Report on experiment supported by the Visionair project: Effect of Visual and Auditory Feedback Modulation on Embodiment and Emotional State in VR

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1 General Information

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Supervisor: Dr. David Swapp, UCL, London, UK
Timeframe: 08/12/2014 - 19/12/2014
Location: One Euston Square building

2 Motivation

Immersive virtual reality is a perfect medium to study complex human behaviour by simulating an environment close to the real world and yet controlling its properties. In this project we modify auditory and visual feedback in VR to investigate the impact of the modification on human behaviour and the emotional state of the participant. The auditory aspect of the feedback modulation consist of changing the sound frequency of the footsteps played back to the user. The visual aspect of the feedback modulation involves changing the gait motion pattern of the self-animated avatar. During the experiment, full body motion of all participants was captured with the state-of-the-art equipment in 3D at high frame rate. Additionally, several times during the experiment the participants were asked to report their emotional state, the degree of the illusion of presence, and perceived body shape. According to our hypothesis, higher sound frequency of the steps and/or

changing human gait towards a happier, more energetic walk will have an effect on the participant's motion trajectories when walking in place in front of a virtual mirror. The reported degree of embodiment of the avatar in the virtual environment, the degree of the illusion of presence, their own body perception and emotional state could, according to our hypothesis, also be influenced by the manipulation. Potentially, this VR setup can be used as a mild positive emotion induction technique. It can be also used as exercise encouragement for people who are otherwise reluctant to do sports.

3 Experiment setup

3.1 Hardware

The experiment used a combination of several pieces of equipment (also see Figures 2-5 in Section 7):

- Oculus Rift head-mounted display, development kit 2
- OptiTrack motion capture system
- Stereo pre-amplifier (SP-24B)
- A stereo 9-band graphic equalizer (Behringers MINIFBQ FBQ800 Ultra-Compact)
- Closed headphones with high passive ambient noise attenuation (Sennheiser HDA 300)
- A pair of strap Arlington sandals by Earth Spirit (EU size 42)
- A pair of Core Sound binaural microphone set; frequency response 20-20000 Hz, attach ed to the sandals with a clip.

3.2 Software and web servises

- Unity3d game engine
- Motive software, part of the OptiTrack motion capture system
- Google Forms for questionnaires
- Body shape visualiser[1], developed in MPI IS Perceiving Systems Department

3.3 Experiment procedure

Each experiment session proceeded as follows. After the participant was instructed about the structure of the experiment and signed the consent form,

[1] www.bodyvisualizer.com

they were helped into the motion capture suit, shoes, head-mounted display and headphones. After the initial calibration was finished, the experiment began.

The experiment consisted of two separate parts. In the first part the participants performed two similar blocks, wearing only the head-mounted display, motion capture suit and the shoes with the microphones. After the two blocks were over the participants took a break of several minutes and then proceeded with four more blocks, this time adding the headphones to the setup.

Full-body motion of the participants was captured with the help of Motive software as part of the OptiTrack system and mapped onto a self-animated stick figure avatar that represented the participant in the virtual environment. The position of the stick figure avatar was co-located with the position of the participant. By looking down the participants could see the legs of the stick figure, by bringing their arms up in front of their faces the participants could see the virtual arms.

The virtual environment was represented by a simple room that contained a virtual mirror and two pillars at the sides of the mirror. In each block the participants performed a walk-in-place task while viewing a virtual environment via the head-mounted display. The participants were asked to look at their reflexion in the virtual mirror. They were asked to walk in place when the pillars at the sides of the mirror were green and to stand in a relaxed manner when the pillars were red. Each block started with an accommodation phase, giving each participant enough time to get accustomed to the virtual environment as well as to make sure that the experiment setup, e.g., the head-mounted display, the motion capture and the virtual environment rendering were working properly. After that a succession of standing and walking phases ensued. Each phase lasted for 20 seconds, each block consisted of 5 walking and 5 standing phases in alternation, each block ending in a walking phase. After each block the participants were asked to remove the head-mounted display and to fill out three intermediate questionnaires (see Section 4.2). At the end of the experiment session the participants were helped out of the equipment and asked to fill out three post-questionnaires (see Section 4.3), compensated for their participation and debriefed upon the research goals of the experiment.

