VR in Psychological Education: Using 360-degree Videos to Teach Students About Dementia

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Abstract

Virtual reality (VR) has been shown to have a positive impact on learning procedural knowledge, and knowledge related to spatial processing. In this study we investigated whether virtual reality could aid learning of contextual and declarative knowledge, specifically knowledge about (neuro)psychological diseases. Seventy-one participants were tested in two experimental groups and one control group. Within the experimental groups, participants were either asked to watch four short virtual reality simulations of patients with dementia, or to read a short text about them. We assessed their knowledge with twenty questions about the studied material. Participants also answered questions about their stress level and filled in the Toronto Empathy Questionnaire. We found that participants who were asked to read about dementia scored significantly higher on the knowledge test than participants in the control group ($p < .01$). Participants who were asked to watch the VR simulation did not differ significantly from the other two groups on their knowledge test scores ($p > .10$, in both cases). Additionally, participants in the reading group showed higher levels of stress after completing the knowledge test than participants in the VR group ($p = .03$). We did not find any effects of empathy on learning ($p = .66$). These results suggested that the text method is superior to the VR method and to not studying. The results further suggested potential in the VR method seeing the performance in this group lay between the reading and control groups. We concluded that the materials used in this study might have partially obscured the effect of the VR method. The videos were originally made for nursing students, and not to match the questions of the knowledge test, which could have caused discrepancies between the two. As the effectiveness of text was demonstrated, we suggest integrating it in the VR method which could lead to an improvement of the effectiveness of studying with VR materials.

Layman's Abstract

In this study we investigated whether virtual reality (VR) could be used in (neuro)psychological education. VR has previously been tested in other types of education where it was found to have positive influence on learning procedures or knowledge where the ability to relate objects spatially plays an important role.

We tested 71 participants in three different groups: one group was asked to watch four short VR videos of people with dementia, another group was asked to read a short text about people with dementia, and the third group did not have to study any material. Afterwards, all participants completed a 20-item knowledge test about the material they studied. Additionally, we measured participants' stress and empathy levels.

We found that the reading group achieved the highest scores followed by the VR group. As expected, the control group achieved the lowest scores. Additionally, we found that participants in the reading group reported higher levels of stress than participants in the VR group. We did not find any effect of empathy on learning. Based on the results, the text method was more effective than the VR method and not studying. The VR method did not significantly differ from either group, however its scores lay between the reading and the no studying groups.

We concluded that while we did not find a positive effect of the VR method in this study, the materials we used could have partially obscured the method's effect, because they were originally created for nursing students. As the videos were not made specifically to match the questions of the knowledge test, this fact might have led to discrepancies between the two. Seeing the effectiveness of the text method, we suggest integration of text in the VR materials, which could help improve understanding of the concepts shown in the videos.

Introduction

Virtual Reality in Education

Virtual reality (VR) has seen a substantial rise in popularity in the last decade. The entertainment industry played a big part in this development as we have seen many new games developed, but also old games reprogrammed to be used in a virtual setting. The potential of VR in entertainment is enormous, however our goal is to explore how we could use this potential in education to improve current methodology.

Previous studies from nursing education have shown that students taught procedural knowledge through virtual reality simulations learned better than students taught the conventional way (Dubovi et al., 2017; Mariscal et al., 2020; Sapkaroski et al., 2019). In the study by Dubovi and colleagues (2017), students who learned medication administration through a desktop VR application proved to have more procedural and conceptual knowledge than students who learned through lectures. Mariscal and colleagues (2020) studied the differences between VR methods and conventional methods in two different cases. In the first case the compared immersive virtual reality (IVR) to a conventional masterclass in teaching how to provide first aid in case of a traffic incident. The group using IVR showed significantly better academic performance than the group attending the masterclass. In the second case, a desktop VR simulation was compared to a regular classroom environment when learning how to handle accidents in a laboratory. In this case there was no significant difference in effectiveness of the two methods, however both methods were found effective when compared to a control group. The results from these two cases suggest the added benefit of IVR over desktop applications and traditional teaching. Comparable results were also found by another research team (Sapkaroski et al., 2019) who studied the benefits of IVR in learning hand-positioning for imaging in comparison with learning by role play. The students in the IVR condition performed significantly better on digit separation, palm flatness, and central ray positioning.

Next to evidence that VR can benefit learning procedural knowledge, benefits in learning knowledge related to spatial processing also exists. In a study by Bogomolova and colleagues (2020), students' knowledge of anatomy was tested after they studied with the help of augmented reality, 3D desktop program or a 2D anatomy atlas. They found that students with lower visual spatial abilities specifically benefited from the use of augmented reality technology to learn anatomy. These studies show evidence that the experience of the 3D aspect of VR may help in learning spatially related knowledge. However, less evidence is present for the effectiveness of VR in learning knowledge not related to procedures and

spatial processing. Our aim is to study whether we could use VR to improve teaching methods in the field of neuropsychology, and potentially other fields where declarative or contextual knowledge is taught.

Mechanisms Underlying Learning with Virtual Reality

Learning, in the broad sense of the word, is dependent on many underlying cognitive processes. Perhaps the most important process is memory, which constitutes out of one's ability to encode, store, and retrieve information (Baddeley et al., 2015). These levels of memory rely on each other: if information does not get encoded, it will not get stored, and if it is not stored, it cannot be retrieved. However, attention is crucial for a successful encoding of information (Craik & Lockhart, 1972). Attention serves as a filter which separates all information from our environment and only lets the relevant stimuli through. We can distinguish it as stimulus-driven attention which is automatic, and goal-directed attention which is controlled (Corbetta & Shulman, 2002). Although these two types of attention are considered separate systems, they still often interact. We can further distinguish attention in types based on the duration of it or what can be accomplished with it. The ability to stay focused on a stimulus for an extended time is called sustained attention (Sarter et al., 2001).

