VR hardware can reach particularly high degrees of immersion, resulting in educationally valuable first person experiences [14]. It is believed that these could be especially beneficial for learners who have difficulties with symbol-based learning activities [16]. Third, current VR systems offer the opportunity to be used for kinesthetic learning, as they allow the user to move freely in a designated area. This can be an especially important advantage, if the learning goals are not limited to concepts only but include knowledge about processes as well. All of these developments render current VR systems a promising medium for teaching and learning and an ideal medium for our designated goals and underlying conditions. Learning and guiding with a non-verbal approach is an established practice and based on using pictographic icons to *provide an equivalent of text* [4].

III. VREANIMATE

VReanimate is a first aid simulation within a virtual environment, which enables the user to learn and practice concepts of first aid in different scenarios. It allows to learn when to defibrillate a person, when to apply a heart massage and how these procedures are done properly. We developed VReanimate with four goals on our mind: (1) To show that non-verbal guidance and learning can work for first aid scenarios in VR; (2) To show that VR is a good option for practicing in a real world-like environment; (3) To communicate knowledge about first aid; and (4) To increase the willingness to help other people in order to enhance the probability of survival in a corresponding situation.

The simulation was designed as an application for the HTC Vive (cf. Figure 1). The player wears the head-mounted-display, which presents a stereoscopic image. Additionally there is a controller for each hand. The tracking area is approximately 5x5 meter space using a line-of-sight tracking system. Furthermore, complementary over-ear headphones were used to provide suitable audio feedback within the simulation. At the beginning, the user finds him- or herself in an empty and boundless room. From there, he can access the included tutorials, exercises and stress scenarios, which we will present in the following paragraphs.

Fig. 1: HTC Vive HMD Family containing two controllers in the left and right front, a head-mount-display that is mounted to the head of the player and two base stations called *Lighthouse*

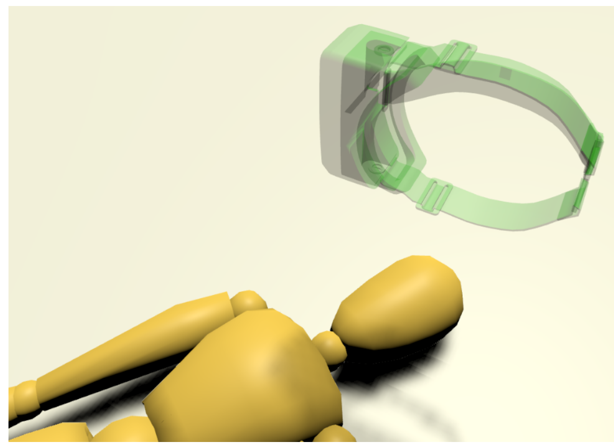


Fig. 2: Green *ghost headset* moving towards the head of the tutorial manikin. The movement of the headset should animate the user to follow its movement with his head to check the breath of the patient.

A. Tutorial

The tutorial teaches the user how to check the breathing of a three-dimensional, visualized puppet or manikin, how to measure its pulse and what the appropriate responses to any recognized symptoms are. Instead of using text or speech to convey this knowledge, VReanimate uses a non-verbal approach, which is realized by the following seven steps.

(1) As the user is immersed in the VR experience, he can associate a green semi-transparent headset with the head-mounted display he is wearing at the time. Therefore, we used the visual of a headset as a self-reference during the simulation. By animating a transparent headset moving towards the head of the manikin the user is shown the location where to check the breathing 2.

(2) Having found the correct position, the user has to determine whether the person is breathing or not. This is revealed by an according sound or the lack thereof. After that, he or she is asked about the breathing state. This can be see in Figure 3. The user has to acknowledge the breathing sound by pressing the button associated with the respective pictograph.

(3) Next, the user finds himself in a scene with a fully animated patient body, not a mere puppet, see Figure 4. In this scene, a transparent controller moves to the throat of the patient until the user follows the action as shown in Figure 5a.

