Physicians’ Use of Deep Features: Expertise Differences in Patient Categorization

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Abstract
Medical doctors make many decisions when interacting with patients, including diagnosing the problem and determining an appropriate treatment of the problem given the patient’s circumstances. While diagnostic reasoning has been studied extensively, reasoning about patient management has not. Using a forced-choice triad task we investigated the use of deep structures related to diagnostic and management reasoning in novices (medical school students), intermediates (medical residents), and experts (endocrinologists). We found that expert participants are generally more likely to choose deep feature matches than intermediate and novice participants. Specifically, experts and intermediates are more likely than novices to choose deep matches on management trials while experts are more likely to choose deep matches than either intermediates or novices on diagnostic trials. These results reveal a difference in performance for intermediate subjects on management, versus diagnostic, trials. We suggest that expertise in management and expertise in diagnosis develop along different trajectories as physicians complete their medical training.

Keywords: medical reasoning; expertise; diabetes; problem solving; medicine; forced-choice triad task

Introduction
Medical doctors make many kinds of decisions when they interact with patients. Even once the diagnosis is completed, the physician must determine what the most appropriate treatment will be, and help the patient manage his disease. For example, when considering a diabetic patient who may need to go on insulin, a doctor must take into account both the biomedical aspects of the patient, and also issues related to the patient’s lifestyle. A patient with severe arthritis might not be a good candidate for any drug that requires self-administration unless he or she has assistance.

While the issue of diagnostic reasoning has been well studied (e.g., Bordage, 1994; Bordage, 1999; Norman & Brooks, 1997), medical reasoning around patient management has received little attention in the literature. Patient management can be defined as treating the patient’s disease or disorder in the context of the patient’s life. The choice of what treatment to use for a particular disorder is not only based on the disease itself, but also on other factors such as medication tolerance, lifestyle, and patient compliance with a treatment regime. If a patient cannot or will not comply with a treatment plan, that treatment will not be an effective one. We believe this is something experienced physicians can take into account, while medical students are unlikely to consider anything other than disease-based or biomedical factors when determining patient treatments. We suggest that patient management is an important part of the physician-patient encounter, and we predict that physicians will demonstrate expertise effects with patient management that is analogous to the kinds of expertise effects that are found in other areas of medicine and other domains in general. Of particular interest to our investigation is the idea that experts can often ignore or suppress attention to the surface features of a problem and attend instead to the deep, solution-relevant features of a problem.

Expertise effects have been well studied in the cognitive literature. For example, Chi, Feltovich and Glaser (1981) asked physics Ph.D. students (experts) and undergraduate students (novices) to sort 24 physics problems based on similarities of solution and to explain the reasons for their groupings. Novices sorted the problems on the basis of surface features. That is, they grouped problems on the basis of the literal physics terms explicitly mentioned in the problem and the physical configuration described in the problem. Experts, on the other hand, sorted their problems on the basis of deep features that were related to the major
physics principles have been found with experts in tree classification and fish classification (Medin, Lynch, Coley, & Atran, 1997; Shafto & Coley, 2003).

These studies have implications for the study of how physicians think about patient management. We argue that expert physicians should be able to perceive deep structures related not only to diagnosis but also to the management of their patients. Perceiving this deep structure could assist the expert physician in making decisions about how to treat the patient, how to interact with the patient, whether or not to follow up with the patient for compliance, etc. We argue that all of these things are central to being a good physician, yet this kind of decision making is not typically the focus of investigation and research, and this kind of thinking process is not typically taught in medical school.

An initial goal for our research was to develop a task that was sensitive to expertise differences in diagnostic reasoning as well as reasoning about patient management. To do this, we turned to a forced-choice triad task that is commonly used in cognitive psychology (Johnson & Mervis, 1997; Lin & Murphy, 2001; Rabinowitz, & Hogan, 2002; Rips, 1989; Smith & Sloman, 1994), which involves choosing one of two items that best matches a target. Rabinowitz and Hogan (2002) successfully used this task to investigate the effects of expertise in statistics: subjects were presented with three statistics problems in a forced-choice triad task. The target matched one problem in terms of surface features (similar story characters and similar kinds of dependent/independent variables) and another in terms of deep features (solution-related features like the kind of statistical tests needed to solve the problem). Rabinowitz and Hogan found a positive correlation between the number of statistics courses taken (expertise) and the tendency to choose pairs that were related in terms of deep features, indicating that more expertise in statistics generally resulted in more attention to deep, solution-relevant features of the problem.