VR as a tool in education has an immense potential in improving sustained attention for the duration of the learning material. Kim and colleagues (2022) found that students studying with 360-degree videos were more focused, immersed, and interested than those studying with 2D materials. The fact that VR can help students be more focused and immersed suggests that VR environments decrease the incidence of distractions, hereby allowing students to stay focused on the material itself. In an experiment by Chuang and colleagues (2023), the researchers used VR as a teaching tool for advanced biology for high school students. Their teachers expressed their satisfaction with the VR tool, mentioning the improvement in attention and learning in their students.

Another reason that the VR methods in education could improve attention is that their use might increase students' motivation. Motivation is considered a modulator of sustained attention and is thought to improve one's ability to stay focused for a longer period (Sarter et al. 2001). Students in the study by Mariscal and colleagues (2020) also showed a very high level of satisfaction with the VR tool as no students expressed low satisfaction in the first case, and more than 50% of students expressed high satisfaction in the second case. If students are satisfied with the method, they might be more motivated to learn from it.

The Influence of Empathy and Stress on Memory

The ability to learn may also be influenced by internal factors, such as empathy or stress. According to Cahill and McGaugh (1998), encoding of memories can be improved with emotional arousal. They posit that the higher level of cortisol and adrenalin released due to an emotional trigger affects consolidation processes, closely related to memory encoding. McGaugh (2004) also relates the improvement in memory encoding to the activation of amygdala when emotional stimulus is encountered. Amygdala is thought to interact with hippocampus, which plays a crucial role in memory. It is also believed that people pay more attention to emotional stimuli, which could also be related to improvement of memory encoding of emotionally charged information (Anderson & Phelps, 2001).

The interaction of emotional state and memory encoding might explain findings from studies investigating the effects of empathy on VR learning. Studies by Shalom and Gross (2022) and Shalom and colleagues (2024) found that personal distress (a subscale of empathy) is negatively correlated to short-term and long-term memory. However, Shalom and Gross (2022) found that both types of memory are positively correlated to empathy, especially the subscale of perspective taking. This finding differed from the study of Shalom and colleagues (2024) where they did not find a significant correlation between memory and empathy.

Additionally, Joëls and colleagues (2006) found that mild to moderate stress can improve encoding of memories. This improvement seems to be present especially for emotionally charged information. The release of stress hormones is thought to interact with the functional connectivity between the amygdala and hippocampus to make this possible. Stress has however been identified as correlating negatively with retrieval of memories (Vogel & Schwabe, 2016).

Present Study

Current findings support the benefits of using VR methods in education, learning procedural knowledge and spatial information, but also increasing students' attention and satisfaction with the method. In this study we aimed to test whether this could also be beneficial in improving students' knowledge about a neuropsychological disease when comparing an IVR method to a conventional textbook-like text. We could potentially generalize our findings to learning other declarative or contextual information. In addition, we also assessed the influence of empathy and stress on learning in the two experimental groups.

Our first hypothesis is that students in the VR condition will obtain more knowledge than students in the reading condition. This hypothesis is key in finding evidence that VR may

be more effective in learning declarative or contextual information than conventional methods. Additionally to the first hypothesis, our second hypothesis is that students in both the VR and reading conditions will have more knowledge than students in the control condition. This hypothesis serves the purpose of verifying that learning material in both experimental groups was adequate for learning about the disease.

In order to investigate the possible influence of empathy and stress on learning during the experiment, we defined two more hypotheses. Our third hypothesis stated that students in the VR and reading groups with higher empathy scores would score higher on the knowledge test than students with lower self-reported empathy. As our fourth hypothesis, we expected that students in the VR and reading groups with higher self-reported stress would score lower on the knowledge test than students with lower self-reported stress.

Methods

Design

We conducted this VR simulation study with an experimental cross-sectional design. We invited participants to the laboratories in the Sylvius building of the University of Leiden where the whole experiment took place. Upon arrival, we randomly assigned the participants to one of the two experimental groups or to the control group. Based on the assigned group, the experiment took between 30 and 60 minutes to complete.

This dataset forms part of a larger project named Dementia Up&Close. In this project we also measured participants on visual-spatial abilities using a mental rotation task, sense of presence, technology acceptance, and subjective method effectiveness.

Participants

All participants were students of the bachelor's in psychology at the University of Leiden. They were tested either in the Dutch language, or in the English language. They were able to sign up for this study through Sona, the University portal for administration of research projects.

Besides the inclusion criterion of being a student of the bachelor's in psychology program at the University of Leiden, we also applied multiple exclusion criteria. We excluded participants if they had already taken the specialization course Clinical Neuropsychology (offered at the University of Leiden for 2nd and 3rd year bachelor students). We also excluded participants if they had previous experience with people with dementia. This includes both

experience with family members of friends who have dementia, and experience working or volunteering with people diagnosed with dementia.

