EXPERIMENTAL RESEARCH VALIDATION FOR THE USE OF 3D IN TEACHING HUMAN ANATOMY

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Abstract: ICAP department of Lyon 1 university developed instructional tools based on 3 dimensional (3D) technologies to assist human anatomy teachers. Three experimental researches aimed to validate the use of these tools. In study 1 we searched for correlations between spatial ability tests and anatomy examination scores. In study 2 we evaluated the effects of specific spatial ability training on anatomy examination results. Study 3 investigated the beneficial effects of using 3D tools during a short term learning session. We found that spatial ability is a predictor of success in learning human anatomy, however the benefits from using 3D tools is not effective during a 2-hours learning session.

1 INTRODUCTION

The effects of Mental Rotation (MR) and spatial abilities on the medical field have been considered in the literature. A large body of research has provided evidence that the spatial ability was related to the success in anatomy learning and procedures in laparoscopic surgery, hence highlighting the crucial role of individual spatial ability in human anatomy learning (Garg et al. 2001; Hegarty et al. 2007; Keehner et al. 2004; Risucci 2002; Wanzel et al. 2003; Rochford 1985). In 2005 instructional design tools based on three dimensional (3D) technologies was developed in Lyon 1 university for human anatomy teaching. Since then, 3D videos as well as other instructional tools (3D images, interactive PDF, course book) are used during anatomy classes. This instructional design is scientifically tested in several didactic studies we conducted in order to validate the use of 3D during human anatomy courses. Our experimental researches intended answering three main questions:

- Is there any correlation between spatial abilities tests scores and anatomy learning scores?
- What are the effects of MR training on learning anatomy?
- Is there any positive learning effect of using 3D tools in a 2 hours class as compared to the use of classical 2D images?

We hypothesized that these instructional tools help the students in forming a clearer mental representation as well as in memorizing the anatomical structures.

2 METHOD

Study 1 (Guillot et al. 2007)

A total of 184 undergraduate students took part in the experiment. At the beginning of the functional anatomy learning module, participants completed spatial ability tests in a quiet room. The Group Embedded Figures Test (GEFT) was used to evaluate the degree of field dependence–independence and the Vandenberg and Kuse Mental Rotation Test (VMRT) evaluated MR ability. At the end of the semester all the students completed the anatomy examination consisting of a multiple choice test made up of 220 propositions within a 60-min period.

Study 2 (Hoyek et al. 2009)

32 undergraduate students attending functional anatomy course took part in the experiment. They were assigned in two groups. In the “MR training group”, 16 students attended 12 MR training sessions of 20 min each, three times per week. In the “Anatomy Control group”, during equivalent time, 16 other students were enrolled in physical activities that did not have any link with MR ability (e.g., gymnastics was proscribed). Before the first functional anatomy learning session, all participants completed the VMRT (pre-test). After the training period all participants completed the VMRT (posttest). The anatomy examination was finally scheduled at the end of the learning module. It was composed of questions that were considered as requiring either MR or specific knowledge. To evaluate the effect of the training sessions on MR ability, the scores on the VMRT was compared in both groups. Finally, the anatomy scores were taken into account to investigate the effect of MR training sessions on anatomy test.

Study 3

180 students enrolled in human anatomy module were randomly assigned into 3 groups. The 2D group learned the femur osteology using 2D black and white images as learning tools. The 3D Video group watched a 3D animated video of the femur during learning. Finally the PDF group had an interactive PDF of a 3D image of the femur as a learning tool. The hall experience was administered during a 2 hours practical class. All groups had the same written support but different visual learning tools. No explanation was given by the teachers, the students were asked to learn the femur by themselves using the common written support and the defined visual tool of their respective group. At the beginning of the experience, all participants completed the VMRT as well as a general anatomy test in order to make sure that they have the same MR and anatomy level (pre-test). At the end of the experience, all participants completed an examination on the femur (post-test). To evaluate the effects of each visual tool the femur examination results were compared among the groups.

3 RESULTS

Study 1 (Guillot et al. 2007)

A significant correlation was shown between visuo-spatial abilities and anatomy examination results for both the GEFT and the VMRT (fig 1).

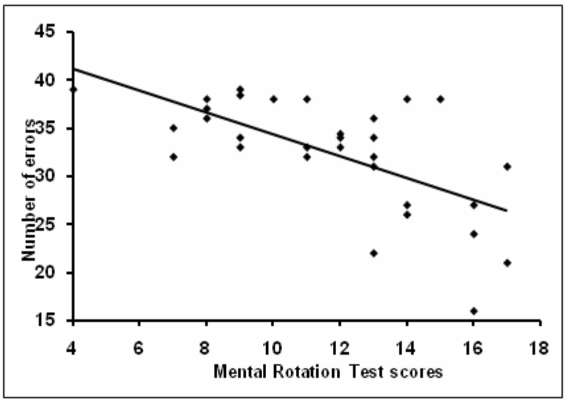

Figure 1: Correlation between anatomy examination errors number and VMRT score. Students having good VMRT scores made fewer errors on the anatomy examination

Study 2 (Hoyek et al. 2009)

No significant difference was found between the three groups, ($F_{2,45}$ = .12, p > .05, ns) on the VMRT pre-test scores hence attesting for their homogeneity. However the performance enhancement was greater in the MR training group compared to the anatomy control group (t = 4.14, p <.001) suggesting a positive effect of MR training sessions on VMRT performance. In MR questions, the MR training group tended to score slightly better than the anatomy group ($F_{1, 29}$ = 3.52, p = .07). By contrast, we did not found any statistical difference regarding the specific knowledge questions ($F_{1, 29}$ = .02, p = .8). Anatomy scores results are shown in figure 2.

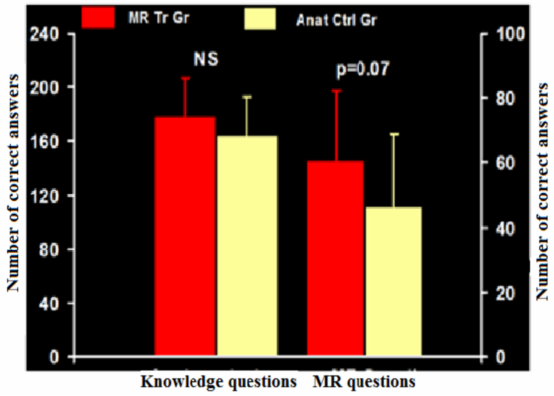

Figure 2: Anatomy examination scores. MR training group (in red) had better results on the anatomy questions requiring MR ability (right histogram)

Study 3

Unexpectedly no significant results were found between the 3 groups on the post-test scores. Consequently, using 3D visual tools was not beneficial in this particular experimental design.

4 DISCUSSION

The correlations found in study 1 underscore the advantage of students with high spatial abilities. Such abilities could therefore be considered reliable forecasters of success in acquiring human anatomy knowledge. Furthermore, such predictive tests could affect technical skills learning and training in various scientific (e.g. architecture and design) and medical disciplines, and help to identify students who might need supplementary teaching modules. Study 2 extended these results. Participants became more accurate in solving the VMRT after practice explaining a positive transfer of spatial reasoning. Furthermore, after MR training, participants may improve their ability to learn anatomical knowledge by increasing their ability to make the anatomical structures rotating. These results emphasize the argument that spatial ability training as well as using 3D technologies may help student in various scientific and medical disciplines. However the unexpected results of study 3 are probably due to the method. We argue that 2 hours are insufficient to master 3D tools and then to acquire new anatomical knowledge. In a future study we will evaluate the effects of using 3D instructional tools over a hall teaching semester.

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