ORIGINAL ARTICLE

Web-Based Software to Assist in the Localization of Neuroanatomical Lesions

Evan Cole Lewis, Melanie Strike, Asif Doja, Andy Ni, Jonathan Weber, Nadine Wiper-Bergeron, Erick Sell

ABSTRACT: ***Objective:*** To evaluate the educational effectiveness of a novel, web-based neuroanatomical localization application. ***Methods:*** A prototype version of a neuroanatomical localization application was developed, limited to lesions involving Cranial Nerve (CN) VII. Second year medical students at the University of Ottawa were recruited to participate in the study. Participants were exposed to a didactic teaching session on CN VII anatomy. They were subsequently randomized to two groups – one group was granted access to the localization application (the "intervention group"), while the other group was given a booklet of standard textbook resources (the "control group"). Participants then completed a case-based multiple choice test on localization of neurologic lesions associated with CN VII, followed by a questionnaire regarding the experience. ***Results:*** Thirty-nine students volunteered to participate. Twenty were randomized to the intervention group and 19 to the control group. There was a mean test score difference of 1.3 ($CI_{.95}$ = 0.2, 2.3) that was significantly higher in the intervention group when compared to the control group. Significance was determined by a Wilcoxon rank test (p = 0.028). Questionnaire results were similar for both groups, showing an overall favourable evaluation of the localization application. ***Conclusions:*** The results support our hypotheses that students using the application would perform better on the multiple choice question (MCQ) test and there would be an overall preference for its use. The demonstrated educational benefit of the application, in addition to the demand for such a resource expressed by the participants, warrant further investigation into the development of a neurological localization application.

RÉSUMÉ: Logiciel Web pour aider à localiser les lésions neuroanatomiques. ***Objectif :*** Le but de l'étude était d'évaluer l'efficacité au point de vue didactique d'une application nouvelle d'un logiciel Web de localisation neuroanatomique. ***Méthode :*** Un prototype d'une application de localisation neuroanatomique, limité aux lésions du septième nerf crânien (VII NC), a été développé. Des étudiants de deuxième année de médecine de l'Université d'Ottawa ont été recrutés pour participer à cette étude. Les participants étaient exposés à des sessions d'enseignement sur l'anatomie du VII NC. Ils ont été randomisés par la suite à deux groupes, un groupe qui a eu accès à l'application de localisation (le groupe intervention) et l'autre groupe qui a reçu un livret indiquant les références pertinentes dans les manuels classiques (groupe témoin). Les participants complétaient ensuite un test à choix multiples concernant la localisation de lésions neurologiques associées au VII NC chez des cas cliniques, suivi d'un questionnaire portant sur leur expérience. ***Résultats :*** Trente-neuf étudiants se sont portés volontaires pour participer à l'étude. Vingt ont été randomisés au groupe intervention et dix-neuf au groupe témoin. La différence du score moyen du test était de 1,3 (IC à 95% : 0,2 à 2,3) significativement plus élevé dans le groupe intervention que dans le groupe témoin selon le test de rang de Wilcoxon (p = 0,028). Les résultats du questionnaire étaient similaires dans les deux groupes, ce qui est en faveur d'une évaluation globale favorable de l'application de localisation. ***Conclusions :*** Ces résultats appuient nos hypothèses selon lesquelles les étudiants qui utilisent l'application réussiraient mieux le test MCQ et qu'il y aurait une préférence générale pour son utilisation. Le bénéfice didactique démontré de l'application, en plus de la demande pour une telle ressource exprimée par les participants, justifie d'étudier davantage le développement d'une application de localisation neurologique.

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Localization of neurological lesions is an essential skill in neurology requiring the analysis of clinical history and physical examination findings that lead neurologists to a particular lesion. Medical students are often overwhelmed by this concept, so much so that Jozefowicz[1] coined the term "neurophobia" to describe student attitudes towards the study of neurology. Risdale et al[2] suggested that brief and unfocussed neurology training in medical school contributes to neurophobia. They emphasized the need for the development of innovations in neurology education to improve competency among medical students.

Computer technology is an integral component of modern medical school curricula[3]. Due to the complexity of neuroanatomy, localization of neurologic lesions is a particular domain where learners could benefit from computer-based instructional tools to facilitate the development of this skill.

