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Abstract

Visual expertise is becoming more and more a crucial part of medical expertise. The amount of medical images has grown tremendously and the last decades have welcomed several new and increasingly dynamic imaging techniques (Krupinski, 2010). Nevertheless, visual expertise has so far mainly been studied in domains using static images, such as X-ray images (Reingold & Sheridan, 2011). This is also true for the domain of clinical pathology, where, in their natural context, pathologists interactively navigate and zoom within microscopic slides. Research in this domain either restricted these navigation possibilities (Krupinski et al., 2006; Tiersma, Peters, Mooij, & Fleuren, 2003) or neglected the visual processes (Crowley, Naus, Stewart, & Friedman, 2003). Hence, not much is known on visual expertise in domains that deal with interactive, medical images.

In this study, 38 clinical pathologists with three different expertise levels, performed diagnostic tasks on a virtual microscope (i.e., computer software displaying scanned tissue samples in a similar way as a light microscope). By measuring eye movements, microscope navigation and thinking aloud, insight in both visual and cognitive expertise was gained. Each participant viewed seven interactive slides, representing different diseases of the colon. At the time of writing this submission, the analysis was not fully completed, yet. However, both literature and a previous study in this project, using static images only, revealed that novices spent less time and fixations in diagnostically relevant areas. This study will contribute to the understanding of visual expertise by developing a methodology which is fit for the study of interactive images.

Introduction

The development of visual expertise of clinical pathologists has so far remained an understudied phenomenon. The studies that have been carried out, used microscopic images with a fixed magnification (Krupinski, et al., 2006; Tiersma, et al., 2003) or did not focus on visual processes (Crowley, et al., 2003). The study described here assesses differences in both visual and cognitive expertise between pathologists of different expertise levels while examining authentic interactive slides, and hence constructs ideas about the development of expertise of clinical pathology.

As a theoretical frame work, the theory on expertise development by Schmidt and Boshuizen was used (Schmidt & Boshuizen, 1993b). This theory describes the development of medical students to medical specialists in three stages, thereby focussing on the development of underlying knowledge structures (Schmidt & Rikers, 2007). The two most relevant of these stages are (1) the development of an extensive causal network of biomedical knowledge and (2) the inclusion of biomedical facts in higher-level concepts (*encapsulations*).

Design and Participants

The experiment was set up as a mixed design, with expertise level as between-group variable, and type of disease as well as magnification level presented in virtual slides as within-group variables. In total 38 clinical pathologists of different expertise levels – 13 experts, 12 intermediates, and 13 novices – participated in this study. *Novices* were actually not yet clinical pathologists but second year medical students; *intermediates* were those in postgraduate training for clinical pathologist; and *experts* were the practicing clinical pathologists. All cases were unknown to the participants. The participants had normal or corrected-to normal vision. They participated voluntarily, receiving a small present as a reward.

Apparatus and Material

Seven digitized microscopic slides were selected to represent different diseases of the colon. They were presented to the participants through a virtual microscope, the software equivalent of a light microscope. The slides were preceded by patient background information.

Participants' eye movements were recorded with an monitor-mounted eye tracker (SMI RED 250 Hz). Verbal data were recorded with a webcam with a built-in microphone. The virtual microscope software recorded the microscope navigation of the participants.

Procedure

Before engaging in diagnosing the slides, participants were trained in thinking aloud and in the use of the virtual microscope. After these exercises, participants diagnosed the seven interactive slides while thinking aloud. Lastly, participants stated the actual diagnosis and explained their diagnosis verbally.

Planned analysis

The eye movements are expressed in parameters such as number and length of saccades, number of repeated fixations and the average and total fixation time. These will be analyzed for clinically relevant and neutral areas.

In the case of the participants' microscopic navigation, the basic parameters are the number of navigational movements in the horizontal and vertical plane, and the time spent on each zoom level. The coverage of the slide and clinically relevant areas will also be calculated.

The think-aloud protocols will be transcribed and segmented. These segments will be rephrased as propositions, consisting of two arguments connected by a relational label (Schmidt & Boshuizen, 1993a). They will then be analysed for the amount of encapsulations that they contain. An encapsulations is the inclusion of 'lower level detailed propositions, concepts, and their interrelations in an associative net under a smaller number of higher level propositions with the same explanatory power' (Schmidt & Boshuizen, 1993a, p. 340).

Last, both the visual and the cognitive data will be combined in a time-locked analysis. In this analysis, encapsulations in verbal data will be isolated and the eye movements made in that time period, analyzed.

This type of analysis has been successfully performed on the data of a previous study with static images as stimuli. This analysis could be seen as a stepping stone towards the analysis of the data of the interactive images, as they are expected to be more complicated.

Results and Discussion

At the moment of writing this proposal, the data were collected but unfortunately not fully analyzed yet. However, a previous study with static images showed that the magnification level of images is decisive for the success in the identification of diagnostically relevant areas. In low magnification images, novices spent less time and fewer fixations in these areas. The same goes for images with diseases in them, versus 'healthy' images, with the disease images being more difficult for novices. Furthermore, novices showed a significantly worse diagnostic accuracy compared with experts and intermediates, but no difference was found between experts and intermediates. For an exemplary viewing pattern of a novice task performer see Figure 1.

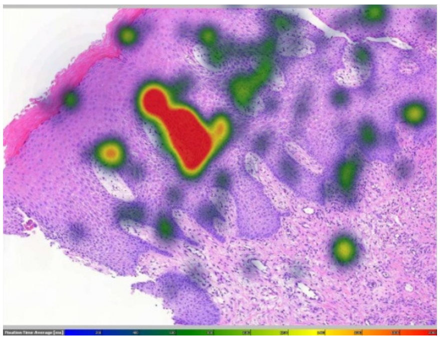

Figure 1: Exemplary viewing pattern of a digital pathological slide by a novice.

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