Materials and Measuring Instruments

In this study two experimental groups and one control group functioned as an independent variable (VR=1; reading=2; control=3). The VR group watched four 360-degree videos of patients with dementia interacting with their family or workers in a nursing home. These videos were previously used for a different project and repurposed for this study. Between each video we provided the participants with a brief description of what they were going to witness. We did this to prevent subjective interpretation of the situations in the videos. Reading between videos also served to prevent dizziness from prolonged wearing of the VR headset. We provided the reading condition with a text written which resembled the exact situations shown in the 360-degree videos. The objective was for the two groups to receive the same amount and kind of information.

We compared the participants in the three groups on several dependent variables. Their knowledge scores were measured with a test consisting of 20 questions. The total score from the 20 multiple-choice questions was used as an interval variable to assess how much the participant learned using either the VR simulation or the text. We also used this knowledge test in the control group. To account for pre-existing differences in academic performance between participants, we used their average grade as a covariate in the analysis. We asked them to report the average of their last three final grades (Dutch grading system, values with one decimal).

We measured participants' empathy using the Toronto Empathy Questionnaire (Spreng et al. 2009). This questionnaire included 16 statements with answers on a five-point scale (Never = 0; Rarely = 1; Sometimes = 2; Often = 3; Always = 4). The sum of the scores was the participants' empathy score. Items 2, 4, 7, 10, 11, 12, 14, and 15 needed to be reverse scored.

Lastly, we measured participants' stress directly after completing the knowledge test. Stress was assessed with the question "How stressed are you now?" with an answer on a 5-point Likert scale (1=lowest; 5=highest).

Procedure

The procedure differed slightly per condition due to the difference in teaching methods. Participants in the VR condition were first invited into the VR lab. We provided

them with the information letter and then they signed the consent form on paper. After that, we installed the VR headset, and they started watching the simulations. Before each of the four videos we asked the participants to take off the headset and read a brief description of the next video. This part of the experiment lasted approximately 30 minutes. Next, the participants moved to a computer. First, they filled in the knowledge quiz. Afterwards, they reported their level of stress and their average grade, and then they filled-in all additional questionnaires: Toronto Empathy Questionnaire (Spreng et al. 2009), Mental rotation task, iGroup Sense of presence (Schubert et al., 2001), Technology acceptance model (Davis, 1989), and subjective method effectiveness. All of this was provided in Qualtrics. This part of the experiment lasted another 30 minutes, therefore the whole experiment in the VR conditions took 1 hour.

Participants in the reading condition were invited straight to the computer where everything was provided in Qualtrics. First, they received the digitalized versions of the information letter and the consent form. Afterwards we gave them time to read the text material prepared for this condition, and then they moved on to the knowledge quiz. Next, they proceeded to the other questionnaires. In comparison with the VR condition, we did not ask them to fill in the Sense of presence and Technology acceptance questionnaires since those were not applicable to their condition. Testing in this condition took approximately 45 minutes in total.

In the control condition, the participants were invited directly to the computer lab. There we provided them with the digital versions of the information letter and the consent form. After signing, they were directed straight to the knowledge quiz and then to the questionnaires. They did not fill in the Sense of presence questionnaire, the technology acceptance questionnaire, and the subjective method effectiveness assessment questions. Testing in the control condition took approximately 30 minutes.

Statistical Analysis

To test the hypotheses that the VR group would score higher on the knowledge test than the reading group, and that both the scores in the VR and reading groups would be higher than in the control group, an analysis of variance was conducted with the group (VR, reading, control) as independent variable, and scores on the knowledge test as dependent variable. We rejected hypotheses if $p>0.05$. Before conducting the analyses, we checked the data for outliers, normal distribution, and homogeneity of variance. Additionally, we conducted an analysis of covariance with students' average grade as a covariate to account for preexisting

differences in academic performance or learning ability. We checked the assumptions of linearity, and homogeneity of regression slopes.

To test the hypothesis that students with higher empathy scores would score higher on the knowledge test, a linear regression was conducted to determine the relationship between empathy and knowledge scores. Similarly, to test that students with lower self-reported stress would score higher on the knowledge test, a linear regression was conducted to determine the relationship between stress and knowledge scores. We also checked the data for homoscedasticity, and normality.

Results

A total of 72 participants were tested in two experimental groups and one control group. We excluded one participant from the control group due to violating one of the exclusion criteria of this experiment, which states that students who took the clinical neuropsychology course may not take part. Therefore, data from 71 participants were analyzed, out of which 9 were male, 60 were female, and 2 were non-binary or third gender. The mean age of all participants was 19,65 years with a range between 17 and 38 years. The three groups were balanced on participants' gender, $\chi^2(4, N = 71) = 2.21$, $p = .70$ (see Table 1). There was also no significant between-groups difference in age, $F(2,68) = 2.31$, $p = .11$, $\eta^2 = .06$ (see Table 1). Despite the study being open to all bachelor psychology students, all participants were first year psychology bachelor students.

Table 1

Descriptive Statistics of Participants per Group

Group	Gender			Age in years		
	Male	Female	Non-binary or third gender	Mean	Min	Max
VR group	3	19	1	18.74	17	26
Reading group	2	23	0	19.56	17	26
Control group	4	18	1	20.65	18	38

While checking our data, we found one outlier in the scores of the knowledge test, $M = 11{,}44$, $SD = 2.89$. After thorough consideration, and seeing we were not aware of any mistakes in data collection we concluded that it was a naturally occurring outlier and we did not exclude it from the analysis.