From the Children's Hospital of Eastern Ontario (ECL, AD, AN, ES); University of Ottawa (MS, JW, NWB), Ottawa, Ontario, Canada.

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Correspondence to: Evan Cole Lewis, Department of Pediatric Neurology – Children's Hospital of Eastern Ontario, 401 Smyth Road, Ottawa, Ontario, K1H 8L1, Canada.

Our goal was to create a prototype neurologic lesion localization application that was web-based and effective as a learning tool. We piloted the prototype among medical students, a group known to have difficulty with neuroanatomical lesion localization[2,4,5]. We sought to determine if this program would be a useful and desirable learning tool. To our knowledge, no study has tested the effectiveness of a computer-based, neuroanatomical localization application with medical students. We hypothesized that individuals using the application would perform better on a case-based test than those using text-based resources. We also believed there would be a preference for the application.

Materials & Methods

This unblinded randomized control trial was conducted at the University of Ottawa's Faculty of Medicine. The study was approved by the Ottawa Hospital Research Ethics Board (OHREB). The purpose and requirements were explained and informed consent was obtained.

Participants

All 156 second year medical students at the University of Ottawa were invited to participate; 39 students volunteered. All participants were mid-way through the undergraduate neurology module, and were considered to have comparable neuroanatomical knowledge at baseline.

Localization Application

A prototype version of a comprehensive neuroanatomical localization application was developed using PHP/MySQL database technology. For simplicity, we limited the prototype to lesions involving Cranial Nerve (CN) VII. The prototype functions by having the user select from a list of clinical findings that narrows after each selection until the user arrives at one of 21 possible lesions. Final lesions are reproduced onto CT/MRI and/or diagrams. The prototype can be accessed at http://www.jonathan-weber.com/work/neuro/localization.

Textbook Resource

Two neuroanatomical textbooks commonly used by medical students at the University of Ottawa during the neurology module were chosen as resources for the control group[6,7]. The authors reached consensus on a selection of diagrams, images and text relating to CN VII anatomy. In the opinion of the authors, there was enough content provided for the control group to adequately answer all multiple choice questions.

Procedure

Participants attended one of two 75 minute sessions in which all data was collected (Figure 1). The complete flow of the testing session is depicted in Figure 1. Simple randomization allocated participants to the intervention or control groups by assigning an odd or even number to each individual as they

