This is the accepted manuscript (post-print version) of the article. Contentwise, the post-print version is identical to the final published version, but there may be differences in typography and layout.

**How to cite this publication**
Please cite the final published version:

doi: 10.1109/VR.2018.8446528

**Publication metadata**

- **Title:** Design of a Virtual Reality and Haptic Setup Linking Arousals to Training Scenarios: A Preliminary Stage
- **Author(s):** K. Kournaditis, F. Chinello and S. Venckute
- **Proceedings:** 2018 IEEE Conference on Virtual Reality and 3D User Interfaces
- **DOI/Link:** [https://10.1109/VR.2018.8446528](https://10.1109/VR.2018.8446528)
- **Document version:** Accepted manuscript (post-print)

---

**General Rights**
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Design of a Virtual Reality and Haptic Setup
Linking Arousals to Training Scenarios: a Preliminary Stage

Konstantinos Koumaditis¹, Francesco Chinello², Sarune Venckute³
Dep. of Business Development and Technology, Herning Campus, Aarhus University

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 10 min in case of failure to complete).

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 the 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,
Preliminary observation on the trainees', presenting a more complex rather than Phase 2. However, it took less tries in Phase 2 to critical subtasks, revealed, is that it was performed faster in Phase is that the data for the more complicated the task occurred. This was expected. The interesting observation subjects had performed (Robertson, 2007).

Our results showed a gradual time reduction on average. This tested by a comparison between Phase 1 and Phase 2 processes experiment so as to determine whether or not the information we invited subjects to participate in Phase 2 of the explorative 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 over time 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.

REFERENCES