(4) When the user's controller touches the throat in VR, the controller's vibrator is activated to emulate the pulse of the patient. While the controller is vibrating, a normal heartbeat cardiogram is shown. This can be see in Figure 5b. Because the patient is alive and doesn't need any treatment, this scene

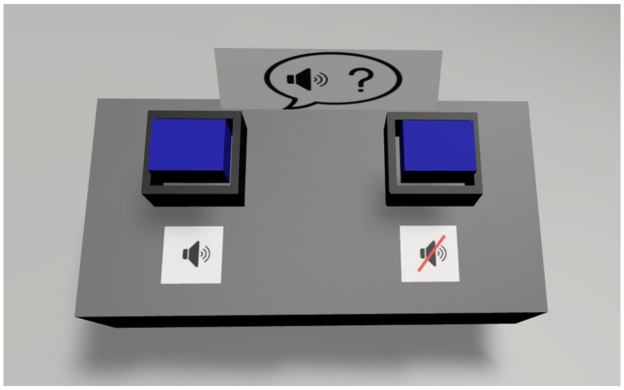
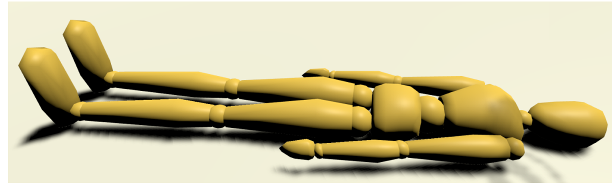


Fig. 3: Screenshot of the breath check. Containing the question *Did you hear the breath of the patient?* formed by a pictograph containing a speech bubble, a volume icon and an question mark. This pictographic question is based on the top of the box. Below are two buttons and answers. These answers are again non verbal pictographic icons *sound* and *no sound* representing the existence to the patients breath.



(a) Manikin tutorial

(b) Manikin exercise

(c) Manikin stress

Fig. 4: This Figure shows the three different patient visualizations. Figure 4a shows the manikin, used in the Tutorial to form a learning friendly environment. The second Figure 4b shows the manikin used in the three exercise scenes and the stress scenarios. The third Figure 4c shows the manikin in the second stress scenario.

concludes with a *pling* sound after a short while. (5) The following scene is similar to the previous scene, however the patient does not emit a breathing sound, the controller does not vibrate and the heart monitor does not show a pulse.
(6) Having checked all of this, one controller is animated to guide the user's next action. It starts massaging the heart of the patient as if it was the user's hand. When the user follows the animation and compresses the chest five times, the scene concludes with a *pling* sound. (7) Now, the user finds himself in a third scene. Here the patient does not emit a breathing sound, however the controller's haptic vibrator feedback emulates an irregular heartbeat and the heart monitor shows an irregular pulse. A guided animation is shown how to apply the defibrillator patches and to defibrillate the patient. When the user follows the instructions, the scene concludes with a *pling* sound.

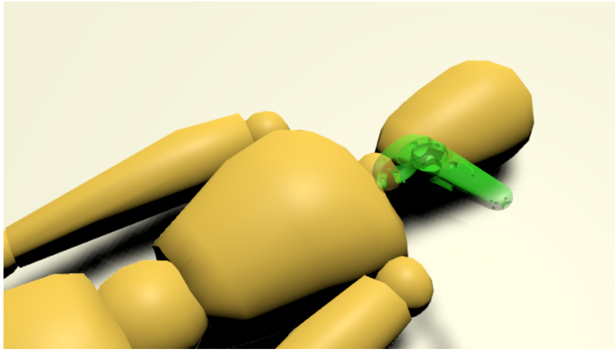
In an earlier approach of VReanimate, we tried to use colors to indicate whether the tutorial or the exercises should be started. Unfortunately, by using a blue button for the tutorial and a red button for the exercise, no one besides the authors of these buttons was able to determine which button to press, even when advised doing so in the tutorial. Therefore, we dropped the idea of using colors for symbolic speech.

