The Effect of Teaching Search Strategies on Perceptual Performance

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Rationale and Objectives: Radiology expertise is dependent on the use of efficient search strategies. The aim of this study is to investigate the effect of teaching search strategies on trainee's accuracy in detecting lung nodules at computed tomography.

Materials and Methods: Two search strategies, "scanning" and "drilling," were tested with a randomized crossover design. Nineteen junior radiology residents were randomized into two groups. Both groups first completed a baseline lung nodule detection test allowing a free search strategy, followed by a test after scanning instruction and drilling instruction or vice versa. True positive (TP) and false positive (FP) scores and scroll behavior were registered. A mixed-design analysis of variance was applied to compare the three search conditions.

Results: Search strategy instruction had a significant effect on scroll behavior, $F(1.3) = 54.2$, $P < 0.001$; TP score, $F(2) = 16.1$, $P < 0.001$; and FP score, $F(1.3) = 15.3$, $P < 0.001$. Scanning instruction resulted in significantly lower TP scores than drilling instruction (M = 10.7, SD = 5.0 versus M = 16.3, SD = 5.3), $t(18) = 4.78$, $P < 0.001$; or free search (M = 15.3, SD = 4.6), $t(18) = 4.44$, $P < 0.001$. TP scores for drilling did not significantly differ from free search. FP scores for drilling (M = 7.3, SD = 5.6) were significantly lower than for free search (M = 12.5, SD = 7.8), $t(18) = 4.86$, $P < 0.001$.

Conclusions: Teaching a drilling strategy is preferable to teaching a scanning strategy for finding lung nodules.

Key Words: Radiology education; pulmonary nodules; medical image perception; search strategies.

INTRODUCTION

Perceptual errors account for a substantial part of misdiagnoses in radiology (1) and can be related to the search behavior of the observer (2). For educational purposes, it is important to identify which visual search patterns are most effective and to investigate if teaching search strategies improves perception.

Visual search characteristics that are related to expertise and high performance have been identified in various radiology perception tasks (3). For example experts tend to fixate on abnormalities faster (4–6) and need less time and a smaller number of eye fixations to inspect the image (7,8). These characteristics derive from experience, and they lack an underlying structure that can be taught to novices.

Some specific visual search patterns are found to be related to high performance (4,9–11). Most patterns apply to visual search in X-rays, such as chest X-rays or mammography. Two visual search types are distinguished for searching chest computed tomography (CT) images: "scanners" and "drillers" (11). Scanners tend to visually search a single slice, before scrolling further through the stack, whereas drillers focus their eyes on one quadrant of the lung fields and quickly scroll through the stack in depth before moving to another quadrant. Drillers outperformed scanners with respect to higher true positive rates and a larger lung coverage (11). One interesting finding was that, when given the option to search freely, more experienced readers tend to select "drilling" as a search pattern (the more effective pattern), suggesting it might be a pattern that has, consciously or unconsciously, evolved through instruction or practice. The relationship between search patterns and experience has been noted in several other studies (4,9–11), although it is unknown if experts unconsciously adopt these patterns or deliberately chose or had acquired one, as a *strategy*.

Teaching junior trainees to use expert search strategies may not necessarily be effective. First, learning the strategy may not be easy, particularly given that most experts acquire their behaviors after years of practice. Second, the improvement in perceptual performance that comes with experience is probably due to multiple factors. Knowledge gained and feedback received are known to be critical factors in developing visual

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expertise (12–15). Therefore, it is not evident that learners' perceptual performance will improve simply by using the search strategies of experts. However, some perceptual tasks, such as finding lung nodules on chest CT scans, do not depend on a large knowledge base, and therefore teaching a search strategy may improve detection. Experimental studies may be beneficial to determine if search patterns can be taught to junior observers, and if this can improve perceptual performance.

