The impact of video games on ultrasound-guided regional anesthesia skills

Atif Shafqat[1], Shumaila Mukarram[2], Nigel M Bedforth[3], Jonathan G Hardman[1,3], Robert A McCahon[3]

1. *Anesthesia & Critical Care, Division of Clinical Neuroscience, University of Nottingham, Nottingham, UK*
2. *London School of Hygiene and Tropical Medicine, London, UK*
3. *Nottingham University Hospitals NHS Trust, Nottingham, UK*

Corresponding Author:

Atif Shafqat, Department of Anesthesia & Critical Care, University of Nottingham, Queen's Medical Centre, Nottingham NG7 2UH, UK; atif.shafqat@nhs.net

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Abbreviations:

USGRA: Ultrasound-guided regional anesthesia

GRS: Global rating scale

MRT: Mental rotation test

GEFT: Group embedded figures test

AH4: Alice Heim group ability test

ABSTRACT

Background: There is an association between video game practice and laparoscopic expertise in trainee surgeons. Ultrasound-guided regional anesthesia has many parallels with laparoscopic surgery. The aim of this study was to explore whether video game experience is associated with enhanced performance in a simulated ultrasound-guided task in novice operators.

Methods: In this prospective observational study, 60 medical student volunteers were recruited. Following characterization of video game experience, they underwent an assessment of visuospatial abilities. Following standardized teaching, the recruits' technical performance of an ultrasound-guided needle task was assessed for overall quality by global rating scale [GRS].

Results: Out of a total possible GRS score of 35, gamers compared to non-gamers demonstrated 5.2 (95% CI 1.9, 8.4) units of better performance. Gamers also performed better in mental rotation test (MRT) scores (Difference 4.1, 95% CI 1.2, 7.0) .

Conclusion: Video game practice is associated with increased mental rotation ability and enhanced technical performance in a simulated ultrasound-guided task.

Keywords: Laparoscopic surgery, mental rotation test, regional anesthesia, ultrasound-guidance, video games

INTRODUCTION

Successful ultrasound-guided regional anesthesia (USGRA) requires competency in multiple procedural steps including image acquisition, anatomical interpretation and hand-eye coordination.(1) Given that video games may require similar skills, it is possible that trainees with a background of video gaming may perform and learn differently to non-gamers.

Visuo-spatial ability, which is defined as the capability to comprehend, reason and retain the spatial interactions or associations between objects or space plays a crucial role in progressive scholastic qualifications. Psychological studies have shown that video game players have superior visuospatial ability, spatial resolution, visual attention processing, enhanced eye-hand coordination, quicker reaction times and enhanced mental rotation ability.(2-4) Enhanced mental rotation skill correlates with surgical performance in residents, and translates to improved surgical performance.(5, 6)

Recent studies suggest that video-gamers have superior laparoscopic skills and that video game practice could offer a cost-effective means to develop basic laparoscopic skill acquisition in surgical residents.(4, 7, 8)

Previously, we have successfully demonstrated that an individual's capacity for mental rotation (the visuospatial ability to mentally rotate and manipulate 2-D and 3-D objects) is predictive of performance of an ultrasound-guided needle task.(9)

As video game playing is associated with enhanced visuospatial ability,(4, 7) and enhanced mental rotation skills may translate into improved performance of an ultrasound-guided needle task,(9) we hypothesized that individuals who play video games would have enhanced visuospatial ability, and that this could perhaps translate into better performance in a simulated ultrasound-guided task compared to individuals who do not play video games.

The aim of the study was to explore whether gamers perform better than non-gamers on a simulated USGRA task or vice-versa.

METHODS

The study was reviewed and approved by the University of Nottingham Medical School Research Ethics Committee (Approval Reference; L13092012 SCS Anesthesia). We collected the data on video game playing habits in parallel with other USGRA task performance-related data, which we have previously published.(9) The primary outcome of this study was the global rating scale (GRS) of gamers versus non-gamers. Written informed consent was taken from all the participants prior to starting the study.