B. Exercises

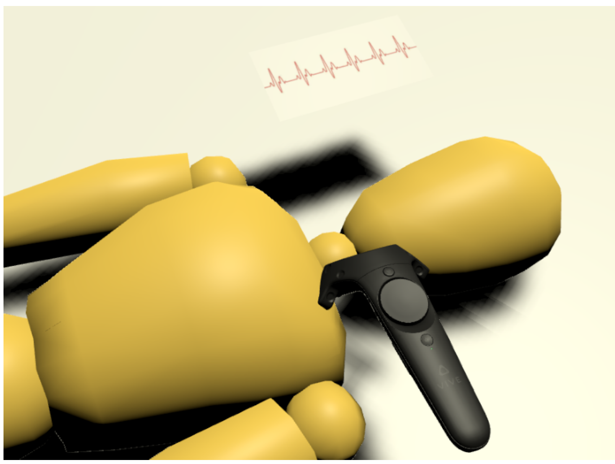
In addition to the tutorial, the user can play one of the three exercises. In each scene the patient has to be treated correctly in order to keep him alive for 50 seconds. This, compared to real reanimation proceedures, rather short timespan has been chosen, because, here, the focus is on the correct decisions in first aid. It is not expected that a longer time will improve the learning of these decisions. If the user succeeds, the scene finishes with a *pling* sound. If the patient dies before this timespan, a *fail* sound is played and the next scene is loaded. With these exercises, the user can consolidate the learned concepts of first aid. In order to communicate that the scenes aren't part of the tutorial, a more realistic manikin is lying on the floor instead of a puppet, as shown in Figure 6. This was also done to foster the transfer of the taught knowledge to a real situation. In the first scene, the patient isn't breathing and has no pulse. The patient requires a heart massage. In the second scene, the patient is healthy and doesn't need any treatment. The third scene contains a patient that's not breathing and has an irregular pulse, necessitating defibrillation.

C. Stress Scenarios

After successfully completing the exercise scenes, the user is confronted with more intense scenarios that challenge his skills in giving first aid. In the first scenario, the user is immersed into a dark, rainy night, in the middle of a forest with cars driving by. The constant movement of the cars, blinding lights of the cars, the noise, the cold and harsh weather not only distract the user visually but they also introduce emotional stress as shown in Figure 7a. The second scenario places the user into a war scene, located in a military bunker while being exposed to gun sounds7b. The third scenario takes place close in a limited space, with insufficient light and potentially



(a) shows the green ghost controller at the neck of the patient signaling the user to feel the pulse of the patient.

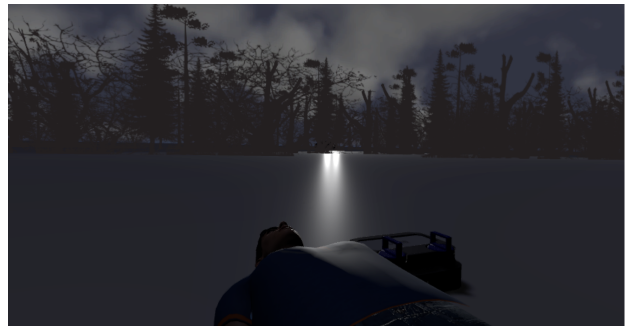


(b) shows the controller at the throat of the patient. While the controller is vibrating a normal heartbeat cardiogram is shown.

Fig. 5: shows visualizations of the pulse measurement. Figure 5a displays the animated green ghost controller and Figure 5b visualizes the user measuring a normal pulse in a tutorial.

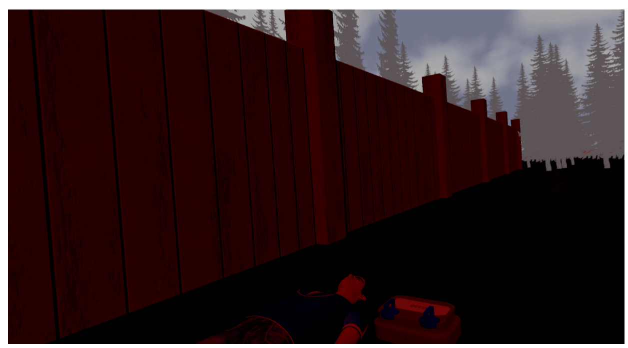
Fig. 6: shows the manikin used in the exercise scenarios within the infinite sterile world. On the right side of the puppet, a defibrillator is placed.

distracting music in the background as displayed in Figure 7c. As in the Exercises, each treatment has to be dealt once and the patient must be kept alive for a 50s timespan. Again, the scenes conclude with a *pling* or *fail* sound.



(a) shows the first stress scenario. In the far trees are placed. The light comes from a car driving by. In the front the torso of the patient can be seen.

(b) shows the second stress scenario. It plays in a military bunker with a half opened door. While being in this scenario the user is exposed to gun sounds.



(c) The third stress scenario plays beside a great wall. With insufficient light and potentially distracting music. To make the content better visible, the screen shot was edited afterwards by lighting it up, changing contrast and shadows.

