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Design of a Virtual Reality and Haptic Setup

Linking Arousals to Training Scenarios: a Preliminary Stage

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ABSTRACT

Using Virtual Reality (VR) to realise immersive training environments is not a new concept. However, investigating arousal in immersive environments is. By arousal, we denote a general physical and psychological activity that in the form of anxiety and stress for example, can affect trainees' performance. In this work, we describe the setup design for a two-phase explorative experiment linking arousal and performance, during training in a Virtual Reality (VR) environment. To do so we are using an appraised well-crafted VR puzzle game, questionnaires (i.e. NASA Task Load Index [3]), and sensors (skin conductance response / pulse). The experiment will involve participants from the public that will be trained in two predefined processes of variant difficulty.

Keywords: Virtual Reality, Haptics, Arousal, Stress, Training.

1 METHODOLOGY

For our investigation we set-up a two-phase experiment, as depicted in Fig. 2, based on an appraised immersive puzzle-type VR game (i.e. "I expect you to die" Schell Games, Pittsburgh, PA 15219, U.S.). Our choice to choose and the aforementioned experience originates in the growing attention of the scientific community and industry to serious gaming and its role in training scenarios [2]. Two parts of the game (level 1 and level 3, referred from now on as *Process 1* and *Process 2*) were included in this experiment due to their variant difficulty (easy and medium levels). The two processes were mapped, analyzed, split in sequential tasks and documented. Trainee's objective is to follow the sequence of tasks and complete the process. As one would in any training scenario.

Phase 1 – The participant/trainees after signing the consent form and answering a general questionnaire (to generate profiles), are introduced to the experiment physical environment, seated and the sensors connected. Next, the scenario and objectives are explained by the researcher acting as a trainer, and a sort familiarization time with the VR headset, controllers and environment is allocated. The manual for *Process 1* is presented and after five minutes of study the VR training for *Process 1* starts with the following sequence:

- 1st try with oral assistance (e.g. by our researcher).
- 2nd try with oral assistance if required.
- 3rd try with no oral assistance (maximum 5 trials or 10min in case of failure to complete).

Figure 1: Phases and Processes scheme.

The trainee is then given a short brake and VR training for *Process 2* commences with oral assistance, and maximum 5 trials in case of failure, given the challenging level design.

With the completion of the training for process 2 (either a successful completion or not) the trainee answers a general questionnaire about his/her experience and the NASA Task Load Index [1] to account for his/her performance.

Phase 2 – After a period of 12-15 days the participants repeat the experience. Starting with a questionnaire to record if any of the profile elements have changed (i.e. they might have been using VR or watching online videos of the game) the same procedure is followed as for the Phase 1.

With the completion of the training for process 2 (either a successful completion or not) the trainee answers a general questionnaire about his/her experience and the NASA Task Load Index to account for his/her performance.

2 VR SET-UP AND SENSORS

The setup is shown in Fig. 2 with all the elements employed during the experiment sessions.

The user in Fig. 2 wears the sensors measuring skin conductance and heart rate. Both sensors are connected to a smartphone to collect and store data. To synchronize the setup of the sensor and data recording, a timer is displayed on the computer screen and starts when the virtual reality scenario is loaded, as seen in Fig. 2. The observers are able to see the user's VR scenario through two screens displaying the camera view, the game frame and the timer. The screen output is captured via software and stored for triangulation of data

3 HAPTIC STIMULI

In this preliminary stage the haptic stimuli is still missing, however, we are preparing the setup to use the device presented in [1] reduced to two single motors. We are planning to generate stimuli (soft skin stretch, and low frequency vibration) inside specific periods of the training session. This, we hypothesize,

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Figure 2: Researcher testing the set up and sensors. The experimental scenario is composed by the virtual environment, a timer and the camera image capturing the action of the trainee. Sensors measure pulse and skin conductance for post processing analysis.

could modify arousal, affect the behaviour of the trainees' and probably the training process consequently. Yet, apparently further research is required and we plan a Phase 3 to include such investigation.