In the present research we asked practicing physicians, residents, and medical students to complete a series of forced-choice triads. We predicted that expert physicians would be better able to perceive and react to deep features and would be able to appreciate the similarity between patients who might require similar management approaches, as well as patients who have similar diagnoses. To the extent that experts perform well on classification in which the deep-feature match deals with management, we argue that this ability develops with relevant clinical experience rather than with explicit medical training. Put another way, we argue that physicians become experts in patient management by managing patients, not by being in medical school. This implies several other predictions. First, we predict that novices should perform poorly on all triads regardless of whether the deep-feature match is related to diagnosis or management because they do not have either the clinical experience or the medical training to recognize deep matches. Second, because they have clinical experience, intermediates should be sensitive to deep-feature relations about patient management. However, since many of our deep diagnostic matches are based on detailed biomedical information, and given that medical residents have not completed their endocrinology fellowship training, it is unlikely they will have the capacity to recognize deep diagnostic matches.

Method

Subjects

Three groups of subjects were tested. Novices were 15 second-year and third-year medical school students who had not yet completed an endocrinology rotation at the Schulich School of Medicine and Dentistry. Novices were recruited via mass email sent by the Department of Medicine to all students. Intermediate subjects were 8 medical residents (postgraduate years 1 and 2) at the Schulich School of Medicine and Dentistry recruited via email from the third and fourth authors. Expert subjects were 13 endocrinologists from across Canada recruited via email from the third author.

Materials

The forced-choice task consisted of a series of ten items, each with three hypothetical patient profiles: a target and two possible matches. All of the patient profiles were designed by the third and fourth authors, and each one was rated by a third physician for understandability and

![Figure 1: Sample Triad](image-url)
readability. The rater used a scale of 1 through 7, 1 being
very difficult to understand/read, and 7 being very easy to
understand/read. All profiles that were used in the study
were rated at least 6 for each of understandability and
readability.

Half of the triads were designed so that the deep match
was one that related primarily to patient management. One
of the triads used in this study is shown in Figure 1. The
target is shown first (Profile A), followed by two potential
matches (Profile B and Profile C). In this example, Profile C
is the surface match because both patients are older females
with similar disease duration. Profile B is the deep match
because both patients cannot be treated with injectable
insulin: neither can check their blood sugars by themselves
due to blindness and arthritis. The other half of the triads
were designed so that to recognize the deep match, subjects
had to pay attention primarily to diagnostic information
(e.g., diagnosing concurrent symptoms or underlying causes
of diabetes).

Procedure
Subjects completed the triad task online. As described
above, subjects were primarily recruited via email, which
contained a link to the survey site. Survey software was
provided by the University of Western Ontario’s ITS
department. Demographic information, including level of
schooling, number of years in practice, and proportion of
patients with diabetes, was completed first.

Subjects were instructed to choose the profile that made
the “best” pair with the target profile; they were not
informed that we were investigating deep matches, or that
we had described some triads as “diagnostic” and others as
“management” related. The ten triad questions were
presented in a fixed random order. On each triad, subjects
made a selection and provided a short explanation to justify
their choice: this justification allowed subjects’ choices to
be verified. Subjects were required to submit an answer
before they could move on to the next question; once
submitted, answers could not be changed. The entire process
took approximately 30 minutes to complete, though there
was no time limit and participants could view questions as
long as they liked. In addition, subjects were permitted to
log out and return to the task if they wished.