Fig. 7: shows screen shots from the three different stress scenarios: Figure 7a *forest and rain*, Figure 7b *bunker* and Figure 7c *wall and music*.

IV. Methodology

This chapter is split into the three sections: Presence, simulating the patient and non-verbal design. The first part of this chapter focuses on sensoric, auditive and visible feedback. The next part depicts the implementation of the included patient, using multiple extended FSM and health values. The end this chapter describes the approach to create a non-verbal environment.

A. Presence

Following the terminology by Slater and Wilbur [17], we understand immersion as a technology's capacity to reproduce the sensorical sensation of the real world. The notion of presence complements this technological perspective by the subjective experience of an immersed person. Generally, presence is felt by the user, if he or she forgets about the technical origin of the experience and is perceiving it as real [18]. In VReanimate, we establish the sense of presence by utilising haptic, auditive and visual feedback. Concerning the latter, the visual sense in our simulation has been addressed by using the software provided for a VR gear, because it ensures a stereoscopic, tracked three-dimensional experience.

From the tutorial scenes to the stress scenarios, VReanimate establishes the visual sense of presence step by step. We thought this bring the user to first aid without creating obstruction: The tutorial uses a puppet representation of the patient. In the other scenes a mannequin represents the patient. These representations are unanimated as patients suffering from arrhytmia don't move. In the stress scenarios, we added realistic graphical effects to the scene, such as lighting (e.g. the floodlights of the cars), particle systems (e.g. to simulate rain) and animations. Concerning the interaction with the environment, we highlighted items with which the user can interact with to provide quick feedback and minimise the cognitive load. This also allows the user to ease into the virtual experience much quicker.

Auditive feedback is provided when the user moves his or her head towards the head of the patient and a sound recording of a human breathing is played. When the user successfully completes a scene, i.e. the patient is alive regarding the model given in Sec. IV-B, a *pling* sound is played. If the patient dies, a *fail* sound is played. A consistent use of the unobtrusive sounds can be intuitively understood and does not jeopardise the experience either, especially since playing these sounds is always associated with the change of a scene as well. Finally, we deployed haptic feedback by the use of the vibrators built into the tracked controllers of the HTC Vive system. This feedback is used to communicate whether the patient has a pulse or not, or whether it comes at regular intervals or not. In addition, we utilize the vibrators when the user compresses the chest of the patient while applying the heart massage. Together with the pictographic feedback during the tutorial, this compensates to some extent the lack of proper haptic feedback in this situation.

B. Simulation of Patients

The patient's condition is internally represented by a finite state machine (FSM), driven by several health parameters. Used values are *torso condition*, the *blood oxygen level*, the *brain oxygen level*, the *amount of water inside the lungs* and the *hearth health*. They generally range from 0 to 1. A hearth massage for example causes a decrease of values of the *torso condition*, slightly decreases the *blood oxygen level* and slightly increases the *brain oxygen level*. If one of the values exceeds its limit, the patient dies. Furthermore, there are several conditions implemented, including: *heartbeat stopped*, *irregular heartbeat*, *not breathing*, *patient lies on back*, etc.

At the beginning of each scene, a subset of all conditions is chosen. These conditions are represented by means of an extended FSM, which implies that the user's input may have different outcomes in different conditions. We also added stochasticity to the respective state transitions according to the corresponding literature. For example the condition *irregular heartbeat* affects the health parameter *brain oxygen level*, as the circulatory system does not work properly any longer. In addition, the *irregular heartbeat* state has a small chance of recovery at each iteration. If the patient recovers from this condition, it switches to the *regular heartbeat* state and his health parameters are not affected negatively any longer. Interaction with the patient can, of course, also impact his recovery. For example, the activation of the defibrillator recovers the patient from the state *irregular heartbeat* with a certain probability. But activating the defibrillator also negatively affects the health parameter *heart health*. This transition gives credit to the high voltage passing through and damaging the body and the heart of the patient. By having more than one extended FSM affecting the patient, we achieve a parallel execution of the condition state machines on the patient's health parameters that can be seen as single resource.

