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Digital training platform for interpreting radiographic images of the chest

Introduction

There have been various systems and devices tested for their effectiveness in the education of healthcare and medical staff.[1,2] A search strategy within image interpretation is a method employed to ensure that all aspects of the image have been checked for abnormal features.[3] Search strategies used by healthcare professionals in image interpretation are often based on a variety of guidelines and sources or otherwise 'self-taught'.[3,4,5] Checklists have also proven to be a valuable resource within the healthcare settings.[6,7]

Eye tracking has been used to help understand the process of image interpretation and secondly to assess and provide feedback/training on the interpretation process. The feedback based on eye tracking data from the participant (expert or novice) was shown to have an effect, with a significant improvement noted following the provision of feedback to participants (p=0.021).[8] Litchfield et al. (2008)[9] reported an improvement in the performance of both undergraduate and postgraduate radiographers when shown a preview of eye movements before their interpretation compared to when they were instructed to 'free search' or preview the image for 20 seconds prior to their image interpretation. Use of eye tracking feedback resulted in a 16% increase in radiology residents' performance compared to showing the observer the image again with no eye tracking feedback highlighted.[10] True positive rate increased and false positive rate decreased, indicating a real improvement in performance.[10]

To date no studies have been found which investigate the effect of using a digital training package based on eye tracking technology during chest image interpretation learning. With the use of eye tracking technology and expert input we aim to establish and evaluate a digital training platform.

Methods

The evidence and literature above informed the choices made regarding content and design of the digital training platform. A platform was developed to include: A) a search strategy training tool to assist reporters during their interpretation of images, and B) an educational tool to communicate the search strategies to trainees using eye tracking technology.

A). Search strategy training tool

Formation of the search strategy training tool:

Members of the research team collaborated to develop a robust search strategy, which is suitable for use in chest image interpretation. The research team combined two approaches to chest image interpretation and with the addition of further content and scrutiny a comprehensive search strategy was developed and finalised following evaluation of the pilot packages. [11] (Personal communications Woznitza 2016)

Use of the search strategy training tool:

The search strategy training tool is viewed simultaneously with a checklist when viewing a chest image during initial image interpretation training. It is envisaged that the user can with practice, overtime, avoid using the search strategy online. Instead they will simply follow the method of image interpretation they have developed and adapted consequent to using the tool.

Layout of the search strategy training tool:

The search strategy comprises of a series of questions and prompts to guide the user to exclude pathologies, systematically search the image and form a diagnosis. The search strategy begins by allowing reporting clinicians to focus on the 'general considerations' of the image presentation. By encouraging participants to firstly technically evaluate the chest image projection and additional image details (i.e. anatomical markers, post processing labels) they have been presented with, the image interpretation process and expectations of the image presentation may be influenced. For example when presented with an antero posterior image rather than a postero anterior image of a chest the reporting clinician's interpretation of the patient's heart size may be influenced.

The search strategy comprises six sections which focus on different anatomy, pathologies and artefacts which may be present within the image;

(1) General image considerations

(2) Tubes/lines/devices

(3) Bony thorax, soft tissues

(4) Diaphragm/heart/mediastinum

(5) Lung zones

(6) Lung shadows

Five University academics who are qualified experienced radiographers reviewed the search strategy training tool and were asked to comment and provide iterative feedback. After considering all feedback, amendments were made to the search strategy training tool.

Following the completion of each section of the search strategy training tool, users are asked to give a preliminary diagnosis. These thoughts are combined at the end of the search strategy tool to enable viewers to combine ideas to generate a complete diagnosis i.e. an iterative process occurs to enable rapid and final differential diagnosis to be created for assessment and feedback.

B). Educational programme

Layout of the educational programme

The educational tool consists of videos comprising expert eye gazes and scan paths recorded during chest image interpretation and collected whilst the expert used the search strategy training tool. Expert input was from qualified reporting clinicians who specialise in chest image interpretation. The expert's eye gaze behaviours were recorded as well as verbalisation of their thought processes during their interpretation which provides a clear description of their search strategy. The training tool, once finalised, was transformed into an online digital format for participant's ease of use.

Eye tracking data such as scan paths were displayed over the image content. Fixations, where the participant concentrated on a specific area of the image, were demonstrated as coloured circles on the image with the area of the circle increasing as more time was spent fixating on an area. The fixations were commonly connected with saccades or a line joining the two areas of fixations. A saccade represents a quick movement of both eyes between areas of fixations. By observing such eye gaze behaviour, trainees can see where an expert fixates on the image and the areas experts gave greater visual and cognitive attention to. Essentially, this provides insight into how experts interpret images and the search strategy they implement.[12]

Expert eye tracking data collection

The eye tracking data collection was completed during the interpretation of 20 chest images by reporting clinicians to include a consultant radiologist and a consultant reporting radiographer trained to interpret chest images. The reporting clinicians were asked to interpret the images and provide the voice recordings for the development of the educational programme. We selected two clinicians to allow the incorporation of both disciplines (i.e radiographers and radiologists).

The Tobii Studio X60 eye tracker and the Tobii studio software© were utilised for data collection and for computing eye gaze metrics.[13] The remote non-intrusive eye tracker collected the data without interference to the participant's interpretation. The eye tracker was positioned inferior to the high resolution (1440px x 900px) 24" LCD monitor that displayed the images, and angled upwards (30° cranially) to align with the participant's gaze.