Table 1: Re-scoring information

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th></th>
<th>Surface to Deep</th>
<th></th>
<th>Deep to Surface</th>
<th></th>
</tr>
</thead>
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<tr>
<td></td>
<td>Number</td>
<td>Proportion</td>
<td>Number</td>
<td>Proportion</td>
<td>Number</td>
<td>Proportion</td>
</tr>
<tr>
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<td>.008</td>
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<td>.028</td>
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<tr>
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<td>.006</td>
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<td>.039</td>
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<tr>
<td>Novice</td>
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<td>.058</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>.058</td>
</tr>
</tbody>
</table>

Re-scoring

Before the primary analyses were carried out, we verified
each subject’s responses (deep or surface) by examining the
justification for each choice. A deep choice should be
accompanied by a justification that indicates recognition of
the relevant features or aspects of the case. If the
justification did not match the response, it could be due to a
guess, an error, or a response bias: in this case, the choice
may not represent the subject’s ability and the response
should be rescored. A small number of responses (fourteen
percent) were changed after scoring by two independent
raters who were blind to the experience level of each
participant. Raters separately decided whether each participant’s text on each question indicated they were using
surface or deep features to inform their match. Item
responses were changed if the participant’s text answer
clearly indicated they were relying on surface (or deep)
structures to make their match when they chose the deep (or
surface) answer; answers lacking enough information to
determine if they used surface or deep criteria were not
changed. Raters then met and compared their scoring
response-by-response. If a consensus was reached, the
answer was changed; however, if consensus could not be
reached, the answer was not changed.

Fifty of a total of 360 responses (36 subjects x 10 answers
per subject) were recoded (14%). See Table 1 for details of
the proportion of responses changed for each group
(novices, intermediates, and experts). Of the 50 responses
that were rescored, 74 percent (37 responses) were agreed
on prior to consultation; 26 percent (13 responses) were
changed through discussion. Seventeen responses were not
changed after discussion, either because agreement could
not be reached, or because through discussion the raters
agreed the response should not be changed.

Results
The primary dependent variable in our study was the
proportion of deep-feature choices by each subject. As such,
we scored each item in terms of deep-feature responding.

1Analyses of Variance were also significant before rescoring for
Overall performance ($F(2,33) = 6.87, p = .003$), performance on
Management triads ($F(2,33) = 4.47, p = .019$), and performance on
Diagnostic triads ($F(2,33) = 4.39, p = .020$).
Each participant’s score on the task was recorded as a proportion ranging from 0 to 1, 0 indicating all surface responses, and 1 indicating all deep responses. Responses were examined both as an overall score, including both types of triads (a total of 10 items), as well as management and diagnostic triads separately (five items in each group). Figure 2 shows the average proportion of deep matches for each group of subjects.

The data show a general effect of expertise in which the experts chose the greatest proportion of deep responses, followed by the intermediates and novices. We entered the overall proportion-deep scores for each subject into an ANOVA with expertise (expert, intermediate, novice) as a between subjects factor. We found a significant effect of expertise, $F(2, 33) = 10.71, p < .01$. A post hoc Tukey HSD test indicated the performance by the experts exceeded that of the novices ($M’s = .48$ and $.17, p < .01$). The performance of the intermediates ($M = .36$) also exceeded performance of the novices ($p < .05$). The performance of experts and intermediates did not differ.

We also examined the proportion of deep responses by subjects for each type of triad separately. Recall that half of the triads were designed so that the deep-feature match was related to patient management and the other half were designed so that the deep feature match was related to a diagnostic issue. An ANOVA with expertise as a between-subjects factor on the proportion-deep responses for the Management triads found a significant effect for expertise, $F(2, 33) = 4.94, p < .01$. A post hoc Tukey HSD test indicated the performance by the experts exceeded that of the novices ($M’s = .48$ and $.19, p < .05$). The performance of the intermediates ($M = .45$) nearly exceeded performance of the novices ($p = .07$). The performance of experts and intermediates did not differ from each other.