3.4 Experiment Manipulations

In this experiment we combined manipulations of two kinds of feedback — visual and auditory. In the first two blocks (Table 1, Part 1), where the

participants were not wearing the headphones, only the visual feedback was manipulated. In the following four blocks (Table 1, Part 2) both auditory and visual feedback were manipulated. Six conditions were thus acquired by combining the manipulations presence or absence, within each part the order of the conditions was randomised for each participant.

Part	Condition	Visual manipulation	Auditory manipulation
1	1	absent	
1	2	present	
2	1	absent	absent
2	2	present	absent
2	3	absent	present
2	4	present	present

Table 1: Experiment conditions. The order of the conditions was randomised for every participant in each part.

3.4.1 Visual feedback manipulation

In the blocks where the visual feedback manipulation was present the gait of the stick figure in the virtual environment was slightly altered. Namely, several joint angles of the underlying skeleton were scaled by joint-specific factors. The scaling factors are based on systematic comparison of neutral and happy walking patterns generated by Prof. Niko Troje as part of his research on human gait patterns and their parameters [1].

The largest scaling factors, as the result of the calculation, have been applied to the lower arms and the upper legs, causing an amplification of the joint angles. Thus, when a participant was lifting their leg in the real world by X degrees, the resulting angle between the upper leg and the body applied to the stick figure in the virtual environment was X+N, where N was a positive angle defined by the [X*scaling factor] equation. None of the participants have reported noticing the visual manipulation although it was present in three blocks out of three.

3.4.2 Auditory feedback manipulation

In the second part of the experiment, consisting of four walking blocks, the participants wore the headphones which allowed us to manipulate the sound of their footsteps. In all the four blocks the sound of the footsteps,

captured by the microphones attached to the shoes, was generally amplified. In two out of four blocks the frequency profile of the footstep was changed by dampening the lower frequencies and amplifying the higher frequencies of the sound spectrum. This manipulation was based on previous research by Dr. Ana Tajadura-Jimenez (in press).

4 Collected Data

4.1 Recorded motion capture

Each walk-in-place block was recorded by the OptiTrack motion capture system. Since in each block the participants performed five walk-in-place exercises, 30 20-second-long walking sequences were captured for each participant at the 100 FPS rate. These motion sequences will be analysed to find out whether auditory and/or visual manipulations have had any effect on the gait style as compared to the blocks with one or both manipulations absent.

4.2 Intermediate questionnaires

After each walking block the participants were asked to fill three questionnaires that aimed to record their emotional and cognitive state changes as the result of acting in the virtual environment. The order of the questionnaires was the same after each block — 1) emotional state, 2) presence, and 3) body shape.

4.2.1 Emotional state

In this questionnaire the participants were asked to report their emotional state by choosing a corresponding value on a 5-point Likert scale for the affect dimensions of 1) valence, 2)arousal, and 3) dominance. The order of the scale remained the same in each response session.

4.2.2 Presence questionnaire

The presence questionnaire was built upon the Presence Questionnaire developed by [2]. The order of the 18 questions were randomised for each response session, the participants were asked to respond by choosing a corresponding value on a 7-point Likert scale, depending on how much they, e.g., agreed with a statement expressed in the current questionnaire item.

4.2.3 Body shape estimation

In this task the participants were asked to adjust the shape of a 3D human figure until the overall shape matched their perceived body shape in the virtual environment. Hidden from the participant, the estimated weight of the resulting shape was recorded by the experimenter (see Figure 1). In the beginning of each block, the height and the weight of the 3D human figure was adjusted. The height corresponded to the one of the participant, while the weight was randomly set to the participants weight plus or minus 25%. The plus or minus adjustments were balanced for each experiment part and performed twice after each walking block.

