Effect of active navigation in an Immersive Virtual Environment on memory

1 MATERIAL USED AND CREATED DURING THE PROJECT

1.1 TOOLS / SOFTWARE / DATA AND OTHERWISE EXISTING THINGS USED IN THE PROJECT

- HTC Vive head-mounted display
- Unity 3D
- Rey Osterrieth complex figure test, used in order to test baseline spatial memory ability
- A4-sized papers & pens

1.2 SOFTWARE / DATA AND OTHER THINGS CREATED AS PART OF THIS PROJECT

- An Immersive Virtual environment where one can walk through by use of a joystick, while wearing a Virtual Reality Headset.
- Scripts for recording and replaying the movement of a player
- Setup for experimental tasks:
    - Free recall of the objects in the environment, measured by how many out of the total number of objects had been guessed right. A set of 12 different kinds of fruits and vegetables were used as objects.

      Recall of the environment (spatial memory), as tested by drawing a map/layout of the environment, measured roughly by how close the drawn map was to the actual environment. For comparison, we drew a map of the correct layout ourselves and divided it up in 10 separate parts. For each part a subject drew correctly, he/she received a point. A maximum of 10 points could be gathered. Misplacing an otherwise correct part would net 0.5 points, as would correctly placed but distorted (yet recognizable) piece.
    - Cued recall, providing the objects in the environment and a map, and letting the participants choose at what point they had seen the object. Measured by how many of the objects had been placed in the correct position (out of 12). We have used a map of the environment with the correct object locations for comparison.

2 Research focus and aim

2.1 Research topic / general goal or context

Active learning is defined as "anything that involves students in doing things and thinking about the things they are doing" (Bonwell & Eison, 1991). Research has demonstrated the benefits of active learning over passive learning (Markant et al., 2016), which is a valuable notion for the development of effective educational programs. With the use of (Immersive) Virtual Environments (IVEs) becoming more and more mainstream in education, it is important to know how active learning can be implemented utilizing this piece of technology.

2.2 Research problem

As stated in 4a, the issue at hand is how active learning can be implemented in IVEs. Several possibilities are considered, including control over how long stimuli are presented for, sensorimotor control over the stimuli that are presented, and active control over one's navigation through the IVE.

2.3 Research purpose

The current study's objective is to investigate whether active control over one's navigation in an IVE leads to better spatial memory of the IVE and recall memory of images in the IVE, compared to being navigated passively. A yoked experimental design is used, where each active participant's path is tracked, which is then followed by a paired passive participant. The results of this study can be interesting when designing an IVE for educational purposes.

2.4 Research question

Does actively navigating through an IVE by use of a joystick leads to better spatial memory of the IVE, and better recall memory of images spread throughout the IVE, compared to passively following a predetermined path?

2.5 Hypothesis or objectives

- We expect that active navigation through an IVE leads to better performance on spatial memory tasks.
- We expect that active navigation through an IVE leads to worse performance on recall memory tasks.

Elaboration: results from previous studies have shown that active navigation leads to better spatial memory of the IVE (Plancher et al., 2013; Brooks, 1999), which can be explained by better memory consolidation due to active motor control and goal-directed decision making (Markant et al., 2016). The Plancher and colleagues (2013) study also found that active navigation leads to worse recall memory of objects in the environment, possibly due to an increased allocation of cognitive resources to navigation and goal-directed decision making.

3 EXPERIMENT, RESULTS, ANALYSIS & DISCUSSION

3.1 OVERVIEW

We wanted to measure the effects of active versus passive navigation through an IVE on spatial and recall memory, to expand the knowledge of how IVEs can be used for active learning. To this end, we randomly divided participants into two conditions: an Active Condition in which participants were able to traverse an IVE by use of a joystick, and a yoked Passive Condition in which participants passively followed the path that was generated by a paired participant in the Active Condition. 16 participants were included in the between subjects yoked experiment, equally divided over both conditions. Participants signed a form of consent, indicating they could stop the experiment at any moment, and making them aware of the risk of motion sickness present in Virtual Reality studies. The participants were also asked how much gaming experience they had on a scale from 1 to 7. The experimental tasks will be explained in the following paragraph.

3.2 TASKS

Baseline memory measure. Since we used memory as a measure of learning, each participant completed a baseline memory task to check if memory abilities were equal between groups. To this end, we used the Rey Osterrieth complex figure task. The complex figure is shown to the participant for one minute, after which the participant is given a distraction puzzle for three minutes. Then, the participant is asked to redraw the complex figure from memory. A standardized grading system is used to score each participant on baseline memory skills.

