Validating hyper-reoriented walking in Virtual Reality

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Kurzfassung: We present a first attempt in validating a technique named hyper-reoriented walking, which was developed for overcoming spatial limitations when simulating large scale spaces in Virtual Reality. In this first attempt, we investigate whether effects of various types of stress on the spontaneous alternation behavior are detectable in a simulation based on hyper-reoriented walking. For this purpose, participants with different personality traits performed a walking task in a virtual maze while they were exposed to different types of stress. Our results show that spontaneous alternation behavior is affected by the type of stress with a significant difference in the number of alternation turns occurring in participants with different personality traits. This outcome supports the utility of the hyper-reoriented walking technique when investigating behavior in Virtual Reality.

Schlüsselwörter: Virtual Reality, Simulation, Stress, Locomotion, Redirection, Maze

1. Introduction

Virtual Reality (VR) has become a popular tool also in behavioral experiments, such as in user studies for testing products, robot – human – collaboration, work organization, and more. VR enables to save time and costs in setting up and running experiments. Furthermore, in VR it is possible to investigate effects of physically unreal situations and to simulate risky scenes without exposing participants to the physical risk, as for instance when investigating pedestrian crossing decisions with autonomous cars (Qi et al. 2023).

One major constraint of VR is the spatial limitation of the so-called game area, the physical area in which the user in VR is tracked. In an earlier work, we presented the hyper-redirected walking (HRW) as a viable solution to the spatial constraint in VR (Ropelato et al. 2021). HRW applies for game areas of any size but is particularly useful, when the game area is small (e.g. 2m x 3m) and the simulated space very large (e.g. infinite). HRW is based on an illusion forcing the user to walk within the small gaming area and does not introduce disturbing or noticeable effects.

After the proof of concept of HRW, we are now investigating the validity of the HRW technique when applied in various settings of user studies. The concept in our validation is based on the reproducibility of known behavioral effects in VR when using the HRW technique. In this contribution, we will present results of a first validation experiment, investigating the Spontaneous Alternating Behavior (SAB, Pate et al. 1971) and

effects of various stress on SAB in user with different Big Five personality traits (Goldberg 1990).

2. Method

A total of 20 participants were recruited for our experiment. Participants were screened for Motion Sickness with the Motion Sickness Susceptibility Questionnaire (MSSQ-short) by Golding 1998, 2006) and a maximum MSSQ score of 30 was applied. The remaining 17 participants had an average MSSQ score of 5.53 (SD=4.6) and their average age was 25.2 y (SD=4.5). Before starting the experiment, the remaining participants completed The Big Five Inventory with 10 question items (BFI-10, Rammstedt & John 2007), in order to assess the participants' Big Five personality traits.

For the experiment, a virtual maze was implemented in VR using the game engine Unity (Unity technologies, San Francisco, California, USA). The maze was presented by means of a head mounted display (HMD, HTC Vive Pro, HTC, New Taipei City, Taiwan). Fig. 1 shows the aisle of the maze as seen from the perspective of the participant. At random and after each turn, a coin was presented at the end of the aisle. The virtual maze had a length of 3 m and the width of the aisle was set to 1 m. The end of the aisle was a T-shape bifurcation where the arms of the bifurcation crossed the aisle at an angle of 90°. When arriving at the end of the aisle, participants could enter either the right or the left arm of the bifurcation. While turning 90° in the virtual maze, the HRW illusion forced the participants to exhibit a 180° turn in real space. Therefore, participants walked back and forth between the two turning points.

