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ABSTRACT

The role of contextual information in the generation of early hypotheses during the clinical interview was studied with expert and novice medical diagnosticians: 18 experienced family physicians versus 5 new physicians and 12 final-year medical students. The 18 experts and 17 novices were presented with 32 short case histories each presented on three slides: a portrait of a patient, a patient chart containing the previous disease history, and a slide with the present complaint. Because of the sequential nature by which patient data became available during a clinical interview, contextual information is expected to be important in the initial hypotheses. Differences in the number of correct diagnoses were predicted for the two groups, if experts used the contextual information, implicitly provided by picture and patient chart, in a more elaborate way. If this prediction was true, it would show in the amount of information explicitly recalled. The data confirmed these predictions. The experts produced 50% more correct hypotheses as compared to the novices and were able to reproduce a larger amount of relevant contextual information. In addition, a high correlation between problem-solving and recall measures was found only for the expert group. (Author/SW)

Contextual Factors in the Activation of First Hypotheses: Expert-Novice Differences

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ABSTRACT

According to Feltovich and Barrows (1984), the general frame used by medical experts to construct a cognitive representation of a particular patient problem, contains a component-part for those illness features that are associated with the acquisition of illness. These so-called "enabling conditions" are recognizable in the context of the patient, like risk factors originating from work, behaviour and hereditary taint; or are derivable from patient's appearance like sex and age.

Because of the sequential nature by which patient data become available during a clinical interview, this contextual information is expected to play an important role in the generation of initial hypotheses.

To investigate the hypothesis, that experienced physicians better utilize this kind of information, a group of 18 experts and 17 novices were confronted with 32 short case-histories each presented on three slides: a portrait of a patient, a patient chart containing the previous disease history, and a slide with the present complaint. It was expected that differences in the number of correct diagnoses would emerge between the two groups, because the experts use the contextual information, implicitly provided by picture and patient chart, in a more elaborate way. If so, this would show in the amount of information explicitly recalled.

The data confirmed these predictions. The experts produced almost 50% more correct hypotheses as compared to the novices and were able to reproduce a larger amount of relevant contextual information. In addition, only in the expert group a high correlation did exist between problem solving and recall measures.

INTRODUCTION

Investigations into expert-novice differences in the ability to solve medical diagnostic problems are useful because they may suggest ways to teach this skill. Research in this area indicates that medical experts perform better than novices on a large variety of expertise-related tasks. They are better at diagnosing dermatological diseases presented on slides (Norman, Muzzin & Rosenthal, 1985), judging X-rays (Lesgold, Feltovich, Glaser & Wang, 1981) or recalling clinical cases (Patel & Groen 1986). They are faster at processing patient information (Claessen & Boshuizen 1985) and show superior recall of texts derived from a medical textbook (Patel, HoPingKong & Mark, 1984). It is however, largely unclear which factors mediate this superior performance on these tasks. One of the reasons for this shortcoming may be that an articulated theory of expertise in this area, despite several attempts (Elstein, Shulman & Sprafka,1978) is virtually absent.

The purpose of this research is not so much to demonstrate differential abilities between physicians of different levels of expertise in yet another domain, but to look for reasons why these differences arise. In particular we were interested in finding an explanation for the known differences in accuracy of diagnostic hypotheses that emerge during the first moments of a clinical encounter. This expertise-related feature has our special interest because the accuracy of the first hypotheses to a large extend determines the accuracy of the final differential diagnosis (Barrows, Neufeld, Feightner & Norman, 1978) (Barrows, Norman, Neufeld & Feightner, 1982) (Neufeld Norman, Feightner & Barrows, 1981).

Characteristic for the early stage of an encounter is, that apart from the complaint with which the patient confronts his physician, little information is given explicitly. A clear discrepancy exists between the small amount of complaint information and the large amount of information that is implicit in the situation. One such an information source is the patients non-verbal behaviour and appearance, another is the doctor's prior knowledge about his patient. He knows the kind of diseases the patient has suffered from in the past, the drugs he uses or has been using, and the nature of his work environment. This kind of information provides a context within which a physician can search for a likely hypothesis explaining the patient's present symptoms. Because of the sequential nature by which patient data become available during a clinical interview, this contextual information is expected to play an important role in the generation of initial hypotheses.

Feltovich and Barrows (1984) have developed a theory that may apply to the present experiment. In their view basic science knowledge (e.g. pathophysiology, anatomy) plays an integral role in the construction of a cognitive representation of a particular patient's problem. It guides the way in which illness features are structured together.

