Spatial understanding of neuroanatomy is essential to neurologic-based medical and surgical specialties, and a comprehensive understanding of neuroanatomy is reliant on thorough knowledge of the relations among the multiple 3-dimensional structures. Traditional teaching methods in medical school such as anatomic dissection prove costly and time consuming, and textbook learning has emerged as a supplemental technique. 2-dimensional images may negatively impact one’s ability to understand complex 3-dimensional spatial relations, potentially impairing neuroanatomical learning. 3-dimensional learning techniques have been proposed as tools to enhance neuroanatomy training. This strategy may decrease the phenomenon of “neurophobia,” and improve medical student’s spatial understanding and retention of neuroanatomy. Virtual reality (VR) may be a logical next step for enhanced 3-dimensional and interactive learning.

**Objectives**

To explore the efficacy and limitations of immersive and interactive virtual reality on neuroanatomy learning.

To examine neuroanatomical knowledge and retention after virtual reality learning and compare these results to more traditional paper-based learning methods.

**Methods**

A longterm retention test was administered 5-9 days postintervention, containing 44 baseline and postintervention questions. In the VR environment, visualization of structures and their labels was controlled by the participant. The paper-based group received a booklet containing 15 colour figures adapted to display labels for the relevant structures. Participant’s scores were converted to percent correct. Primary statistical analysis consisted of a 4x2x2 mixed-measures analysis of variance (ANOVA) on Percent Correct, with Test and Question type as within-subject factors and Group as a between-subject factor.

**Results**

The 2 groups did not differ significantly in age, prior neuroanatomy training, or other demographics. Both groups performed comparably on the baseline questions and showed significant performance improvement on the test questions following study.

**Primary analysis:** Significant main effects of Test and Question type and a significant Test x Question type interaction existed (p<0.001 for all 3 variables).

**Mixed-measures ANOVA:** Significant main effects of Test and Group existed for the Test questions, and the difference between groups for baseline questions 7 days postintervention was significant (p=0.002). No other significant interactions or differences existed.

**Satisfaction:** 94% of VR participants agreed or strongly agreed with the statement "This method should be used in the curriculum," versus 33% of the paper-based group. The corresponding values for "I feel less afraid with the complexity of neuroanatomy," were 81% for VR participants versus 13% of the paper group, suggesting decreased neurophobia following VR learning.

**Discussion**

Both groups showed significant improvement in scores on the test questions after the intervention that persisted at 7 days, providing evidence that both methods were successful learning techniques. The fact that a main effect of group was found for the test questions, with the VR group having significantly greater accuracy than the paper-based group, suggests that VR is an effective learning tool for understanding the complex spatial relations between different structures of the brain. Based on both the quantitative results and the satisfaction survey results, there is evidence that VR technology may provide an effective supplemental tool for learning neuroanatomy by decreasing neurophobia and increasing knowledge retention.

It should be noted that our follow-up period was relatively short, and we used a limited number of questions to evaluate knowledge retention. Future studies should examine retention outcomes from VR teaching over a longer time period with a greater amount of information learned. We believe that this technology is applicable not only to medical students but also to undergraduate students in relevant fields and neurology and neurosurgery trainees. Further research may be directed at the utility of VR in these populations.

**Conclusion**

Based on both quantitative results and satisfaction survey results, this study provides evidence that immersive and interactive VR technology can improve neuroanatomy knowledge attainment and retention and decrease neurophobia in medical students. The potential applications and benefits of this technology may extend beyond undergraduate medical education.

**References**

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