We asked both expert reporting clinicians to speak aloud during the image interpretation session, both to verbalise the search strategy and help translate the search strategy to users watching the eye tracking videos. Voice recordings of the expert were also presented with the eye tracking data. They coincide with the eye tracking data and allow the expert to explain how he is systematically searching the image and why he is looking at specific areas of the image.[14]

Images

Images were presented on the eye tracking software using the Tagged Image File Format (TIFF). Images could not be presented in Digital Imaging and Communications in Medicine (DICOM) format on a calibrated monitor as used in clinical practice, due to limited access to equipment. The TIFF format enables lossless compression presentation of the images on the display monitor and image quality was maximised within the training package. Images were chosen from a test bank previously used in research and were reported on by two radiologists, both were in complete agreement in all cases. [This paper is currently under review for publication]. [15] The reference standard was therefore a strong source and images were already anonymised for patient protection. Permission to use these images was achieved from the test bank source. A maximum selection of 20 images were chosen to demonstrate the use of the search strategy to avoid causing fatigue to the user. Of the twenty chest images interpreted by the reporting clinicians; 11 images were normal in appearance with no clinically significant pathologies evident and nine images were abnormal in appearance, with at least one significant pathology presented in the image. The images that were abnormal in appearance were classical examples of pathologies which reporting clinicians would encounter when interpreting images in clinical practice (for example pneumothorax, effusion, consolidation).

Digitising the tool

Iterative discussion by the research team created a paper based final version of the search strategy training tool. A research associate developed the training platform into a web-based interactive tool, which could be easily accessed online. The digital training platform was developed using web technologies enabling interpreter engagement across various platforms and devices. Hypertext Mark-up Language version 5 (HTML5) was employed to structure and display webpages across numerous web browsers, whilst an engaging user experience was created through implementing Cascading Style Sheets (CSS3). The web-scripting language, JavaScript, in combination with JQuery (a Document Object Model (DOM) manipulation library), was implemented to facilitate interactive participation from interpreters. Toggling buttons and text inputs were used to collect interpreter annotations. Reactive animations were employed via JavaScript as a form of interpreter feedback when collecting interpreter annotations. The Hypertext Pre-processing language (PHP) was used to save data to a My Structured Query Language (MySQL) database. An example of the layout and display of the platform, post digitisation, is demonstrated within Figure 1, Figure 2 and Figure 3.

A login feature monitors the use of the eye gaze enhanced videos and the search strategy training tool. Users must enter a user identification code before being granted access to the platform.

Discussion:

A digital training platform for use in chest image interpretation was created based on evidence within the literature, expert input and two search strategies[11] previously used in clinical practice (Personal communications Woznitza 2016). Images and diagrams, aiding translation of the platform content, were incorporated where possible. The images and diagrams feature colour and labels to ensure information is supplied clearly. The platform is structured to allow the chest image interpretation process to be clear, concise and methodical. A search strategy was incorporated within the tool to ensure users would devote attention to all aspects of a chest image. Given the lack of evidence based practice on use of a particular search strategy within image interpretation, it was important to investigate the use of a search strategy, with the possibility that it could be recommended as an evidence based approach for use by reporting clinicians. It was decided to implement expert eye tracking and voice recordings to explain the search strategy which is being used and to help explain how it is used during the interpretation process. Provision of clinical history with a chest radiographic image could prompt the reporting clinician to search the image in a particular method. No clinical history was provided with the images within the eye tracking videos to avoid interference with the search strategy incorporated within the training platform.

The digitisation of the training platform was completed for ease of use. As the platform is presented and used in digital format, it can be used easily within learning/clinical environments. Furthermore it can be reused as it avoids the use of CD/downloads etc. to watch the eye tracking videos.

A checklist, to allow ease of use of the training platform, was included within the search strategy training tool. Although checklist fatigue was suggested as a possible problem by Kramer[6] the implementation of this checklist whilst practicing and learning about chest image interpretation allows possible ‘checklist fatigue’ to be minimised. The participants will probably cease to use this online checklist once they have completed their initial image interpretation training and adopt their own strategies. This tool supplies them with a checklist and search strategy when initially developing their image interpretation skills. Where a bottom up approach is necessary on encountering previously unseen appearances or combinations of to develop a deductive reasoning approach to the final diagnostic opinion with differentials.

The training platform has the potential to be used for user’s self-assessment and image interpretation learning support. The ‘preliminary diagnosis’ sections and the ‘final diagnosis’ section are recorded and stored within an excel database. This feature of the platform can be used retrospectively to pinpoint common user errors in their image interpretations or to record their performance as an assessment method. The presentation of the ‘preliminary diagnosis’ sections to the user when making their decision, prompts them to consider a differential diagnosis for each image. This element is similar to the image report generated by the decision support tool of Wang.[7]

Conclusion:

The original documents used to develop the training platform (the PowerPoint search strategy and the written checklist) were used in practice by reporting clinicians and complemented each other well to form a search strategy training tool. The PowerPoint presentation supplied a visual method of explaining the search strategy and the written checklist provided a structured set of questions to guide the user through the image.

The eye tracking videos help translate the search strategy and allow the use of a new and innovative technology to be used in an image interpretation learning platform. Many users will not be familiar with viewing eye gazes when learning about image interpretation, in which case this could pose an obstacle for their learning or alternatively represents an exciting new method of learning. Eye tracking videos are easy to comprehend and follow, aided by the voice recordings of the expert, which should reduce any issues users have when viewing and comprehending the eye tracking videos.

Once an internet connection is opened the display of the platform is structured, with instructions of its use provided where necessary. A user login feature allows monitoring of the use of the platform and enables investigation into whether there is a relationship between its use and users image interpretation. The training platform for use in chest image interpretation learning has been designed, created and digitised by the research team and will be investigated for its use in chest image interpretation in further studies.

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