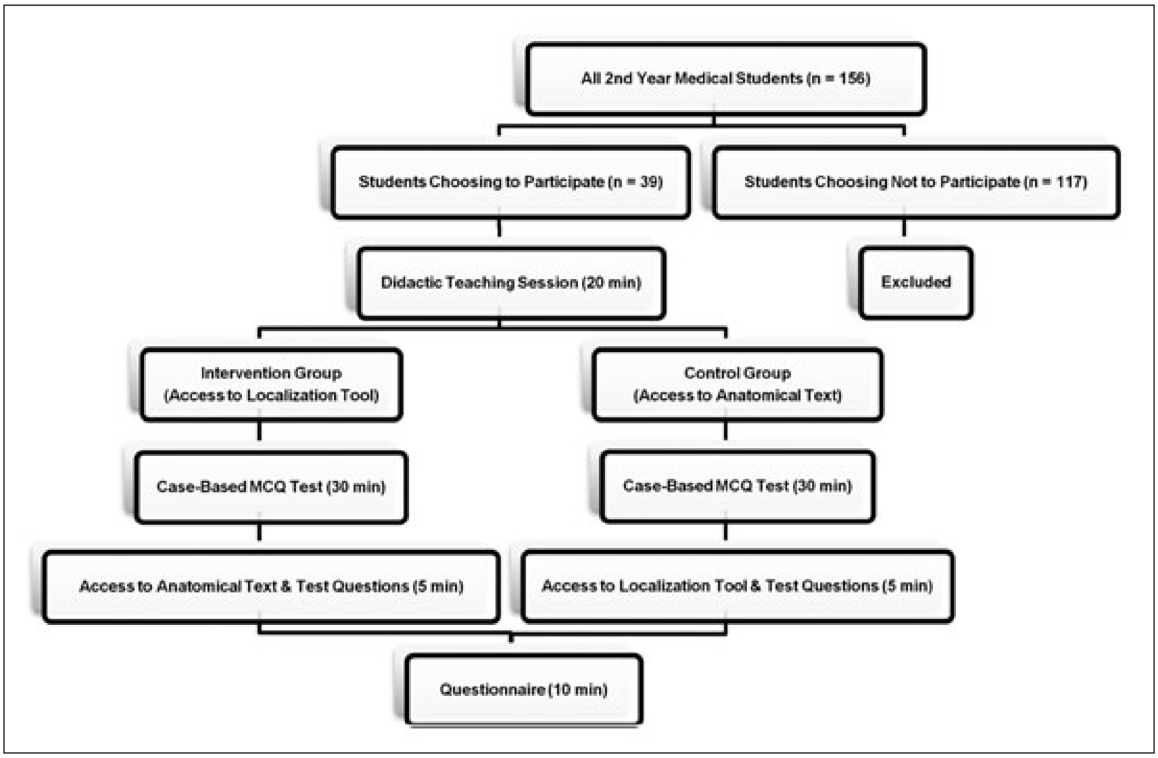

Figure 1: *Study Design. This flow chart details the design and flow of the study through selection of participants to evaluation of the intervention. MCQ = multiple choice question*

Sample of Questions from Multiple Choice Test

Question 1 Sample:

In general, where is the most likely location of the lesion that explains all the patient's neurologic findings?

Possible Answers:

A. Cervical Spine	*E. Cerebellum*
B. Medulla	*F. Internal Capsule*
C. Pons	*G. Motor Cortex*
D. Midbrain	*H. Infranuclear Cranial Nerve VII*

Question 2 Sample:

The patient's pattern of weakness is best explained by a:

Possible Answers:

A. Right-sided supranuclear Cranial Nerve VII lesion
B. Right-sided infranuclear Cranial Nerve VII lesion
C. Left-sided supranuclear Cranial Nerve VII lesion
D. Left-sided infranuclear Cranial Nerve VII lesion

***Figure 2:** Question Sample from Multiple Choice Test. Sample of two questions taken from the multiple choice test completed by all participants in the study. The sample here depicts both broad and specific localization-type questions.*

entered the room. All participants received didactic teaching on localization of neurologic lesions and CN VII neuroanatomy. The teaching consisted of a 23 slide powerpoint presentation with an overview of major motor and sensory pathways and details about cranial nerve anatomy with a focus on CN VII. Relevant examples of neuroanatomical localization were also discussed. Students were not allowed to ask questions during the teaching session. Next, all participants completed a multiple choice question test in which the intervention group was given access to the localization application and the control group was given access to the textbook resource. All participants were allowed 30 minutes to complete the test. Following test collection, participants in the intervention group were given access to the textbook resource and unanswered test questions, while participants in the control group were given access to the localization application and unanswered test questions. Both groups were given time to use the other group's resource prior to answering a questionnaire based on the experience.

Data Collection

Demographic data was collected including computer usage and proficiency. The test consisted of three clinical cases with associated multiple choice questions amounting to a total score out of ten. The cases and questions were designed by the investigators and reviewed and edited by an independent focus group of neurologists, neurosurgeons, neurology residents and medical students. The questions ranged from asking the participant to broadly localize the suspected lesion in the given case to specifically localize certain findings from the case history or exam. A sample of two questions from the test is depicted in Figure 2 and is representative of most questions encountered by the participants. Additionally, a six item, four

