Radiological Expertise and the Effects of Perceptual Scaffolding on the Diagnosis of Mammograms

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Introduction

This study investigated the differences in the underlying cognitive processes used by staff radiologists and radiology residents while diagnosing breast diseases as depicted on mammograms. The research: (1) characterized the cognitive processes of both novice and expert radiologists by conducting in-depth analyses of verbal protocols, (2) incorporated an *augmented* experimental condition (to test the hypothesis that highlighted critical findings would facilitate the attainment of a diagnostic schema and increase diagnostic accuracy), (3) analyzed the film tracings made by both residents and radiologists and their relationship to diagnostic accuracy, and (4) rectified certain methodological and analytical inadequacies of previous cognitive studies in visual domains.

Method

A total of twenty (N=20) subjects, 10 staff radiologists and 10 senior radiology residents from McGill University's five teaching hospitals participated in this study. The staff radiologists had an average of 14 years of mammography experience (diagnosed an average of 30,000 mammograms, and diagnosed an average of 66 cases per week). The residents had an average of 6 months of mammography experience (had diagnosed 25 to 1000 mammograms, and did not diagnose mammograms on a weekly basis).

Ten relatively difficult breast disease cases were selected for the study. Each case was comprised of a brief clinical history and a set of 4 mammograms. Each subject solved a total of ten breast disease cases (5 authentic and 5 augmented). In the augmented condition, the critical mammogram findings relevant to the diagnosis were highlighted. In the authentic condition, the critical mammogram findings were not highlighted. The cases were counterbalanced across conditions and subjects.

The experimental procedure involved: (1) instructing the subject to "think out loud" while he/she diagnosed each case (and solved a practice case), (2) presenting the clinical history to the subject, (3) displaying the mammogram set on a view-box and (4) instructing the subject to point to the critical film findings while diagnosing each case. Each session was recorded on audio and video.

Results

The verbal data (in conjunction with the video data) were subjected to protocol analysis techniques (Ericsson & Simon, 1993; Patel & Groen, 1986). Expert diagnostic reasoning in visual diagnosis of mammograms was characterized by: (1) top-down and bottom-up cognitive and perceptual processes, (2) schema-based problem-solving which facilitates accurate characterization of film features, integration of clinical history cues followed by rapid and accurate diagnosis, and (3) use of forward reasoning processes during the diagnostic process. Residents' diagnostic reasoning process was characterized by: (1) mostly bottom-up reasoning involving the characterization and subsequent integration of film features, (2) use of abductive reasoning in generating diagnostic hypotheses and eliminating them based on the presence or absence of clinical cues and/or film features, and (3) inferior characterization of film features which was directly related to diagnostic inaccuracy.

Two separate repeated measures ANOVAs yielded no significant differences between the mean number of clinical findings and clinical observations by levels of expertise and experimental conditions. In addition, residents (1) provided slightly more differential diagnoses, and (2) were less accurate in their diagnoses than staff radiologists.

Discussion

The contributions of this study include: (1) a comprehensive cognitive model of diagnostic reasoning in radiology, (2) enhanced understanding of the perceptual and cognitive processes underlying radiological diagnosis, (3) an initial theory of learning in ill-structured domains, and (4) empirical evidence for the design of a computerized system for training radiology residents to diagnose mammograms.

References

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Patel, V. L., & Groen, G. J. (1986a). Knowledge-based solution strategies in medical reasoning. *Cognitive Science, 10*, 911-116.