To provide the user with an environment in which he can learn and practice first aid more efficiently, we decided to exclude untreatable conditions like *vomiting* patients. As the greatest challenge in first aid is to have bystanders respond, we also increased the likelihood that certain treatments lead to recovery and let medically adverse interactions be more forgiving. The patient's death, as the drastic result of wrong treatment or lack of engagement, occurs within a short time frame of 50 seconds. This puts on pressure on the user but it also alleviates the need of sustained heart massage over a long period of time, which is exhausting even without proper haptic feedback. The simulation does not differentiate between the symptom and different causes for the symptom. If necessary this information could be added to the FSM in order to enable a more differentiated analysis of the patient state.

C. Symbolic Speech

Using a text-based approach does not seem suitable for first aid: First of all, first aid should be applied almost instantly by muscle habituation The correct procedures therefore must be performed or seen, not only read. Additionally, relying on texts as a medium creates a limitation for potential users. For example young children or people with reading difficulties would be inhibited by such a text-based approach. Therefore, we do not deem textual descriptions appropriate for every learning scenario but such a non verbal approach should work for almost any user interface on some sort of virtual monitor. Instead of text, the simulation uses graphic symbols combined with ghost controllers and buttons to form an easily understandable environment [4]. These graphical symbols should be universally recognizable. In order to guide the user's movement, we chose to project a *green semi-*

transparent ghost controller or a corresponding *headset* into the virtual space. These ghost projections can be augmented by additional pictographs. Given a specific context, the resulting combinations carry certain meanings. For instance, we tried to ask the user whether the patient is breathing, which can be seen in Figure 3.

V. Evaluation

To evaluate to what extent our approach to use non-verbal guidance was suitable and successful for teaching first aid, qualitative semi-structured interviews were conducted. This survey method was chosen, because we wanted to learn more about the specific impressions by the users, like how they felt when playing the simulation or which thoughts they had in mind. We felt that otherwise it would not have been possible to properly investigate how well the approach of non-verbal guidance worked out or if there are particular crucial points when applying such a approach. Furthermore it seemed to be more suitable to assess other important points like the role of authenticity or questions concerning the usability. Such questions could not have been answered by other methods like questionnaires or observations due to their lack of a possibility to communicate the subjective experience.

This chapter describes the process of the study, from selecting participants to the results of the study, in four sections: The first section describes how the eight participants were selected in order to form a heterogeneous test group, and how the study was conducted. The second section describes the methodology of the qualitative content analysis [19] used to evaluate the conducted study. Within the interviews the testers were asked to answer questions concerning their impressions of the simulation. The third section sums up the findings of the interviews and excerpts of the given answers that are important for the resulting conclusion. The fourth and final section presents the results concerning our specified research questions and discusses the implications of these results.

A. Participants

In order to create a test group as heterogeneous as possible, we focused on the three criteria age, experience with VR and knowledge of first aid. This seemed necessary to us, as a training of first aid skills affects almost everyone and thus needs to be suitable for as many people as possible. All eight participants were between 18 and 54 years old. Furthermore, the participants were selected by a range from *never had a first aid course* (2x) over *had one first aid course* (5x) to *graduated nurses* (1x). Additionally, they had different levels of experience with the medium VR, varying between *didn't know anything about the medium VR* and *plays VR games on a regular basis*. Each participant completed the study separately. At first the testers had to play and finish the simulation, afterwards they were interviewed.

B. Methodology of Evaluation

Participants took part in the study separately. At the beginning they were told about the simulation and its purpose. Furthermore, we explained to them that VReanimate is still under development and thus it can not be guaranteed that all medical information is correct, e.g. it is not possible to simulate a realistic heart massage with only a HTC Vive controller. Then we introduced the participants to the setup described in Section III and started VReanimate. During the Simulation, the only advice that was given when needed, was, that participants struggling to continue should *look around*, and afterwards that *there are two buttons they can interact with*. After the simulation was finished, the participants were asked several questions. These interviews were recorded.

After conducting all interviews, these were transcribed and a qualitative content analysis in accordance to Mayring [19] was performed. This includes five steps: At first we created paraphrases from the transcribed text. Second we generalized these paraphrases. In the third step we summarized these paraphrases, before in a forth step, the paraphrases were mapped to the research questions and were again reduced. Finally, we drew conclusions from the paraphrases focusing on our research questions. These results are presented in the following sections.

C. Interviews

To acquire usable data for our study, we asked the participants several questions about their impressions of the simulation. This chapter summarizes the findings of the interviews and gives extracts of the answers that are important for the drawn conclusions.