Comparing Virtual Reality to Conservative Methods of Learning

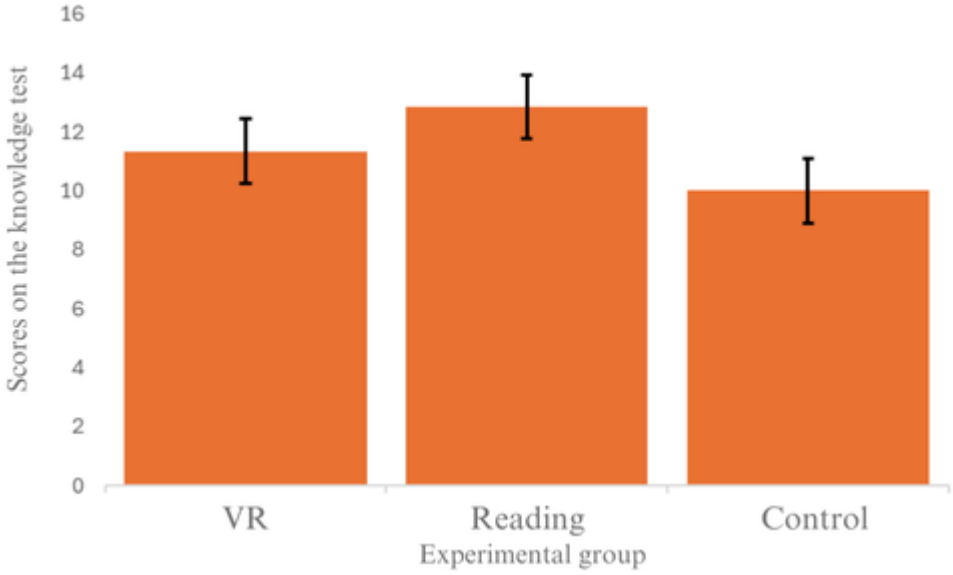
An analysis of variance was conducted to test whether the VR method is more effective than the reading method when learning about dementia. We used experimental group as a factor, and total score from the knowledge test as a dependent variable. Before conducting the analysis, we checked the data for violations of assumptions. The data was robust against violations of normality ($n \geq 15$ for each group), and against violations of homogeneous variances ($n_{max}:n_{min} < 1.5$). The assumption of independence was not violated given the study design.

Comparing means of the three groups on knowledge scores yielded a significant result, $F(2,68) = 6.74$, $p < .01$, $\eta^2 = .17$. This meant there was a significant difference between

at least two groups in the model. Figure 1 illustrates the differences in group means. To see differences in means between each of the groups, a Bonferroni post-hoc test was performed (see Table 2). Based on the post-hoc test, the reading group differed significantly from the control group, $p < .01$. The VR group did not differ significantly from the control group, $p = .28$, nor from the reading group, $p = .18$.

Figure 1

Comparison of Group Means of the Knowledge Test Scores



Note. Comparison of group means of scores on the knowledge test. Error bars represent the 95% confidence intervals.

Table 2

Comparison of means

Experimental group (I)	Experimental group (J)	Mean Difference (I-J)	Mean
VR	Text	-1.49	11.35
	Control	1.35	
Reading	VR	1.49	12.84
	Control	2.84*	
Control	VR	-1.35	10.00
	Text	-2.84*	

Note. This table demonstrates the Bonferroni post-hoc test and the group means.

*sig < .01

Pre-existing Differences in Learning Ability

In addition to the first analysis, we decided to add a covariate to the previous model to control for preexisting differences in learning ability. We used participants' average grade as a covariate, while experimental group remained our factor, and scores on knowledge test remained the dependent variable. Due to unforeseen circumstances during data collection, the covariate (average grade) contained 21 missing values. We therefore performed this second analysis with data from 50 participants (n VR = 18; n reading = 16; n control = 16). The data was robust against violations of normality ($n \geq 15$ for each group), and against violations of homogeneous variances (n_{max}**:**$n_{min} < 1.5$). The assumption of linearity was not violated based on the visual check of matrix scatterplots. The assumption of homogeneity of regression slopes was violated as the interaction between the factor variable and the covariate was significant, $F(3) = 6.50$, $p < .01$.

Adding the covariate yielded comparable results as the previous model without covariates. The model was significant, $F(2,46) = 4.19$, $p = .02$, $\eta^2 = .28$, with significant difference between the means of the reading group and the control group, $p = .02$. The VR group was not significantly different from the reading group, $p = .28$, nor from the control group, $p = .65$.

The Influence of Empathy and Stress

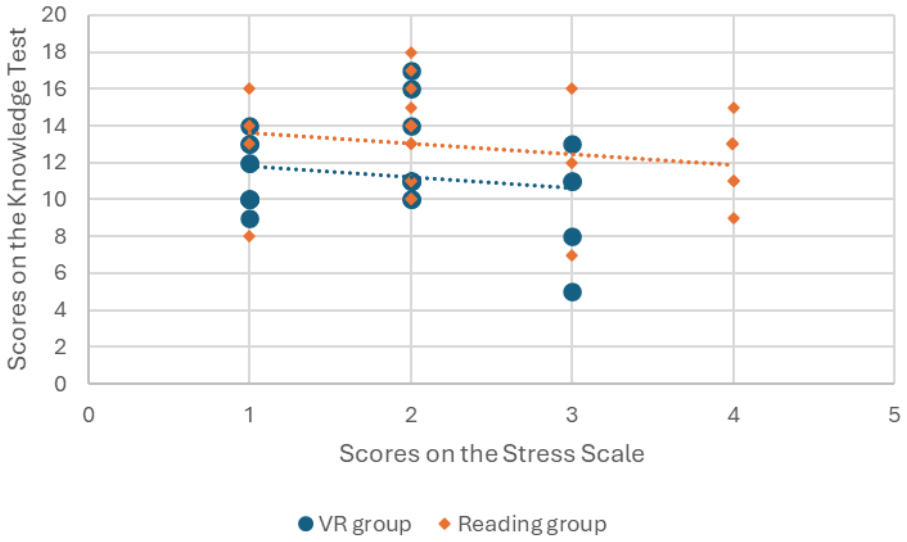
To test our hypotheses that empathy and stress have an impact on learning in the VR and reading groups, we conducted regression analyses with total knowledge scores as dependent variable, and scores on the Toronto Empathy Questionnaire and stress scale respectively as the independent variables. The assumptions of normality and homoscedasticity were not violated in either analyses.