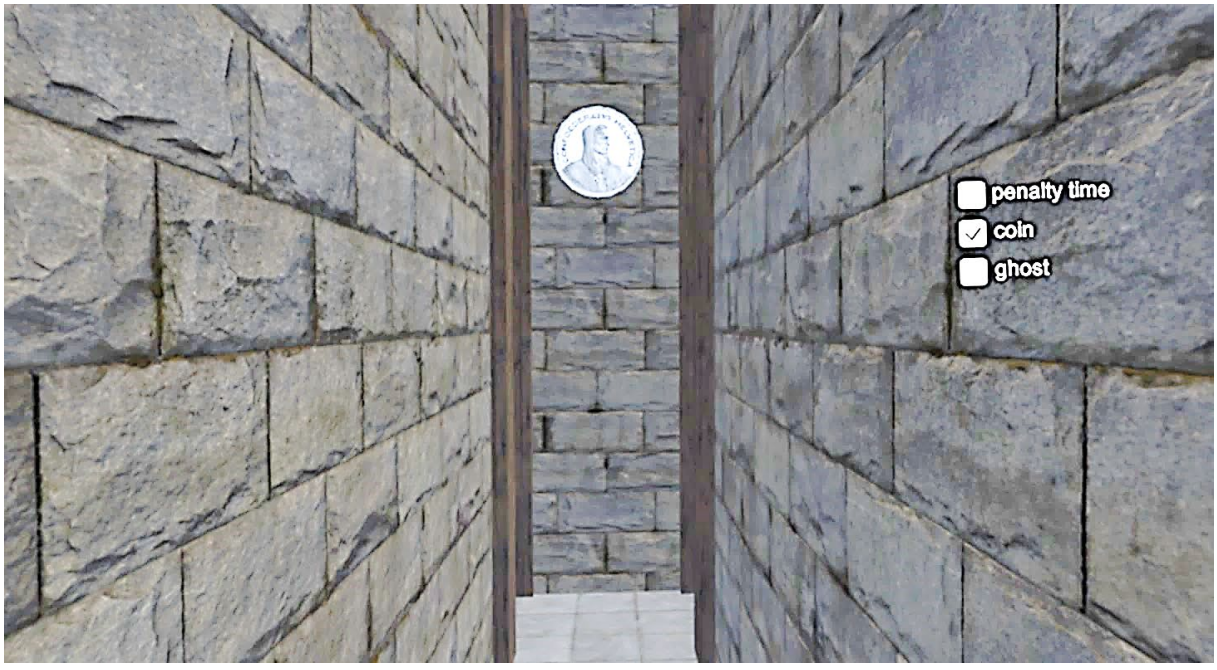

***Figure 1**: View of the virtual maze as seen from the perspective of the participant. The coin at the end of the aisle appeared randomly after the participant had performed the turn at the other end of the aisle. The checkboxes on the right hand side were only visible to the experimenter and served to select the experimental setting, which were no stress, temporal stress, and fear (ghost).*

Participants were asked to collect as many coins as possible, which were randomly appearing at the ends of the aisles of the maze. The task was repeated for three conditions of stress: no stress, temporal stress, fear. Fear was produced by introducing a background sound of the laughter of the ghost and creaks caused from its walking on an old wooden floor. Participants were told that coins were lost in case they were caught by the ghost.

For each stress condition, participants performed a total of 16 turns. The HMD was tracked during the whole experiment. A Unity script evaluated the turns and stored the direction of each turn with a time stamp in an excel file for further processing.

The study protocol was approved by the ethics committee of the local university.

3. Data Analysis, Results, and Discussion

From stored data, successive turns were analyzed to compute the number of alternations, which is the number of sequences in which the participant turned in an opposite direction when compared to the previous turn. For instance, if a participant first turned clockwise and in the next turn the participant turned counterclockwise, this was counted as an alternation. Alternation turns are considered as the normal behavior, when exploring an environment without specific instructions on the path to take. According to Riechmann et al. (1986), alternation behavior in path has been observed across different species including high- and low-level species such as simple cell organisms.

Based on the BFI-10, participants’ results were sorted into groups according to the expression of their traits (high, low) considering reference data reported in GESIS (2010).

The proportion of alternation turns was evaluated with binomial tests, one for each stress condition. The number of alternation turns was compared across stress conditions and personality trait groups by means of an analysis of variance (ANOVA).

The result of binomial tests showed that the proportion of non-alternation turns was not as expected, indicating a failure in revealing spontaneous alternation behavior. This result is true for all three stress conditions tested.

When considering individual personality traits, results show that participants with a high level of neuroticism trait showed a higher average of non-alternation turns (which is “abnormal”) in all three stress conditions. Participants with a high level of openness trait showed a lower average of non-alternation turns when compared to participants with a low level of openness trait.

Further results as well as the detailed statistical analysis of the results will be published in the near future elsewhere.

4. Conclusion

The results show that the present VR environment using hyper-reoriented simulation is valuable for studying spontaneous alternation behavior in human. Significant effects of stress on the spontaneous alternation behavior require to consider individual personality traits.

In conclusion, results support the validity of the VR scenario in which hyper-reoriented walking is used.

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