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A Cognitive Perspective on Medical Expertise: Theory and Implications

Abstract—A new theory of the development of expertise in medicine is outlined. Contrary to existing views, this theory assumes that expertise is not so much a matter of superior reasoning skills or in-depth knowledge of pathophysiological states as it is based on cognitive structures that describe the features of prototypical or even actual patients. These cognitive structures, referred to as "illness scripts," contain relatively little knowledge about pathophysiological causes of symptoms and complaints but a wealth of clinically relevant information about disease, its consequences, and the contexts under which illness develops. By contrast, intermediate-level students without clinical experience typically use pathophysiological, causal models of disease when solving problems. The authors review evidence supporting the theory and discuss its implications for the understanding of five phenomena extensively documented in the clinical reasoning literature: (1) content specificity in diagnostic performance; (2) typical differences in data-gathering techniques between medical students and physicians; (3) difficulties involved in setting standards; (4) a decline in performance on certain measures of clinical reasoning with increasing expertise; and (5) a paradoxical association between errors and longer response times in visual diagnosis. Acad. Med. 65 (1990): 611-621.

Nearly two decades ago, a major emphasis in medical education was the teaching and assessment of medical problem-solving skills. The notion was simple—physicians’ daily activity was directed to the solution of patient problems, so it seemed reasonable that students should acquire the skills required to complete this task—data gathering by history taking and physical examination, data interpretation, diagnosis, clinical reasoning, management, and so on. Evaluation methods such as the patient management problem1 evolved to assess these skills, and new curricula were developed to teach problem solving and problem-based learning.2 These approaches to teaching and assessment had in common the assumption that clinical skills essentially consisted of a set of reasoning strategies or heuristics that were largely domain-independent and that would enable those who had acquired them to solve problems successfully, even problems that would be new to them. Basic and applied research were initiated to elucidate the components of the skills,3,4 and related research was conducted in domains ranging from preclinical medical education to quality-of-care appraisal in practice.

Recurrent Problems
From this research, a number of recurrent problems emerged, casting doubt on some of the fundamental assumptions about the nature of clinical competence. Some of these are summarized below.

Content Specificity
A consistent finding across many studies was that correlation of performances across problems was low. This was apparently true regardless of the nature of the problems or the scoring method used.4 Elstein and colleagues5 labeled this phenomenon "content specificity," implying that (biomedical) content knowledge could not be separated from problem-solving heuristics as easily as had once been supposed. In fact, the low correlation across different problems seemed to indicate that problem-solving performance is highly dependent on the availability of knowledge relevant to a specific problem and that availability of knowledge for one problem does not automatically imply that adequate knowledge for another problem is also available. Interestingly, however, although this explanation has become an axiom of current research, there have been few demonstrations of a positive association between knowledge and problem solving at the level of the individual problem. Certainly, if sufficient problems are used and the sampling of knowledge is extensive, a high correlation between knowledge and problem solving can be demonstrated.6 Nevertheless, at the level of the individual problem it has proven difficult to demonstrate a relation between the
knowledge deemed necessary to solve that problem and its successful solution.47

Expertise and Data Gathering

A second basic assumption of early problem-solving research—and indeed an assumption that pervades many other domains of assessment related to competence, such as quality-of-care appraisal—is that the expert will gather more data, or, if not more data overall, will gather more of the significant, critical, or essential data, than the novice. This assumption has also found little support. Early studies of quality of care by Clute8 and Peterson9 showed that general practitioners did far less history taking and physical examination than was deemed necessary, and observational studies of medical students and physicians showed virtually no difference between the amounts of critical or significant data they gathered.4 Resolution of the issue is particularly important for the use of patient management problems (PMPs), since most of the scoring options for PMPs are based on data gathering, and studies using PMPs have shown that experts gather less, rather than more, data, and as a result score lower than relative juniors.10

Criterion Setting

It seems self-evident that there are both an optimal approach and a minimum approach to the solution of a class of medical problems such as chest pain or otitis media. Indeed, the development of objective methods for standard setting and quality-of-care appraisal rests on this assumption. However, it appears that the development of such standards is not nearly as straightforward as might have been imagined. Friedman and colleagues11 recently commented on the issue for standard setting in medical schools. Several years ago, Bligh12 showed that score weights derived from random numbers (with the correct sign) did as well as expert weights in scoring PMPs, and Swanson and co-workers13 have commented on the marginal gains derived from elaborate scoring schemes. Moreover, the problem is not only one of dealing with the various ways a clinical problem may present: Norman and colleagues14 asked general practitioners to develop criteria for specific simulated patients and found that the same physicians did approximately half of what they recommended when the patients were introduced into their own practices.

Intermediate Effects

A common approach in the validation of assessment methods is to compare the performances of students at various levels. A consistent finding of such studies is that it is relatively easy to demonstrate differences between junior and senior students but much more difficult to show differences between final-year medical students or beginning residents and practicing clinicians.15,16 In fact, quite often declines in performances on certain measures of clinical reasoning have been demonstrated.17,18 Several hypotheses explain this intermediate effect. It is possible that indeed students possess the most formal knowledge at graduation, or that they are the most motivated then, or that they have acquired "testmanship" skills. Nevertheless, the notion that expertise should peak at graduation appears at variance with common sense. The literature does not provide a satisfactory explanation for this phenomenon; at least it would seem likely that experts are acquiring some form of specialized knowledge that is not being assessed by the testing methods used.

Errors in Clinical Diagnosis

It is commonly assumed that errors in clinical diagnosis by experts are a result of taking shortcuts, inattention to detail, or lack of knowledge of the explicit rules. However, some recent evidence in visual domains of medicine, specifically radiology and dermatology, casts serious doubt on this assertion.19,20 One would expect to observe inaccurate diagnoses mainly in those cases where experts make quick decisions about the nature of the problem; Errors in these visual domains, however, are associated with longer, not shorter, viewing times. Also, novices appear to recognize abnormalities as frequently as experts; expertise is often associated with recognizing normal variations, and with reduced rates for false positives.21 All these issues represent continuing dilemmas for those involved in assessment in medicine at all levels from undergraduate to continuing education. Although there are technical solutions, the most obvious being to increase the sample sizes of cases used for assessment,22 there is no evidence yet as to why these phenomena arise. Certainly, these issues are not restricted to medicine,23 and considerable research has been mounted in other domains of expertise to elucidate the nature of expertise.24 Recent research in medicine has examined the development of expertise in medicine, focusing on issues of memory and using theories and methods strongly influenced by approaches in cognitive psychology. Although these studies have demonstrated many interesting performance differences between novices, intermediates, and experts, no attempt has been made to interpret these differences within one unifying framework, nor have these efforts yet resulted in new insights into the issues raised above.

We feel that a synthesis of research findings that would shed light on the issues raised in this introduction is now possible and that the findings can be understood in terms of a single theoretical framework. To that end, we present a theory of expertise in medicine based in part on recent research in that area but also grounded in contemporary theories in cognitive psychology. We then interpret the issues and findings raised in the first section in light of the theory. Finally, we describe some implications of the theory for medical education.

The present discussion is restricted to those investigations in medicine using cognitive methods. As such, we are deliberately excluding from the analysis artificial intelligence approaches,25 decision analysis,26 and policy-capturing methods.27 This exclusion is not meant to imply that such methods do not have potential