Due to a technical error during data collection, the Toronto Empathy Questionnaire was only completed by 14 participants in the VR group, and 16 participants in the reading group. When analyzing the data from all 30 participants, we found no significant relationship between the knowledge scores and empathy scores, $R^2 = .01$, $F(1, 28) = .20$, $p = .66$. Results remained insignificant when conducting a regression analysis for each group separately, $R^2 = .03$, $F(1, 12) = .33$, $p = .57$ for the VR group, and $R^2 = .09$, $F(1, 14) = 1.39$, $p = .26$ for the reading group.

Scores of all 48 participants were analyzed to test the relationship between stress and knowledge scores. The analysis yielded a non-significant result when both groups were analyzed together, $R^2 = .09$, $F(1, 46) = .41$, $p = .53$. A non-significant result was also obtained for the VR group, $R^2 = .03$, $F(1, 21) = .73$, $p = .40$, and for the reading group, $R^2 = .04$, $F(1, 23) = .97$, $p = .34$. However, visual representation of the distribution of perceived stress and knowledge scores (see Figure 2) prompted us to compare the means of stress in the VR and reading groups. We used an analysis of variance with experimental group as a factor, and scores on the stress scale as a dependent variable. We found the groups to be significantly different from each other, $F(1,46) = 4.88$, $p = .03$. Based on the estimated marginal means, stress scores in the reading group were higher, $M = 2.36$, $SD = .18$, than the scores in the VR group, $M = 1.78$, $SD = .19$.

Figure 2

Interaction of Stress Scores with the Scores on the Knowledge Test



Observations

Most of the participants showed interest in the VR method during their participation in this experiment. After completing their participation, many students from the reading and control groups also took the opportunity to watch our VR videos. Given that the purpose of this study was improving current teaching methods, we were also curious about the opinions of the students.

Students were mostly commenting on the seriousness of dementia as portrayed in the VR videos. Many of them mentioned they did not know that patients could get “this bad.” They also often mentioned how much respect the gained for the staff at different institutions after watching them handle the patients. Some participants expressed new ideas after watching the VR simulations, for example one student wondered whether premorbid characteristics of patients with dementia could dictate which symptoms become most prominent. Most students showed a very positive attitude towards the possibility of using VR to study and praised the VR method for its realistic representation of the patients. Two students were more skeptical about this method claiming that it would be too difficult to translate what they had watched into knowledge.

Discussion

With this study we aimed to show that VR could be used to improve the learning of declarative and contextual information in the field of neuropsychology. We tested this by comparing students' knowledge after studying with VR videos or reading a text about dementia. Additionally, we compared both experimental groups to a control group to further investigate the quality of materials of each method.

We found that students in the reading group achieved the highest results from all three groups. Therefore, we rejected our hypothesis that VR would be more effective than text. However, even though students in the VR group achieved lower scores than students in the reading group, their scores were still higher than scores in the control group. We found that results of the VR group were not significantly different from the reading group, but also not significantly different from the control group. Based on these results we cannot posit that the VR group performed significantly worse than the reading group. But we also cannot say that the VR group performed significantly better than the control group.

An explanation to the ambiguous results may lie in the suitability of the VR materials used in this study. Originally, the videos used were created for nursing students to learn about situations they may encounter with patients with dementia. Therefore, the focus in these videos was more on practical rather than theoretical knowledge. We hypothesize that to aid the learning of theoretical concepts with such simulations, students would need an explicit explanation in the form of text integrated in the simulation. Such an approach would combine the benefits of the VR method and the benefits of the text method. Such theory is also supported by the opinions of some of the students who experienced the VR simulation. A few students mentioned having difficulty in understanding the theoretical concepts in the scenes without explicit explanation.

We tried to provide such explanations during this study by having each participant read an explanation of what they were about to watch. Before each of the four VR videos the participants took off the headset and read a brief explanation on paper. However, we think that having to take of the headset to read the text each time impacted the immersive benefits of the VR method. We therefore believe that such explanations should be integrated in the simulation and given simultaneously with the scenes.

We also wanted to investigate the possible effect of empathy and stress on learning. We hypothesized that students with higher empathy scores would perform better in both experimental conditions. This hypothesis was based on theories which suggest that emotional

arousal aids memory encoding and consolidation (Cahill & McGaugh, 1998; McGaugh, 2004), and a theory that people pay more attention to emotional stimuli (Anderson & Phelps, 2001). Our last hypothesis posited that students with lower self-reported stress would score higher on the knowledge test. This hypothesis was based on the claim of Vogel and Schwabe (2016) that stress has a negative effect on memory retrieval.