An ANOVA with expertise as a between-subjects factor on the proportion-deep responses for the Diagnostic triads found a significant effect for expertise, $F(2, 33) = 9.29, p < .01$. A post hoc Tukey HSD test indicated performance by the experts exceeded that of the novices ($M’s = .48$ and $.16, p < .01$). The performance of the experts nearly exceeded that of intermediates as well ($M = .29, p = .07$). The performance of intermediates and novices did not differ from each other. In short, for the management triads, experts and intermediates were equally likely to make deep matches and were also more likely to do so than the novices. For the diagnostic triads, the intermediates and novices were equally likely to make surface matches, and were more likely to do so than experts were.

**Comparisons within groups**

Although we were primarily interested in the effects between groups, we also analyzed the data within each group. That is, the data shown in Figure 2 indicate that experts seem to perform similarly on both management and diagnostic triads, as do novices. The intermediates, however, seem to be more likely to make deep matches on the management triads than the diagnostic triads. In order to examine this effect, we conducted three paired t-tests. Each test compared the difference between diagnostic and management performance for each group of subjects. As expected, there was no difference between management and diagnostic triads for the experts, $t(12) = 0.0, ns$, or for the novices, $t(14) = 0.35, ns$. However, we did find a nearly significant difference between the management and diagnostic triads for the intermediate subjects, $t(7) = 2.20, p = .06$.

**Discussion**

The suggestion that experts and novices would differ in their ability to classify patients was investigated using a forced-choice triad task. We found an overall effect of expertise such that experts chose the deep feature match more often than did the novice subjects. This was true both for triads in which the primary deep feature match was diagnostic in nature and triads for which the deep feature match was related to patient management. Novice subjects, on the other hand, were unlikely to make deep matches on any triads and generally tended to choose matches on the basis of surface features. This suggests that our triad task was quite sensitive to the difference between novice and expert subjects. The tendency to make decisions on the basis of deep features is a hallmark of expert-level performance in many domains, (Chi et al., 1981; Rabinowitz & Hogan,
management triads, perhaps even better than our expert manage patients, would be likely to make deep matches on other experts. For example, we expect that nurses, who use deep study shows that experienced physicians are more likely to not be consciously aware of using these categories, our disparate patients may be very similar. Though doctors may these categories, recognizing that treatment for app as a student begins seeing patients, they may be creating feature match. Management categories of patients could categories of patients that diagnose the relevant conditions. Therefore, less intermediates do not have the required knowledge to depend on detailed knowledge about concurrent illnesses, or it may simply take longer to develop.

We suspect that both kinds of expertise, management and diagnosis, depend on some combination of direct experience with patients and training. Since the diagnostic triads depend on detailed knowledge about concurrent illnesses, secondary causes of diabetes, or specific complications of diabetes, it is likely that the novices, and even some of the intermediates do not have the required knowledge to diagnose the relevant conditions. Therefore, less experienced subjects likely do not have the diagnostic categories of patients that are required to make the deep feature match. Management categories of patients could come online much earlier in a physician’s training: as soon as a student begins seeing patients, they may be creating these categories, recognizing that treatment for apparently disparate patients may be very similar. Though doctors may not be consciously aware of using these categories, our study shows that experienced physicians are more likely to use deep features to classify patients than novices are.

Our results provide predictions for other situations and other experts. For example, we expect that nurses, who manage patients, would be likely to make deep matches on management triads, perhaps even better than our expert sample, since much of their attention would be on management, rather than diagnostic, issues. However, since they do not have the specific training required, we expect they would often use surface features when matching on diagnostic triads.

It is also unclear at this point what physicians would do if management and diagnostic triads were pitted against each other. In our current task, there is only one deep match in each triad; however, it is possible to design a triad such that subjects would have to choose between a diagnostic match or a management match. This kind of design would allow us to determine which type of match is more salient to physicians of differing levels of experience (or different types of experience, such as nurses), or if there are certain situations that make management or diagnostic issues more salient. For example, when seeing a patient in the intensive care unit (ICU) management issues may be more relevant. Two patients could require immediate care for survival, even though they do not share a diagnosis. On the other hand, when seeing patients as a family doctor, it is possible that physicians could match patients based on either management or diagnostic issues. Further research will be required to determine how deep structures compete with each other.

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References