1) First impression: On the question *What was your impression of the Simulation?* the participants were quite positive. One participant said that the *simulation is uncomfortable almost like in the real world*. Another one said that by *caring for the patient the environment became second*. One participants mentioned that *the tutorial wasn't elaborate enough* and the simulation was *great but buggy*.

2) Tutorial: On the second question *When thinking of the flow, specifically the tutorial, how well did you get through the Simulation?* most participants felt that it was understandable. Although, three people mentioned that they *missed some sort of verbal guidance*, the feedback was rather positive: Five testers categorized it as *very understandable*, two as *understandable* and one as unintelligible. The green transparent ghost headset and controller animations were understood by every tester, and half of them specifically mentioned them positively. One tester mentioned that the that the headset was difficult to understand because it was rotated sideways. Everyone understood that they should listen for whether the patient is breathing and to feel for a pulse. However, two people mentioned that they were *unable to feel a different pulse*. The professional nurse mentioned that the pulse and breath were *not distinct enough*.

The buttons to communicate if the patient was breathing worked great for 6 participants. All of them pressed the correct button. The other two *noticed that there were buttons but didn't know what to do*. After telling them that there are two buttons that can be pressed, they pressed the correct button signaling that the patient was breathing. Notwithstanding that the button didn't work at the first press, none of the participants tried the other button. Everyone understood what the success and fail sound effects mean.

3) Learn: Further on, we asked *Which sequences did you learn from the tutorial?*. There were three sequences we tried to teach:

- If the patient is breathing and has a normal heartbeat you shouldn't do anything.
- If the patient isn't breathing and doesn't have a pulse a heart massage is required.
- If the patient isn't breathing and has an irregular pulse the defibrillator should be used.

Five of the eight tester were able to name the three sequences correctly. Two confounded irregular pulse and no pulse. One tester understood that you should check for a breath, check for a pulse pulse and apply help afterwards. However, he learned that the correct treatment is always applying a heart massage first and *if this doesn't help defibrillate him afterwards*. This tester also mentioned that he couldn't feel any differences between the pulses of the patient in the tutorial.

4) Practice: Afterwards we asked the question *How was it to practice the learned knowledge?*. Six participants *knew what to do* and tried to act accordingly. Two of these six participants had difficulties feeling a different pulse and because of that had issues choosing the correct treatment. One tester didn't realize *that the scenes were different and thought he should practice using the defibrillator*. The tester that had learned to massage and defibrillate afterwards applied this knowledge consequently.

5) Feedback: On the following question *Was there enough feedback?* we received positive feedback. Three people felt there was a lack of information about wrong decisions: When they use the wrong treatment, they would like to get more information on *how to do it right* or *what did I do wrong*. Only one participant missed information about *why a treatment should be applied*. For example *why to use a heart massage when the patient doesn't have a pulse*. All seven other participants didn't miss this information.

6) Realistic scenarios: When asked about their *impressions from the realistic scenarios* most participants accepted them as realistic. Seven of the eight testers experienced the scenarios as *close to reality*. One user mentioned that some of the scenarios are *not realistic scenarios for the country the tester lives in*. One tester experienced the scenarios as unrealistic. Five of the participants didn't feel distraction by these scenarios. They *only focused on treating the patient and didn't focus on the environment* around the patient. The other three participants got distracted form the environment and experienced a *pressing, urgent* feeling.

D. Research Questions

We performed a qualitative content analysis in accordance to Mayring [19] on the gathered interview data. The results concerning our research questions are presented in this chapter.

1) Does non-verbal guidance work in VR?: The conducted interviews confirmed that the non-verbal guidance could help to learn about first aid. In the following paragraphs, we discuss each concept we implemented in accordance with the results of the interview.

Pictographic approach: Showing the user what he should do with a ghost controller and a ghost headset worked really well: All participants were able to understand and perform the necessary movements at the appropriate points. No problems were mentioned. Pictographic descriptions turned out to be helpful to understand the context and be suitable to check what the user learned. Nevertheless, we discovered that this non-verbal approach is not easy to understand for everyone: In our scenario, two out of eight participants did not press any button, because they were *not sure, if the question relates to the breathing of the patient*. Such non-verbal communication seems to be context-sensitive for most participants: When breathing is heard, a volume icon can be understood as breathing. *Auditive feedback*: Commonly used auditive feedback cues like the *pling* and *fail* sound were understood by everyone. However, a fail sound alone did not seem to be enough for most users to communicate failure. Many of them expressed the wish to know what they *did wrong*.