Medical students at the University of Nottingham were invited to participate through poster advertising. Students who expressed interest were emailed a participant information leaflet and an invitation to attend the study. The participants with previous experience of ultrasound scanning or performing regional anesthesia were excluded. Participants were free to withdraw from the study at any time. This single center, prospective, blinded observational study was conducted at the University Department of Anesthesia & Critical Care, University of Nottingham, Queen's Medical Centre, Nottingham University Hospitals NHS Trust, Nottingham, United Kingdom. The study comprised three phases (figure 1).

Study Phases

Phase 1. Demographic questionnaire and identification of gamers

All participants were asked to complete the demographic questionnaire. At present we know of no standard method to define or categorize "*video game experience*". Similarly, there is no validated model questionnaire to record "*previous or current video game experience*". Rosser and colleagues developed a scale for their study to record the "*amount of video game experience*" but did not publish it for further public use.(4) Other studies employed diverse methods for documenting game experience; therefore, on a theoretical basis, we proposed a definition of video game experience and classified 'gamers' as participating in 'frequent or daily playing of video games' and 'non-gamers' as not playing video games at all.

Phase 2. Assessment of visuospatial ability

Assessments of visuospatial ability were paper-based and administered under strict (examination) conditions. Participants underwent the following assessments of visuospatial ability:

Mental rotation Test (MRT) (10): There are four different variations, based on the original Vandenberg & Kuse (1978) mental rotation test figures. These include MRT–A, MRT–B, MRT–C and MRT–D respectively. We used MRT–A, which consists of 24 problem figures, all to be completed in nine minutes.

Group Embedded Figures Test (GEFT) (11): The GEFT measures field-independence, which is the ability to perform a focal task independently of any background information or distracters. Participants were allowed 20 minutes to complete the 18 problems.

Alice Heim Group Ability Test (AH4) (12): The AH4 is designed as a group test of general intelligence, which primarily assesses deductive reasoning including spatial reasoning skills. The test consists of 65 questions and participants needed to complete them in 10 minutes.

Phase 3. Assessment of technical ability

In this phase participants were given 30 minutes to watch and review an 11-minute video mapped to specific learning objectives, which modelled expert performance of ultrasound-guided needle advancement in a turkey breast model.(13)

The specific learning objectives of the ultrasound-guided needling task included:

1. Switch on the ultrasound machine (S-Series, Sonosite Ltd, Hitchen, UK)
2. Correctly orientate the ultrasound probe (linear, 38 mm) in relation to the display on the screen.
3. Ensure adequate application of conducting gel to enhance ultrasound transmission and picture quality.
4. Locate and identify the target 'Olive' within the turkey breast.
5. Adjust the gain function to improve the quality of the image by altering brightness of the picture.
6. Alter the depth of the image to obtain a suitable image of the target.
7. Using an in-plane approach insert a 50 mm Stimuplex® A needle (B Braun, Melsungen, Germany) into the turkey breast and aim to place the needle tip at the 12 o'clock position, as indicated by the attending assessors, above the upper edge of the target, without piercing the target.

The participants were then asked to complete the needling task on a turkey-breast model, using a 38-mm high-frequency linear array ultrasound transducer (HFL38X 13-6 MHz, Fujifilm Sonosite Limited, Luton, UK). In order to increase realism and to provide some anatomical context for the procedure, the turkey-breast was placed in the groin recess of a manikin (IV-Torso, Laerdal® Medical Limited, Orpington, Kent, UK). The participants received no help or feedback before or during the task. Study participation ceased once the ultrasound-guided needling task was completed.

Each participant's technical performance was independently assessed by two anesthetists experienced in USGRA. The task performance was evaluated in terms of '*overall quality*'. The overall quality was assessed and calculated by GRS [Appendix 1]; the assessment tool had been previously validated by our group and others.(9, 14-16) Prior to study commencement, both investigators had undergone specific training and practice in the use of this assessment tool. The GRS consisted of seven items each rated on a five-point scale. The GRS predominantly assessed more general behaviors and the overall performance of the participant.

Participants' demographic data and their completed visuospatial assessments were concealed from the investigators. Participants were blinded to the study hypothesis and their test scores. Data analysis was blinded and was performed by AS and SM.

The primary outcome measure was the global rating scale (GRS) of gamers versus non-gamers. Secondary outcomes included visuospatial assessment score (MRT, GEFT, AH-4) of gamers vs non-gamers, and reliability of the GRS.