Our analysis did not show any connections between stress and the results on the knowledge test. This was the case when tested in both groups together, but also when tested in each group separately. Interestingly, we found that students in the reading group were significantly more stressed after the completion of the test than students in the VR group. While we cannot make claims about the effect of stress on learning, we can highlight the desirability to make learning less stressful for students. As shown by the results of our analysis, stress was not a necessary factor for learning. It might however be a negative factor in other aspects of students' lives, and it could affect learning indirectly. In addition to having evidence that students in the VR group were less stressed, we also observed mostly positive attitudes of students towards the use of VR in education.

Limitations

Despite careful effort in collecting data, a few limitations should be considered when interpreting the results of our analysis.

Firstly, we planned to control for students' pre-existing learning ability when analyzing their knowledge scores. We asked each of them to report their average grade from the last three exams. We incorporated this data into an analysis of covariance, and we found comparable results to the original analysis without the covariate. However, the assumption of homogeneity of regression slopes was violated. As a result, an incorrect regression slope may have been used to adjust the groups means, resulting in inaccurate mean calculations. In addition to the issue with regression slopes, we ran this analysis with a smaller sample because of a large number of missing values on the average grade variable.

Secondly, as mentioned in previous sections, the VR videos used for this study were repurposed from a program for nursing students. While there was nothing wrong with the portrayal of patients with dementia, the delivery method was perhaps not completely suited for the type of knowledge we investigated.

Lastly, our population was entirely made up of first year bachelor psychology students. We expect that all these students had approximately the same level of knowledge

about dementia. Therefore, more studies like this should be conducted to show how effective the methods would be for students with diverse levels of knowledge.

Conclusion

In this study we did not find the VR method to be more effective than the text method. However, we also have reasons to believe that the VR method needs to undergo changes to be successfully implemented in theoretical and conceptual education, such as education about neuropsychological disease. We suggest the integration of text in the simulation. Seeing that we found text to be the most effective out of the studied methods, we expect it could improve understandability of the materials. While we did not find any connection between students' knowledge, and empathy and stress, respectively, we did find that students in the reading condition experienced more stress. This, along with the fact that students showed positive attitudes towards the VR method should be reasons to continue trying to improve the VR method.

References

Anderson, A. K., & Phelps, E. A. (2001). Lesions of the human amygdala impair enhanced memory for emotional events. *Nature, 411*(6835), 305-309. https://doi.org/10.1038/35077094

Baddeley, A. D., Eysenck, M. W., & Anderson, M. C. (2015). *Memory* (2nd ed.). Psychology Press.

Bogomolova, K., Ham, I. J. M., Dankbaar, M. E. W., Broek, W. W., Hovius, S. E. R., Hage, J. A., & Hierck, B. P. (2020). The Effect of Stereoscopic Augmented Reality Visualization on Learning Anatomy and the Modifying Effect of Visual-Spatial Abilities: A Double-Center Randomized Controlled Trial. *Anatomical Sciences Education, 13*(5), 558–567. https://doi.org/10.1002/ase.1941

Cahill, L., & McGaugh, J. L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends in Neurosciences, 21*(7), 294-299. https://doi.org/10.1016/S0166-2236(97)01214-9

Chuang, T.-F., Chou, Y.-H., Pai, J.-Y., Huang, C.-N., Bair, H., Pai, A., & Yu, N.-C. (2023). Using Virtual Reality Technology in Biology Education: Satisfaction & Learning Outcomes of High School Students. *The American Biology Teacher, 85*(1), 23–32. https://doi.org/10.1525/abt.2023.85.1.23

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience, 3*(3), 201-215. https://doi.org/10.1038/nrn755

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*(6), 671-684. https://doi.org/10.1016/S0022-5371(72)80001-X

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319–340. https://doi.org/10.2307/249008

Dubovi, I., Levy, S. T., & Dagan, E. (2017). Now I know how! The learning process of medication administration among nursing students with non-immersive desktop virtual reality simulation. *Computers and Education, 113*, 16–27. https://doi.org/10.1016/j.compedu.2017.05.009

Havola, S., Haavisto, E., Mäkinen, H., Engblom, J., & Koivisto, J.-M. (2021). The Effects of Computer-Based Simulation Game and Virtual Reality Simulation in Nursing Students' Self-evaluated Clinical Reasoning Skills. Computers, Informatics, *Nursing*, *39*(11), 725–735. https://doi.org/10.1097/CIN.0000000000000748

Joëls, M., Pu, Z., Wiegert, O., Oitzl, M. S., & Krugers, H. J. (2006). Learning under stress: How does it work? *Trends in Cognitive Sciences, 10*(4), 152-158. https://doi.org/10.1016/j.tics.2006.02.002

Kim, J., Kim, K., & Kim, W. (2022). Impact of Immersive Virtual Reality Content Using 360-degree Videos in Undergraduate Education. *IEEE Transactions on Learning Technologies, 15*(1), 1–1. https://doi.org/10.1109/TLT.2022.3157250

Mariscal, G., Jiménez, E., Vivas-Urias, M. D., Redondo-Duarte, S., & Moreno-Pérez, S. (2020). Virtual reality simulation-based learning. *Education in the Knowledge Society, 21*. https://doi.org/10.14201/eks.20809

McGaugh, J. L. (2004). Memory and emotion: The making of lasting memories. *Science, 305*(5692), 501-505. https://doi.org/10.1126/science.1097064