2) Learning in VR: The answers of the participants showed that 5 out of 8 people were able to learn the exact knowledge we tried to teach them. We assume that the feedback from what the user experienced is necessary to strengthen the recently learned knowledge. The simulation requested such feedback after the user heard the breathing of the patient. Feedback like this could be crucial to adopt and gain knowledge in order to use it in a similar situation later on. We came to this conclusion, because checking breath worked way better than the haptic feedback of the controller. The user had to acknowledge checking the patient's breath by pressing a button. This was not done for checking the patient's pulse. As Butler et. al. [20] demonstrated, it is crucial for gaining knowledge to experience this kind of feedback and repetition.

3) Knowledge applied in VR: Some participants had problems to feel the correct pulse or hear the breathing of the patient in one of the stress scenarios. As long as these problems did not break the gameplay, the participants had no problem to apply the knowledge they learned in the tutorial. However, if they learned something else in the simulation - beside what we tried to teach - they applied and strengthened what they learned in the exercises. We assume that this could be reduced by improving feedback when the user fails.

4) Lack of why: A non-verbal approach usually tells the user *how* to do something, but does not communicate *why* he has to do it. Only one out of eight participants expressed the wish to gain more information on why to apply a specific treatment. Despite users being content with the lack of causal information, the authors believe that a causal understanding can be beneficial. It can enable users to generalize their knowledge and apply it to different scenarios that haven't been specifically trained, but require similar problem solving.

5) Stressing scenarios: Most of the participants felt it was a realistic experience. Only one participant did not feel present. However, only two out of eight testers got distracted by the created stress scenarios. All other participants said they focused on the patient and did not get distracted by the simulation. Thus, they expressed no problem with applying the learned knowledge in more stressful scenarios.

E. Discussion

By conducting semi-structured interviews about our simulation, we found out that non-verbal guidance and learning has great potential when implemented properly. Showing what should be repeated is simple. Pictographic descriptions also work well in VR and can be used to learn a lot of information that does not require too much background knowledge like concepts of first aid. In our study 75% of the participants had no problems understanding the created language. The rest did understand the language with minor help. However, it is possible that this language is not universally understandable, because pictographic items such as the used volume icon must also be recognized to interpret such language which is similar to the observations of Shneiderman in another context[4].

VI. Conclusion

Due to the numerous possible ways of implementation, other approaches like a practice-based approach should be evaluated as well. For example the inclusion of an animated manikin that demonstrates the concepts of first aid in the tutorial could be interesting to examine as well.

Not all findings from the conducted explorative study, especially about learning first aid processes in VR, can be directly applied to other fields. For example when learning something where the causality is crucial for applying the gained knowledge, a non-verbal approach might be less suited. To generalize the conclusions more evaluations are needed. However, the study indicates that such a non-verbal approach in VR can help to learn (5 out of 8 participants), but seems to require further improvement to be suitable for everyone.

By creating a more consistent tutorial, making VReanimate compliant to today's first aid guidelines, or making VReanimate more immersive, the results of the study could be improved:

First, results of the study could be improved by a more consistent tutorial: For example users could give feedback whether the felt pulse could be described as *regular* or *irregular*. Such feedback could then strengthen the understanding of this interaction with the patient. Furthermore, if the first three exercises would give better feedback on failure like some participants requested, this could result in more people learning what the correct course of action was. By appropriate direct feedback on how the situation could be resolved correctly, the user could on one hand easily reject wrong knowledge and on the other hand learn the correct process.

Second, the results could be improved by making VReanimate compliant to todays first aid guidelines: Improving the simulation with experts in the field of first aid would lend it more authority and improve the quality of the conveyed information.

Third, using the HTC controllers, the system doesn't give the haptic feedback that can be experienced at a real first aid scenario. Therefore, including tracked gloves like the Manu Gloves [21] could improve the feedback and immersion created in VR. For even more immersion a first aid puppet could be included to gain better feedback when applying the heart massage.

During the survey we could observe an optimistic *I can do it* effect and we are confident that VReanimate is able to reduce hesitation and increase willingness when rendering first aid in a real first aid scenario. Thus, we see this first attempt and evaluation as a promising starting point for further research.

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