The general frame which is used by the experienced physician to construct this representation consists of three component parts that are interrelated with each other. Illness features that are associated with the acquisition of illness are termed **enabling conditions.** Instances of enabling conditions are predisposing factors like alcohol and nicotine abuse, or boundary conditions like sex and age. They provide relevant context of how the patients condition came to be. The second category of features: **faults,** contain the major malfunctions that lead to certain **consequences.** An example of this is the inadequate oxygen supply of myocardial tissue (which can be defined the fault), leading to anginal symptoms and eventually cardial or systemic complications (consequences). In the problem representation model of Feltovich and Barrows (1984) the previous mentioned contextual information can be classified as enabling conditions.

In order to investigate the role of context in the activation of early hypotheses, groups of family physicians and graduate or near-graduate medical students were presented with 32 short case-histories, each containing a picture of a patient, the previous disease history and the present complaint. After reading each case, the subject was asked to formulate a diagnosis. Exposure times were fixed. It was expected that differences in the number of correct diagnoses would emerge between the two groups and that, according to Feltovich's theory, the experienced physicians process relevant contextual information more extensively than novices. If the more experienced group uses certain contextual information provided by the picture and previous disease history in a more elaborative way, leaving memory traces of greater distinctiveness, this would show in the information recalled, because more elaborative processing of information produces better recall (Anderson & Reder, 1979). Therefore subjects were asked to recall all the information they considered to be important to the case.

METHOD

Subjects: Subjects were 35 physicians and graduate medical students. The group of experts consisted of 18 family physicians who on the average had 11.1 ± 7.7 years of experience in health care. Average age was 38.2 ± 9.1 years. The novices were 12 final year medical students who were about to graduate and 5 physicians who graduated less than one month prior to the experiment. Their average age was 25.5 ± 3.3 years.

Materials: It was already outlined that enabling conditions are not explicitly available in the early moments of an encounter. We have tried to simulate this condition by presenting the information with a portrait and medical card of the patient. In doing so, we were able to give information about sex, age, profession, previous disease history, etc. in an implicit way. The portrait, patient chart and the presenting complaint were presented on three separate slides. The stimulus materials consisted of 32 case histories selected from a larger set of information about patients available at the University of Limburg Medical School. The cases were selected in such a way that contextual information could play an important role in the interpretation of the complaint. The pictures were selected from a set of 110 portraits specially produced for the experiment. They were only to convey information concerning age and sex of the patient. Therefore, only pictures were utilized on which the person showed a neutral facial expression and no signs of any disease (like exophthalmus or a drooping corner of the mouth). Previous disease history was typed on a patient chart. In addition, this chart contained information about the patient's profession, marital status, medication, family history of diseases and risk factors. The items were selected in such a way that data included both relevant and irrelevant information as related to the presenting complaint. The presenting complaint consisted of one or two sentences as expressed by the patient, for instance: "I have a cold fever for already two days, doctor. I sometimes lie down shaking in my bed". The complaints covered all organ systems.

Procedure: The 32 cases were presented in a standardised way. First, the subject was exposed to the portrait for about 4 seconds, then the patient chart appeared on the screen, followed by the presenting complaint. Exposure times were fixed, but varied between 3 and 42 seconds for the chart, and between 3 and 9 seconds for the complaint, because some patient charts and complaints contained more information than others. The times were established in several pilots with experts and novices. Mean exposure time per case was 32 seconds. Finally, a black slide was projected for about 15 seconds. During that interval the subject was asked to state the most likely diagnosis, given the information presented.

After an instruction session, the 32 cases were presented in two series of 16 each. After both series, each of the 16 presenting complaints was read back to the subject, together with the tentative diagnosis the subject had generated. Subsequently the experimenter asked the subject to recall which information embedded in the case gave rise to the particular hypothesis. All responses were audiotaped. Presentation-order of the two series was varied systematically over subjects.

Scoring: A verbatim transcription was produced from the audiotaped responses. For each subject and for each case it was determined whether the hypothesis generated was correct and how much information was retained.

Diagnostic accuracy. As a criterion for the accuracy of the hypothesis the actual diagnosis of the particular patient was used. Two judges compared the statement of the subject with the actual diagnosis. Interrater agreement for this task was 95.4%.

Accuracy and completeness of recalled information. In order to judge how much information about each patient was recalled, the information on the patient chart was segmented into information-units. An information-unit was defined as a statement containing one singular fact or idea. The portrait of the patient and the name and birth-date on his chart were considered to contain two units of information: sex and age. For each information-unit it was determined whether it was relevant to the correct diagnosis or not.

The segmented case-information was compared with the verbatim transcripts of the subject's responses.

The accuracy and completeness of recalled information was determined as follows. Of every unit recalled it was decided whether it could be considered literal or paraphrased recall, partial or inferred recall, or a summary of the contextual information presented.