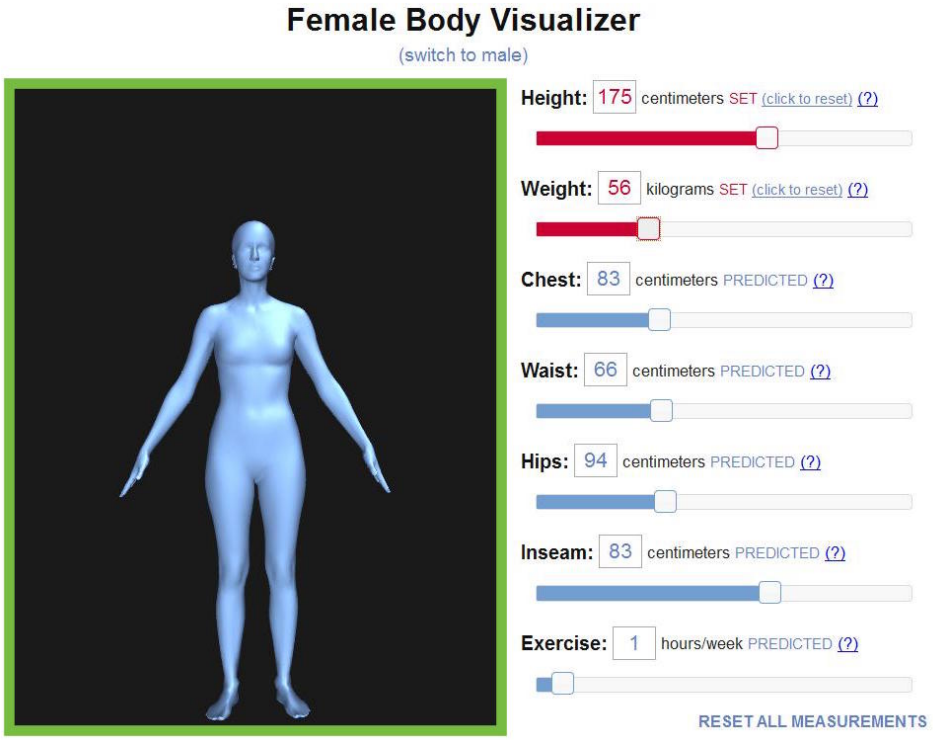

Figure 1: Screenshot of the body shape estimation task. Only the part framed in green was visible to the participant. The current figure represents one of the two possible starting points for a female participant 175 cm tall and 75 kg heavy. In this case the starting point is set to the "-25% off participant's real body weight"

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4.3 Post-questionnaires

4.3.1 "Big 5"

The short version of the "Big 5" questionnaire [3] has been used to record the major facets of the participants' personalities. The participants have been asked to estimate their measure of agreement with each of ten questions on a 5-point Likert scale. The order of the questions was randomised for every participant.

4.3.2 Eating Habits

Since during the experiment the participants were asked to estimate their perceived body shape, it was important to control for possible eating disorders, which was done by asking the participants to fill out the eating disorder questionnaire [4]. In this questionnaire the participants are asked to report their eating habits for the last 28 days, as well as their attitude towards their body weight and body shape.

4.3.3 General Questions

In this short questionnaire the participants were asked to report their gender, age and handedness. These questions had not been asked in the beginning of the experiment in order to avoid trigging any bias in the participants' answers and behaviour. Their height and weight was asked in advance under the excuse of motion capture system calibration. The body height and weight were used in the body shape estimation tasks.

5 Participants

Twenty four participants (eleven male) took part in the study. Two participants, one male and one female, had to be excluded from the study due to the technical problems with the equipment during the experiment. The behavioural data from the remaining 22 participants will be analysed in the following months. None of the participants reported motion or cyber sickness. Informed written consent was obtained prior to each experiment session. Participants' and data from participants were treated according to the Declaration of Helsinki. The recording methods of the database and the subsequent validation experiment were approved by the local ethics committee for the University College London (Project ID Number: Staff/1213/003).

6 Acknowledgements

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References

[1] Troje NF (2002) Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. Journal of vision 2.

[2] Witmer BG, Singer MJ (1998) Measuring presence in virtual environments: A presence questionnaire. Presence: Teleoperators and virtual environments 7: 225–240.

[3] Gosling SD, Rentfrow PJ, Jr WBS (2003) A very brief measure of the big-five personality domains. Journal of Research in Personality 37: 504 - 528.

[4] Fairburn CG, Beglin SJ (1994) Assessment of eating disorders: Interview or self-report questionnaire? International Journal of Eating Disorders 16: 363–370.

