Teaching Systematic Viewing to Final-Year Medical Students Improves Systematicity but Not Coverage or Detection of Radiologic Abnormalities

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Abstract

Purpose: Systematic viewing of images is widely advocated in radiology; it is expected to lead to complete coverage of images and consequently more detection of abnormalities. Evidence on the efficacy of teaching systematic viewing to students is conflicting. The aim of this study was to investigate the effects of teaching systematic viewing to final-year medical students on systematicity of viewing behavior, coverage of the image, and detection.

Methods: Final-year medical students (n = 60) viewed 10 chest radiographs in a first series before training and another 10 radiographs in a second series after training. Between series, students were taught basic chest radiographic viewing, in either a systematic or a nonsystematic manner. With eye tracking, systematicity (Levenshtein distances), coverage (percentage of image viewed), and detection (sensitivity and specificity) were measured.

Results: In a mixed two-by-two design, significantly higher sensitivity was found after training compared with before training ($F_{1,55} = 6.68$, $P = .012$, $\eta_p^2 = .11$) but no significant effect for type of training ($F_{1,55} = 1.24$, $P = .30$) and no significant interaction effect ($F_{1,55} = 0.12$, $P = .73$). Thus, training in systematic viewing was not superior to training in nonsystematic viewing. A significant interaction of training type and time of viewing was found on systematicity ($F_{1,49} = 20.0$, $P < .01$, $\eta_p^2 = .29$) in favor of the systematic viewing group. No significant interaction was found for coverage ($F_{1,49} = 0.43$, $P = .51$) or specificity ($F_{1,55} = .124$, $P = .73$).

Conclusions: Both training types showed similar increases in sensitivity. Therefore, it might be advisable to pay less attention to systematic viewing and more attention to content, such as the radiologic appearances of diseases.

Key Words: Education, perception, systematic viewing, eye movements

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INTRODUCTION

A systematic approach is widely recommended to medical students when they are taught to interpret radiologic abnormalities [1-3]. Such systematic viewing approaches may differ in the order in which anatomic structures should be looked at, but all concur that students need to adhere to one specific order for all images. The principle behind pursuing the same specific order is that students will be less likely to overlook anatomic structures in their viewing process and will therefore be most complete. By completely covering images, medical students are expected to miss less abnormalities. Although it is common practice in radiology departments to teach novices a systematic approach, little research has been performed on its efficacy.

The effects of systematic viewing on detection were investigated by Peterson [4] and Auffermann et al [5]. Peterson found that students who used a complete but nonsystematic search pattern performed significantly

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better than students who used any other search pattern. Peterson's study, however, had only an observational design, and therefore effects of training systematic viewing on detection remained unknown. Furthermore, search patterns and completeness were deduced from think-aloud data rather than from more objective data. Using think-aloud data as a measure of viewing behavior carries the assumption that one could objectively report where one is looking, which is an assumption that does not hold [6]. To objectively measure viewing behavior, the movements of the eyes need to be captured, which can be done by measuring participants' eye movements with eye-tracking apparatus [7].

Auffermann et al [5] investigated the effect of training in systematic viewing on physician assistant trainees evaluating chest radiographs. They found that trainees who participated in the training detected significantly more abnormalities in comparison with the control group. Unfortunately, the control group of this study did not have equal exposure to training in chest radiographic interpretation. Thus, it is unclear whether the increase in detection was the result of the greater educational exposure [3,8] or the result of the instruction to systematically evaluate images. Furthermore, Auffermann et al [5] did not use measures for search patterns or coverage in their methodology, and effects of training on search patterns are therefore unknown.

Thus, to establish the effectiveness of training in systematic viewing, research is required that uses objective (eye-tracking) data to quantify systematic viewing. Furthermore, the effectiveness of training in systematic viewing needs to be established against training in nonsystematic viewing that has equal educational exposure. In this study, we compared a group of final-year medical students who received training in systematic viewing with a similar group who received similar training that did not focus on systematic viewing. Eye movements were measured using eye-tracking methodology. The aim of this study was to answer the following research questions: (1) Does detection of abnormalities increase after training in systematic viewing when medical students view chest x-rays? and (2) Do eye movements change after training in systematic viewing, showing increased systematicity and coverage when medical students view chest x-rays?

METHODS

Participants

Final-year medical students (n = 60; 73% women; mean age, 24.8 ± 1.54 years) participated in this experiment. All students were recruited from Maastricht University Medical Centre or affiliated hospitals. Students were recruited via the electronic learning environment of Maastricht University.

All participants had some experience in viewing chest radiographs during their prior clinical rotations but had not received any formal training. Students who had followed an elective chest radiology rotation or who were performing final-year internships in a radiology department were not included. Participants were randomly assigned to one of the two groups; 31 were allotted to the systematic viewing group and 29 to the nonsystematic viewing group. The participants received a €10 gift voucher as a reward.

Materials

Apparatus. Eye movements were measured using an SMI RED remote eye tracker (SensoMotoric Instruments, Teltow, Germany). The head movements of participants were not physically restricted. However, to ensure optimal data quality, participants were instructed to avoid head movements as much as possible. The sampling rate was set to 250 Hz, and the eye movements of participants' right eyes were used. The images were shown on a Dell 22-inch liquid crystal display, with a resolution of 1,650 × 1,080 pixels. Before the start of the first (pretraining) and the second (posttraining) series of images, the eye tracker was calibrated using a nine-point calibration. Calibration was repeated until a deviation of less than 1° of visual angle on both the x axis and y axis was acquired. Eye-tracking data from nine participants were excluded from the analysis because of insufficient data quality (ie, the threshold of 1° of visual angle could not be reached). Data were analyzed using IBM SPSS Statistics version 21 (IBM, Amsterdam, The Netherlands).

Radiologic Images. In this study chest radiographs were used. Chest radiographs not only account for considerable amounts of work in every radiology department [9], but viewing them is also difficult to master [10]. Therefore, using chest radiographs would minimize potential ceiling effects. To ensure the inclusion of images with distinct pathology and distinct normal images, all chest radiographs were individually evaluated by two senior radiologists. Images were included only when the radiologists agreed in their evaluations. All images were stripped of any identifying information. Of the total set of 20 chest radiographs, 17 contained 2 or more abnormalities, and the other 3 were normal. The number of abnormalities was 56 in total: 33 in the pretraining image series and 23 in the posttraining image series (Fig. 1). The abnormalities on the images differed in