4 DISCUSSION

Summarizing the data analysis generated in Phase 1, it can be stated that VR was depicted as a preferred training method with distinctive indication that oral guidance during the VR training was a helpful aid to complete the task. While the use of a manual was proven somewhat helpful, however should be kept as an optional tool for trainees.

Performance – Preliminary observation on the trainees' performance revealed that all participants increased performance (reducing execution time and error frequency) as the training progressed from Phase 1 to Phase 2. On the other hands, some variation was evident in *Process 2*, presenting a more complex task sequence respect to *Process 1*. The group having previous VR experience performed better both in time and error-frequency. Yet, a closer inspection with more data, from *Phase 2*, might provide a clearer identification of the value of this observation.

Repeating processes overtime helps to create stronger connection within the brain sectors responsible for memory formation parts, encoding (categorising experience), storage (placing it), and retrieval (ability to member information) [5]. With this in mind, we invited subjects to participate in Phase 2 of the explorative experiment so as to determine whether or not the information from Phase 1 has been stored in their long-term memory. This was tested by a comparison between Phase 1 and Phase 2 processes Serial Reaction Time (SRT) (e.g. for measuring implicit learning). Our results showed a gradual time reduction on average. This gradual time reduction, performing the same task in several times on a row, depicts subjects' growing expertise in the task [4] (Robertson, 2007).

In more detail, it was possible to observe, that the majority of subjects had performed *Process 1*, with 19th critical subtasks, better in Phase 2 than in Phase 1, when their first encounter with the task occurred. This was expected. The interesting observation is that the data for the more complicated *Process 2*, with 37 critical subtasks, revealed, is that it was performed faster in Phase 1 rather than Phase 2. However, it took less tries in Phase 2 to

complete the task. In other words, people took more time in Phase 2 but increased their efficiency considerably.

Arousal – Since this is a preliminary publication, the data from the two sensors have not been integrated and analyzed yet as post, processing results is in progress. Yet we inspected the data and considered them as a measure to crosscheck validity of findings. To this end, observing the video capture of the trainees' experiences, it can be reported that: a) by inspection both from VR experienced and no-VR experienced participants the start and end of the immersive experience is evident by high arousal levels (spikes) and b) VR experienced participants express different arousal values than no-VR experienced. Preliminary data depicted that while no-VR experienced participants produced high arousal during VR experience the VR experienced revealed no traceable difference being in a VR experience or not (e.g. a non-VR experience was studying the manual). In other words, the VR experienced users considered their immersive environments quite normal. Yet further analysis is required.

5 CONCLUSION AND FUTURE WORK

A preliminary setup status for explorative experiments in VR training scenarios linking performance and arousal is presented. In this work the methodological and technological perspective has been introduced, while the haptic test performances is still in progress. Initial observations pointed out both the intention to integrate different biometric sensors but also points the attention to evidence VR and no-VR experience users' differences. Despite more investigations are in progress, preliminary findings highlighted different performances in Phase 1 and Phase 2 of trainees. In particular, Phase 1 concluded with subjects' best time performances, while Phase 2 (in both *Process 1* and *Process 2*) with the minimum number of failures and, in other words, more efficient tasks. This leaves space to further investigations. One of this focuses on analysing the role of haptics for this training scenario. This will be integrated in the experiment in a successive Phase 3. The haptic device, presented in [1] is designed to provide cutaneous stimuli for navigation purposes, and is composed of four different modules, each of them containing a motor. In this study a reduced version using only two motors will be employed, in order to reduce the complexity of the stimuli provided. According to the device working principle when the motors are rotating along the same direction, they generate a transversal soft skin stretch on the forearm. Moreover, it is possible to control the rotational speed of each motor and this allows to us to create profiles of cutaneous vibrations, with different magnitudes and frequencies. Given the presented design, the study in Phase 3 will involve the generation of vibrations and soft-stretch to analyze how such cues alternate the arousal and memorization process in task sequence.

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