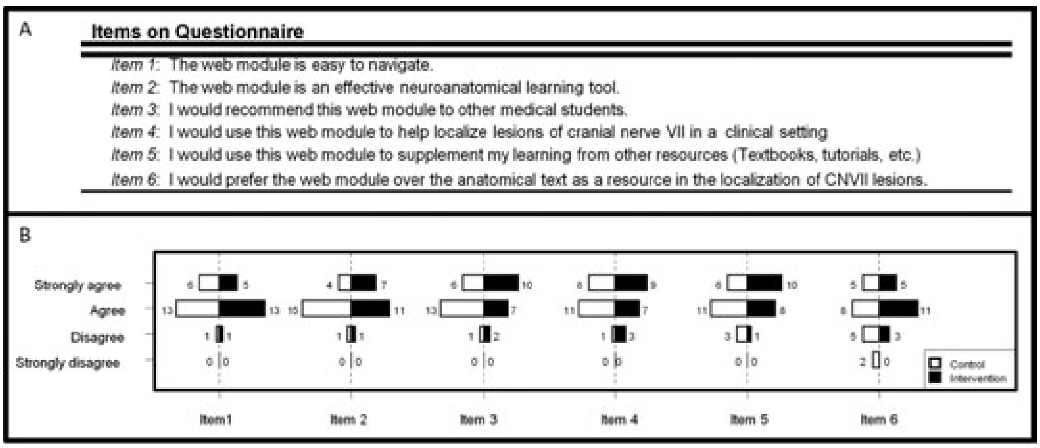

***Figure 3:** Summary of the Questionnaire Results. (A) Specific wording of the items on the questionnaire. (B) Bar chart summarizing the questionnaire results per item from both the intervention and control groups.*

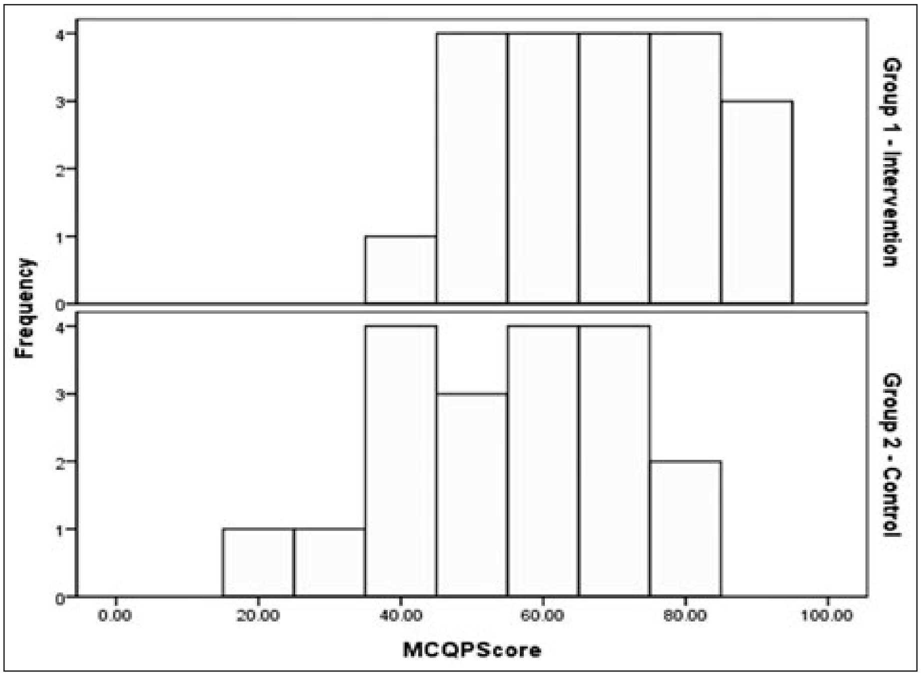

Figure 4: *Student Performance on MCQ Test as a Percent Score. This histogram breaks down the performance of the intervention and control groups on the MCQ test.*

point Likert questionnaire (Figure 3) assessed subjective preference of the application and its perceived utility for clinical and educational purposes. An optional comment section was available. The questionnaire was also reviewed by the focus group. Finally, both the test and questionnaire were further refined using feedback obtained by 12 third year medical students in a rehearsal session.

Statistical Analysis

A minimum sample size of 20 was determined in advance after review of the literature and power calculation was not done due to the small number of potential participants and the pilot nature of the study. Statistical analyses were conducted in SPSS 18.0 (SPSS Inc., Chicago IL). Presented p-values were two-sided, and considered statistically significant if less than 0.05. Summary statistics were generated for demographic variables. A Wilcoxon rank test compared the mean test score between study groups. Bar charts were used to summarize questionnaire responses (Figure 3).