7 Supplementary Figures: Experiment Setup

Figure 2: Oculus Rift DK2 head mounted display

Figure 3: Full body motion capture with OptiTrack, motion capture suit

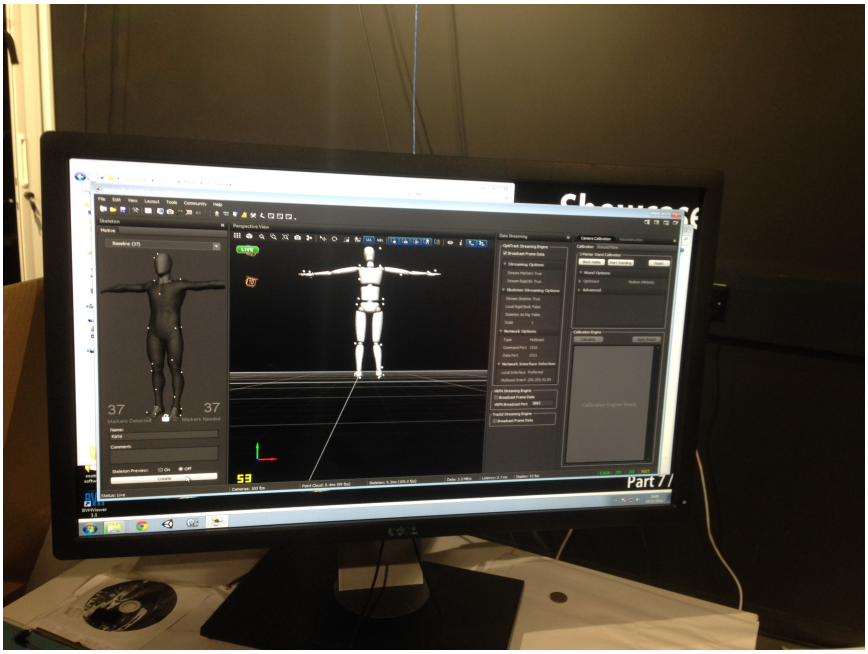

Figure 4: Full body motion capture with OptiTrack, Motive software

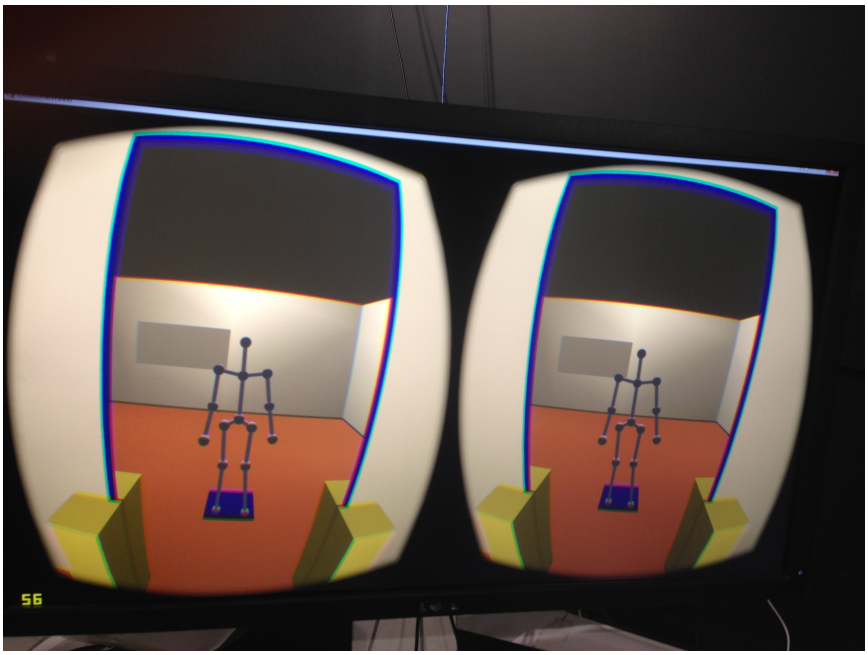

Figure 5: Stick figure in the virtual environment, reflected in the virtual mirror, desktop representation of the Oculus Rift stereo view rendering