VR task. We created an IVE for use with the HTC Vive we had at our disposal. The environment was based on a Japanese city, consisting of a parking lot, and multiple streets intersecting at different points. Each participant started at a random location and was present in the IVE for five minutes. Scattered throughout the IVE were billboards with images of fruits or vegetables on them, which were used for the recall task. To ensure the participants made an effort to process the environment, they were told to look for an NPC (Non-Player Character) that would be somewhere in the IVE. The NPC was not present, however. Furthermore, participants were told to try to remember as much about the environment as possible.

Spatial and recall memory tasks. When the VR task was finished, several memory tasks were administered. To measure recall memory, the participants were asked to write down as many fruits and vegetables that were depicted on the billboards as they could (Free Recall Task). A total of twelve billboards were present, and participants were graded on the number of correct images remembered. Furthermore, since a profound component of spatial memory is the formation of a cognitive map, one of our measurements was redrawing from memory a map of the environment (Map Drawing Task). This map was graded on the number of correct streets and intersections, as well as whether these streets were drawn correctly in relation to one another. A maximum score of 10 was established. Three experimenters graded the maps in agreement, blind to the condition the participant was in. Another aspect of spatial memory is the use of landmarks to identify one's position in an environment. We therefore devised a task where participants had to point out on a correct map of the environment where they encountered which billboards (Cued Recall Task). The images depicted on the billboards were presented to them on a computer screen. The amount of correctly placed images was calculated as a score.

3.3 RESULTS

Paired t tests were performed to check for significant differences between conditions. No significant difference was found for any of the tasks, however. The means and standard deviations (SD) are shown in Table 1. Furthermore, the mean gaming experience of the participants were equal among both conditions.

		Map Drawing	Free recall	Cued recall	Rey Osterrieth (baseline)
Active condition	Mean	5,2	7,3	3,3	20,9
	SD	2,4	3,7	3,6	5,1
Passive condition	Mean	5,9	7,3	3,8	23,3
	SD	2,9	1,2	2,8	5,7

Table 1. Means and Standard deviations (SD) for both conditions on all four tasks. No significance was found for any of the tasks.

Removing outliers, and excluding data from participants that indicated experiencing motion sickness did not change the results.

3.4 DISCUSSION

There was no significant difference between the conditions on the Rey Osterrieth task, this means participants in both conditions displayed the same level of baseline memory. Unfortunately, there was a lack of significance between conditions in all three other tasks. This leads us to reject our hypotheses: based on our findings we must conclude that active navigation through an IVE does not lead to improved spatial memory, and does not lead to decreased recall memory of the environment. This is in contrast with results from previous studies (Plancher et al., 2013; Brooks, 1999). There are several possible explanations for our findings.

First, it could simply be that we did not include enough participants in our study, which could lead to individual differences playing a too big role. Furthermore, even though the memory tasks we used showed great similarity to those used in other studies that did get significant results, they were not standardized, neither did we have the opportunity to validate them beforehand. It could be that our tasks fail to measure the components we intended to measure (evidence that speaks against this: scores on the Rey Osterrieth task significantly correlated positively with the Map Drawing Task and the Cued Recall Task). Lastly, it could be that our IVE did not lend itself adequately for the purpose we intended. It could be that our environment was too complex, or perhaps too simple, for differences between active and passive navigation to emerge. More thorough analysis of how IVEs are processed spatially is needed to answer this.

Due to what is described above, any contributions our study has made to the field of active learning in IVEs should be stated with caution. Since the influence of active navigation in IVEs on memory has not yet been thoroughly investigated, our findings could be interpreted as casting doubt on previously demonstrated results. Perhaps more research is needed to draw robust conclusions regarding the matter. It could also be that the degree to which one feels one is navigating through the environment is of importance. As stated earlier, in our study participants traversed the IVE by use of a joystick, which might not adequately simulate actual walking. This is in contrast with the Plancher and colleagues (2013) study, where participants used a steering wheel and a gas pedal, which accurately mimics a situation of actual driving. An idea for future research could be to incorporate different levels of realism of navigation, to see if this has any influence. For now, we consider our project as a very educative experience regarding scientific experiment, and hope we will get the chance to expand upon the findings we have currently made in the future.

4 REFERENCES

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