Sapkaroski, D., Baird, M., Mundy, M., & Dimmock, M. R. (2019). Quantification of Student Radiographic Patient Positioning Using an Immersive Virtual Reality Simulation. *Simulation in Healthcare: Journal of the Society for Medical Simulation, 14*(4), 258–263. https://doi.org/10.1097/SIH.0000000000000380

Sarter, M., Givens, B., & Bruno, J. P. (2001). The cognitive neuroscience of sustained attention: Where top-down meets bottom-up. *Brain Research Reviews, 35*(2), 146-160. https://doi.org/10.1016/S0165-0173(01)00044-1

Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The Experience of Presence: Factor Analytic Insights. *Presence: Teleoperators and Virtual Environment, 10*(3), 266–281. https://doi.org/10.1162/105474601300343603

Shalom, M., & Gross, Z. (2022). The link between memory, narrative and empathy in teaching difficult knowledge in holocaust. *Frontiers in Education, 7*. https://doi.org/10.3389/feduc.2022.866457

Shalom, M., Luzzatto, E., & Gross, Z. (2024). Remember lest we forget: the link between long-term memory and narrative, empathy and previous knowledge in Israel. *Israel Affairs, 30*(2), 333–349. https://doi.org/10.1080/13537121.2024.2318174

Spreng, R. N., McKinnon, M. C., Mar, R. A., & Levine, B. (2009). The Toronto Empathy Questionnaire: Scale Development and Initial Validation of a Factor-Analytic Solution to Multiple Empathy Measures. *Journal of Personality Assessment, 91*(1), 62–71. https://doi.org/10.1080/00223890802484381

Vogel, S., & Schwabe, L. (2016). Learning and memory under stress: implications for the classroom. *NPJ Science of Learning, 1*(1), 16011–16011. https://doi.org/10.1038/npjscilearn.2016.11

Appendix

Reading Materials

Dementia Up & Close

Dementia is a neuropsychological condition characterized by worsening of cognitive functions such as memory or executive functioning. The chance of developing a type of dementia grows substantially with age.

One of the symptoms that often emerges from the early stages of dementia is difficulties with memory. Patients may forget where they put their keys, or they may forget certain events or important information. As the disease progresses, they often find themselves unable to memorize new information. For example, a father with dementia may wonder at a family reunion why his daughter's husband did not come, only to be informed that they have been separated for months. Throughout the reunion he however may keep asking why his son-in-law is not present simply because he cannot remember this new information.

Perhaps because of their declining ability to remember information, patients with dementia often tend to cling onto habitual daily routines or objects as these might bring a sense of familiarity. This need to do things a certain way may become compulsive. Reasoning with patients with dementia may be especially hard, as they persevere in their behavior, even if their environment encourages them to do things differently.

In some cases, conflict can arise in a mundane, everyday situation. For example, if a patient asks for a cup of coffee, it could happen that they do not want to hear any explanation as to why they actually have to wait a few minutes for their beverage.

Patients with dementia may be impulsive or lack patience. There is an underlying process which explains this behavior: decreased inhibition. Deterioration of the brain in patients with dementia typically goes from the front to the back of the brain. Frontal regions of the brain are associated with cognitive control, and as these regions are affected first, early on patients' ability to inhibit themselves will be lowered. This may become apparent through a number of symptoms: patients could struggle with anger management, react out of proportion, be impatient, or behave inappropriately in social interactions. Related to their lack of inhibition, they might not even be able to tell what an appropriate reaction is and what not.

In addition to inappropriate behavior, another common characteristic of people with dementia is their impaired emotional functioning. A lot of patients with dementia develop apathy, a state in which they appear uninterested, unconcerned, or even unhappy. Their loved ones often say that it feels as if their family member as they knew them before no longer exists. Apathy may show in patients having little motivation and not being very active. Patients with dementia may also develop problems with giving affection to others, even though they may

sometimes experience loneliness. Feelings of loneliness often occur in patients who reside in a care facility, which is an unfamiliar environment for them. While they get professional treatment, they might miss affection or intimacy which they used to have at home. As patients with dementia likely exhibit disinhibition, they also tend to be irritable, and overly sensitive. They could get overstimulated if there is a lot happening around them because they are slower at processing what is happening.

In addition to the previously discussed behavior symptoms, individuals with dementia may experience confusion in time and place. While older memories may be spared, they may forget more recent memories and could therefore lose track of time. They might not be able to tell what day, month, or even what year they are in. Related to this, they might get confused because they do not recognize where they are. This could happen especially if they have been relocated to another care facility or another room. Their confusion might additionally worsen because of mental slowing that they experience as their disease progresses. The mental slowing only makes the situation worse when they are in an unfamiliar environment.