Statistical analysis

Statistical analysis was performed using STATA/IC version 10.0 (StataCorp, Texas, USA). Descriptive statistics for demographic and outcome measure data were calculated. The distributions of the primary and secondary outcomes were determined by Shapiro-Wilks and Skewness/Kurtosis tests and examined graphically using q-q plots. GRS and MRT followed a normal distribution and were presented as mean and standard deviation (SD), while GEFT and AH-4 followed a non-normal distribution and were presented as median and interquartile range (IQR).

Independent sample t-tests were used to compare the mean scores of GRS and MRT for gamers and non-gamers. Wilcoxon-Mann-Whitney test was used to analyze the mean scores of GEFT and AH-4 for gamers and non-gamers. The difference of the GRS mean scores of gamers versus non-gamers and the 95% CI of the difference of mean were reported as a measure of the effect size.

To achieve a study power of 0.8 ($\alpha = 0.05$), we calculated that we would need to recruit 60 participants for this model with an assumed moderate effect size(17) ($r = 0.3–0.5$).

Reliability of the GRS, was evaluated using intra-class correlation coefficient, Cronbach's alpha coefficient and standard error of the measurement as a percentage of the mean (SEM%).(18) In all cases, we considered p-values less than 0.05 (two-tailed) to indicate statistical significance.

RESULTS

Sixty medical students completed all three study-phases. Seventeen out of 60 participants were classified as ‘gamers’ according to the criteria discussed in detail in the methodology section. The demographic, visuospatial and technical characteristics for gamers and non-gamers are presented in table 1.

Table 1. Demographic, visuospatial and technical characteristics of gamers and non-gamers. SD, standard deviation; IQR, Interquartile range (first to third quartile); MRT, Mental Rotation Test; GEFT, The Group Embedded Figures Test; AH4, Alice Heim Group Ability Test; GRS, Global Rating Scale. A higher score in the visuospatial and technical characteristics is associated with an overall better performance of the task.

	Gamers	Non-gamers	p value[a,b]
Demographic characteristics			
Sample size: n (%)	17 (28.3)	43 (71.7)	
Gender: male/female n (%)	14 (82.4) / 3 (17.6)	16 (37.2) / 27 (62.8)	
Age (years): mean (SD)	23.2 (3.7)	23.3 (4.6)	
*Visuospatial and *technical characteristics*			
MRT Mean (SD)	16.9 (4.6)	12.8 (5.2)	< 0.01
AH4 Median (IQR)	62 [60 to 63]	58 [51 to 63]	0.09
GEFT Median (IQR)	17 [15 to 18]	17 [14 to 17]	0.67
*GRS Mean (SD)	23.5 (6.0)	18.3 (5.4)	< 0.01

a: p value compares gamers versus non-gamers

b: Independent sample t-tests used to compare means and Wilcoxon-Mann-Whitney test used to compare medians.

Assessment of technical ability

Overall quality (GRS) of the ultrasound-guided task:

Gamers demonstrated enhanced technical ability for the GRS (table 1, figure 2). The overall quality of the ultrasound-guided task improved in gamers compared to non-gamers with gamers scoring 5.2 units greater than non-gamers. (5.2, 95% CI 1.9, 8.4).

Assessment of visuospatial ability

MRT: Gamers further showed superior visuospatial ability for the MRT (table 1, figure 3). The MRT scores were larger in gamers compared to non-gamers with gamers scoring 4.1 units greater than non-gamers. (4.1, 95% CI 1.2, 7.0).

AH-4: Gamers scored greater than non-gamers but with no statistically significant difference (table 1).

GEFT: Both gamers and non-gamers had equivalent scores with no statistically significant difference (table1).

Reliability of the GRS

The intra-class correlation coefficient and SEM (%) for GRS was 0.91 (8.53%), which reveals a high degree of inter-rater agreement. Similarly, Cronbach’s alpha coefficient and SEM (%) for GRS was 0.96 (5.69%) that determines a high degree of inter-item consistency.