The aim of this research study is twofold: (1) to investigate if drilling and scanning search strategies can be taught to junior radiology trainees, and (2) to compare the effect of teaching each search strategy on trainee's perception accuracy of lung nodule detection. We hypothesized that junior radiology trainees could adopt a new search strategy after instruction and that the use of a drilling strategy would improve the trainees' perceptual performance compared to a scanning strategy.

MATERIALS AND METHODS

Design

An experimental study was conducted to compare the effect of two teaching methods on perceptual performance. A randomized crossover design was chosen to adjust for individual variation in performance, differences in search strategies prior to any search strategy instruction, and possible differences in search behavior due to the sequence of the search strategy instructions. The design is illustrated in Figure 1.

Study Population and Procedure

Over a 3-month period, 19 (70%) first and second-year radiology trainees of a US academic medical center's radiology residency program enrolled in the study. Participants were randomly divided into two groups: both groups first watched an instructional video that provided lung nodule definitions. For the purpose of the study, a pulmonary nodule was defined as a solid opacity with a diameter greater than or equal to 3.0 mm. Ground glass or calcified nodules were not included. The instructional video showed examples of true nodules and also addressed other pulmonary abnormalities that were not considered nodules, such as consolidations, linear densities, pleural irregularities, and apical scarring, all illustrated by examples. Study participants then completed a pretest using free search (Test 1).

After the free search test (Test 1), group A started with the drilling instruction video, followed by Test 2, the scanning instruction video, and Test 3. Group B received the scanning and drilling instruction in opposite order. The drilling instructions explained the drilling search strategy: mentally dividing each lung into three regions (anterior, middle and posterior) and scrolling through each region individually, while keeping the eyes fixated in that region. The scanning instruction explained the scanning search strategy: reviewing all visible lung parenchyma at once (both sides), while slowly scrolling down, image by image.

In all three tests, participants were asked to mark as many true pulmonary nodules as possible, while avoiding marking any foci not meeting the study's definition of a true nodule. There was a time limit of 4 minutes per case.

The digital assessment program VQuest (www.vquest.eu) was used for the viewing and marking of lung nodules. This program is designed to deliver tests containing volumetric images, and allows for registering all scroll movements and mouse clicks. During the tests, participants could scroll through the stack of images, zoom in or out, adjust contrast settings, and measure findings. All stacks were viewed in axial plane. To select a lung nodule, participants were instructed to place a marker by clicking in the center of the nodule.

Tests

Tests 1, 2, and 3 were unique tests, each containing seven volumetric pulmonary CT scans. In total, each test consisted of 31 true nodules spread out over the seven CT scans. Nodules were 3 to 6 mm, with an average of 4 mm. The scans were retrieved from the picture archiving and communication system of the institution and were reviewed by two experienced radiologists (with 10 and 5 years of experience). Disagreement was resolved in consensus format. The selected chest CT scans had, on average, 349 slices, and slice thickness was 1.25 mm in all cases. The tests were made as equivalent as possible, by means of a test blueprint (Table 1). Each test was similar with regard to total number of nodules, the size of the nodules, the distribution of cases with fewer and more nodules, and the distribution of easy versus difficult cases. Nodules attached to vessels, bronchi, mediastinal structures, or diaphragm were considered difficult, whereas all other locations were considered easy.

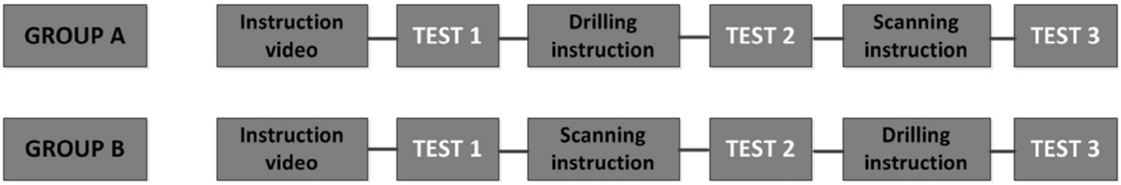

Figure 1. Study design.