Knowledge Test

1. Peter, a patient with dementia is visiting a friend's home. On his way out he sees *his friend's* keys on the hanger next to the door. Without thinking, he takes the keys and heads out of the house. Based on this event, which executive function may be impaired in Peter?
   a. Inhibition
   b. Mental Slowness
   c. Memory
   d. Perseveration
2. Which of the following cognitive processes is not impaired in dementia?
   a. Speech production
   b. Processing speed
   c. Emotional functioning
   d. Inhibition
3. Statement 1: Patients with dementia mostly develop very homogeneous symptoms.
   Statement 2: Older people have a higher chance of receiving a dementia diagnosis.
   a. Only statement 1 is true.
   b. Only statement 2 is true.
   c. Both statements are true.
   d. Both statements are false.
4. Which information is a patient with dementia more likely to forget?
   a. Their home address.
   b. The names of their children.
   c. How to drive a car.
   d. That they lost their job last year.
5. Imagine a case during a cold winter's day where a patient with dementia refuses to wear warm shoes outside because they like their slippers better. Which of the dementia-related symptoms could explain the patient's behavior?
   a. Oppositional behavior

b. Mental slowness
c. Perseveration
d. Memory loss

6. Which one of these patients can be best described as experiencing apathy?
   a. Linda spends her days in an armchair at her daughter's home. Most of the time she would be watching the TV or reading a book. Days like this are not very exciting, but every time her grandchildren are around, they bring a smile on her face, and she tries her best to interact with them.
   b. Betty lives in a care facility. Her family visits her all the time, but their visits are not eventful. When they try to cheer Betty up, it is as if she could not hear them or comprehend what they are saying, even though she has no visual or hearing impairments. She barely ever makes conversation and never asks about her grandchildren. When her son asked the nurses what his mother does during the day, they said that she does not really do anything.
   c. Harry has been living in a care home for two years now. He never made any friends as he always comes across quite grumpy and has been seen raising his voice at the staff. His family comes to visit him once in two weeks, but they do not usually stay for long. He spends his time alone reading the newspaper or looking out of the window.
   d. Maarten lives with his wife, but things have not been going so great. His wife is getting older and cannot take very good care of him anymore. At moments when his mind is clear, he feels sad about this situation, but he loves his wife.
7. Which one of the following statements is <u>not</u> an example of lack of inhibition?
   a. A patient makes sexual comments to a nurse while she comes to wash them.
   b. A patient gets angry at the dinner table because his coffee was not served.
   c. A patient needs their blood taken, but the nurse misses the vein on the first attempt. The nurse apologizes, but the patient starts shouting that the nurse is incompetent.
   d. A patient in a care facility gets up in the middle of a group activity and insists they have to go home to call their friend at 18 o'clock.
8.
   Statement 1: Lack of patience is a sign of apathy.
   Statement 2: Mental slowness causes memory loss in patients with dementia.
   a. Only statement 1 is true.
   b. Only statement 2 is true.
   c. Both statements are true.
   d. Both statements are false.
9. A nurse in a care home is trying to explain to a patient with dementia that they need to take their medication. The conversation is not going very well. Which one of these is likely <u>not</u> a dementia-related reason?
   a. The patient does not understand anything the nurse is saying.
   b. The patient forgot who the nurse is.
   c. The patient is confused about their whereabouts and doesn't understand why they should take medication.
   d. The patient is angry and throws the medicine out of the nurse's hands.
10. Which one of these emotional reactions are common in patients with dementia?
    a. Excessive anger.
    b. Visible confusion
    c. Indifference.
    d. All of the above.

11. Family members of a patient with dementia are arguing. She proceeds to cover her ears, starts to scream, and storms out of the room. What is the most likely explanation?
    a. She got overstimulated and wanted to get away.
    b. Because of her perseverations, she cannot stand disagreement, so she wanted to stop it.
    c. Her verbal communication is slowed too much, and she was not able to join the discussion.
    d. All of the above.
12. Why might dementia patients in care homes feel lonely?
    a. They are not allowed to socialize anymore.
    b. They do not remember who they are.
    c. They are missing physical contact.
    d. The coffee gets served at a different time.
13. Lessened ability to give affection is a sign of _____.
    a. Memory problems
    b. Apathy
    c. Confusion
    d. Mental slowness
14. Statement 1: Patients with dementia especially forget events that happened a long time ago.
    Statement 2: Patients with dementia are likely to forget events that happened recently.
    a. Only statement 1 is true.
    b. Only statement 2 is true.
    c. Both statements are true.
    d. Both statements are false.
15. Which of these situations could be a sign of mental slowness?
    a. A patient with dementia is trying to find their way to the cafeteria, but they cannot seem to identify and understand the signs that indicate directions.
    b. A patient with dementia is struggling to understand a conversation they are overhearing.
    c. Watching a tv show has become less enjoyable for one patient, as she has trouble following the storyline.
    d. All of the above.
16. Which one of these options is an example of disinhibition?
    a. A patient reacts out of proportion.
    b. A patient wants to have a cup of coffee right before going to bed.
    c. A patient asks their spouse what day it is.
    d. A patient seems very unconcerned.
17. Which one of these memory problems are <u>not</u> typical for a patient with dementia?
    a. Forgetting about people in their lives.
    b. Forgetting where they put their keys.
    c. Forgetting how to use a spoon.
    d. Forgetting what day it is.
18. The pairs below describe a symptom and an underlying process. Which of these pairs belongs together?
    a. Lack of affection – Inhibition
    b. Disorientation in time and place – Memory
    c. Feeling overstimulated – Inattention
    d. Impulsive behavior – Mental slowness

19. Statement 1: Patients with dementia often continue doing things a certain way (i.e., they perseverate).
    Statement 2: Inappropriate behavior as often seen in patients in dementia is the result of apathy.
    a. **Only statement 1 is true**.
    b. Only statement 2 is true.
    c. Both statements are true.
    d. Both statements are false.
20. Patients with dementia often cling onto objects or things. What could explain this behavior?
    a. Because of their memory problems, patients with dementia tend to cling onto familiar things.
    b. Patients with dementia are often lonely and do not want to change.
    c. Because patients with dementia do not know how to behave normally anymore.
    d. None of the above.