DISCUSSION

This study gives us the opportunity to further unravel our understanding of ultrasound guided regional anesthesia and to explore whether gaming is associated with enhanced visuospatial skills. In particular, we hypothesized that individuals who played video games would be associated with better MRT scores, which could translate into improved ultrasound-guided task performance in regional anesthesia. We found that gamers achieved good scores compared to non-gamers. These findings reflected better performance and therefore have the potential to influence patient safety and outcomes.

Of the three visuospatial ability assessments, MRT scores were higher in gamers as compared to non-gamers. This is important as it shows that the probable mechanism for the advantage seen for gamers is not the cognitive ability to reason about shapes (AH4) or to be able to dissemble foreground from background (GEFT), but specifically the ability to mentally rotate images. However, we must be cautious because causation cannot be assumed (i.e. we do not know that video game practice necessarily enhances mental rotation skills). For example, it may be the case that an individual's mental rotational skills have improved through video game playing or it might be that they already had better mental rotational skills, and this made them enjoy video games more, and thus more likely to play them.

Video game practice has been shown to enhance visuospatial abilities.(2, 3, 19) For example, Green and Bavelier illustrated that video game practice improves visual attention capacity and spatial distribution.(2) Similarly, Li confirmed that contrast sensitivity (the ability to detect small increments in shades of grey on a uniform background) improves with video game practice.(19) By extension, there is ample evidence to suggest a positive correlation between video gaming and generalized surgical ability including open, laparoscopic, endoscopic and robotic surgery.(20, 21) As such, we believe that our findings are in agreement with these previous studies of surgical expertise, in that the gamers in our study depicted superior MRT skills and demonstrated improved technical performance of the USGRA task. However, we must also not underestimate the fact that the differences in the images and visual spatial skills required between the high-resolution videos, particularly in fiberoptic and laparoscopic procedures when compared to the images observed on an ultrasound screen could limit some of our inferences and, this is where we need to invest efforts in exploring such disparities.

A number of limitations must be acknowledged. These include the use of medical students instead of practicing doctors and use of a turkey-breast model instead of *in-vivo* task performance. However, we know that medical student performance of an ultrasound-guided task is comparable to that of novice resident doctors, which mitigates against previous USGRA experience.(14) Secondly, the use of a turkey-breast model is accepted as a means of novice evaluation in ultrasound, and it avoids the ethical problems associated with allowing novice practitioners to practice on real patients.(22) Furthermore, the combined stress and fear of 'live assessment' could produce detrimental and variable effects on performance such as that in clinical practice.(23) Specific limitations included lack of randomization, absence of a control group and investigation at a single healthcare institution.

We also accept that this study is based on self-reporting of medical students as 'gamers' and 'non-gamers'. However, at present there is no standard measure to define "*video game experience*". Some studies have employed many diverse methods for documenting game experience. These included total hours of game experience, self-assessment of video game expertise and whether an individual had an interest and merely liked video games.(24) Van Dongen classified video game experience as '*an average playing time of at least 10 hours per week*', although he failed to collect a group of individuals who played 10 hours per week.(25) The Pew research center has conducted a study regarding how individuals see themselves as gamers and signified how complicated this classification truly was.(26) Furthermore, the emergence of different styles of video games ranging from gaming consoles, joysticks and other controllers to touch screen games could add to the complexity and could potentially convolute the categorization.

Although existing evidence suggests that mental rotation skills are malleable(27) and spatial skills are influenced by video game playing,(2, 3, 19, 28) we are unsure whether or not the technical differences identified in this current study would translate into meaningful clinical differences. However, we believe that the 5.2 difference of a change in gamers' performance as assessed by the GRS score is large enough to generate interest in future research efforts.

CONCLUSION

Gamers performed significantly better than non – gamers, and thus predicted the psychomotor performance of an ultrasound – guided needle task. There is an association of video game experience with USGRA skills. However, the predictive implication of these inferences is uncertain. Future studies should be more consistent and adequately powered, so that stronger evidence on this topic can be accomplished.

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FIGURE LEGENDS

Figure 1. Study flow diagram.

Figure 2. GRS scores of the ultrasound-guided task for gamers vs non-gamers. GRS, global rating scale.

Figure 3. MRT scores of the ultrasound-guided task for gamers vs non-gamers. MRT, mental rotation test.