Results

A total of 39 second year medical students (25%, 39/156) from the University of Ottawa participated. Twenty were randomized to the intervention group (45% male, 55% female and mean age 25.4 years) and 19 to the control group (47% male, 53% female and mean age 25.6 years). More than 20 hours per week of internet use was reported in 85% (17/20) of the intervention group and 84.2% (16/19) of the control group. Computer use was also similar between the two groups: 100% (20/20) of participants in the intervention group and 94.7% (18/19) of participants in the control group reported at least 20 hours of computer use per week. The majority of participants in both groups, 90 % (18/20) in the intervention group and 84.2% (16/19) in the control group, rated their computer proficiency as "good" or "very good." All participants took between 26 and 30 minutes to complete the test.

Mean percent score on the test in the intervention group was 67.5% (SD = 15.2%, min = 40.0%, max = 90.0%) and 54.7% (SD = 16.8%, min = 20.0%, max = 80.0%) in the control group. A mean raw score difference of 1.3 ($CI_{.95}$ = 0.2, 2.3) was significantly higher in the intervention group compared to the control group (Figure 4), as demonstrated with a Wilcoxon rank test ($p = 0.028$).

Questionnaire results were similar for both groups, showing an overall favourable assessment of the localization application (Figure 3). The general response to question six (Figure 3) by both groups was less favourable for the application.

Discussion

We set out to create a tool to assist in the localization of neurologic lesions that would overcome limitations of other neuroanatomical diagnostic programs. Most studies of computer-assisted neuroanatomical pattern recognition programs were designed in the 1980's and 1990's, and thus employ outdated computer technology[8-10]. More recently, Kamo et al[11] developed a sophisticated tool demonstrating that computer memory could be valuable in identifying causative lesions based on neuroanatomical pathways. This program, however, was not tested among medical students or front-line physicians. Therefore, the suitability of the program for these populations is unknown. In addition, the software was not web-based, limiting its accessibility and ability to adapt with technological advancements. Conversely, our prototype is web-based, making it accessible and amenable to adaptation using input from clinicians world-wide via built-in Web 2.0 capability.

The program was designed to be comprehensible for medical students, and results indicate this goal was achieved. The majority of questionnaire responses from both groups suggest the application is easy to navigate and effective as a learning tool. However, shortcomings of the prototype were made evident. Some students predicted the prototype would be more useful in a clinical context, once they gain exposure to clinical neurology. Another suggestion was to include additional diagrams and references to enhance its educational utility. The current prototype has limited educational utility due to its limited focus on CN VII. Expansion of the program's bank of neuroanatomical pathways will render it a more comprehensive localization tool and perhaps more useful as a learning aid.

Our results indicate there is educational value in neuroanatomical localization software. To our knowledge, this is the only study revealing such findings. Studies have demonstrated educational advantages of computer-assisted medical training over traditional teaching methods[12-14]. These studies, in conjunction with our findings, support the development and integration of e-learning methods (i.e. via computer and/or internet) with traditional written or lecture-based instruction. Our results may also indicate a potential for educational advantages in computer-assisted neuroanatomical localization tools.

Our study suggests there may be demand for neuroanatomical localization software among medical students. Participants of both groups agreed they would use the prototype in a clinical setting. Other studies support a similar desire among medical students for computer-assisted learning[5,15]. However, we found less consistent preference of the prototype over text-based resources. Interestingly, individuals who did not prefer the localization application over text-based resources (Figure 3, Item 6) tended to comment that the tool lacked detail, diagrams, and supplementary information. This speaks to the quality of the current prototype. These shortcomings would be addressed in a future, full-scale version of the application.

There are limitations to this study. Relative to similar studies evaluating computer-based educational tools, our sample size was small[5,14]; although, it was suitable for a pilot study. Power was not calculated, since the sample size was calculated based on the availability of participants. A future study of a full-scale version of the application would require a larger sample size to provide adequate power, with prior estimation of the minimal difference required for a statistically significant result. Also, the unblinded design may have introduced bias on behalf of participants and investigators. Finally, samples were not stratified according to demographic data, and inconsistencies in computer use and proficiency between groups may have skewed the results in either direction.

Conclusions

Our study demonstrated a possible demand for a neuroanatomical localization application amongst medical students, and a potential educational benefit to such a tool. Our results warrant investigation into the development of computer-assisted neurological localization applications and further study of how students, residents and clinicians would utilize such tools.

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