These responses were weighted. Each literal or paraphrased information-unit recalled was scored as 3 points. Partial or inferred information units were scored 2 points, whereas a summary was scored as 1 point. For instance; the patient who presented with the complaint of shaking chills was a male born October the 15th 1931. He had had a hematuria, after which carcinoma of the bladder was diagnosed. This diagnosis led to a total cystectomy with diversion of the urine by uretero-ileostomy. Examples of literal or paraphrased recall by subjects are: "fifty-five years old..." and "they removed the bladder...". Examples of partial or inferred statements are: "older patient..." and "bladder operation...". An example of a summary is: "there was something in the chart about urinary tract problems...".

In this way complete answers of subjects could be scored as follows. With regard to the above described patient-case, subject 8 motivated his hypothesis in these statements: "this man has had a total cystectomy, then you get..........there will be an isolated ileal loop with implanted ureters. Well in such a case you often see ascending infections". This subject scored a total of 9 points, that is to say, 3 points for "man", 3 points for "total cystectomy" and 3 points for "isolated ileal loop with implanted ureters". Subject 1 was much shorter in his motivation: "I believe there was something on the chart about urinary tract problems, that's why an infection came high on my list. Beside that, fever can be very high then". This subject scored 1 point for his summary as already exemplified above.

Interrater agreement of two judges for this task was 93.4% on one fifth of the material. The remaining responses were scored by one judge.

Group differences in diagnostic accuracy and in recall of contextual information were analysed by means of a one-way-analysis-of-variance.

RESULTS AND DISCUSSION

Table 1 shows the average number of correct hypotheses produced by experts and novices.

Table 1: Average number of correct hypotheses, produced by experts and novices (with standard deviations)

	N	Mean	SD
Experts	18	12.11	2.52
Novices	17	8.88	2.12

The observed difference is statistically significant: $F(1,33)=16.75$, $p=.0003$. These results indicate that experts produce more accurate first hypotheses than novices do, given a very restricted amount of information about a patient. It is interesting to observe how well experts, in the absence of additional data such as the results of physical examination or laboratory tests, are able to solve a diagnostic problem. Even before history-taking they are already on the right track in almost 40% of the cases.

The central thesis of this research is that experts are better able to utilize the available information in an information-restricted environment than novices do, even if this information is not overt related to the complaint at hand. Recall of information summarized over two series of trials are shown in Table 2. For the purpose of this study it was important to discriminate between recall of relevant, and recall of irrelevant information-units.

TABLE 2: Average recall scores by experts and novices (standard deviations between brackets)

	Experts	Novices	F	P
Total recalled	216.05 (52.84)	163.35 (48.56)	9.41	.004
Relevant	180.33 (40.99)	136.24 (36.50)	11.25	.002
Irrelevant	35.74 (14.68)	27.11 (13.02)	3.35	.076

The recall of information-units by the experienced physicians exceeds that of the noviced, with the exception of recall of irrelevant information-units. The effect is most striking for the information that was relevant for a correct interpretation of the complaint. This differential retrieval of information indicates that the representational format used by experts to understand a patient's problem (e.g. illness scripts: Feltovich & Barrows, 1984) must include structures for storing relevant context.

The data presented do not automatically imply that experts produce better hypotheses **because** they use contextual information in a more elaborative way. Whether the scores are the retinue of a causal relationship remains to be questioned. An alternative explanation for the superior performance as shown in Table 1 might be that the experts have better lists of possible diagnoses stored in memory, that are activated by the presenting complaint alone. This would imply that their guesses are better, not so much because contextual factors are critical to their performance, but because they have developed more appropriate lists of diagnoses in relation to certain sets of complaints. However, this alternative explanation cannot account for the observed expert correlations in as shown in Table 3, because recall of complaint information is not included in the scores.

TABLE 3: Product-moment correlations between number of correct hypotheses and recall measures for each group

	correct hypotheses	
	Experts	Novices
Total Recall	.54*	.12
Relevant Recall	.63**	.15
Irrelevant Recall	.17	.03

*p<.05 **p<.01

Table 3 shows high correlations between total number of accurate hypotheses and recall of contextual information for experts. Since correlations between recall and problem solving measures are absent in the novice group, the previously mentioned alternative explanation might provide an accurate model for the well-performing novice. In our view the only reasonable explanation for the expert-novice differences in the observed correlations is an expert-novice difference in elaboration on contextual information. Only a difference in reconstructive processes during retrieval, not related to a better elaboration, could also have an effect on recall. However, such a difference cannot cause a better diagnostic performance. The knowledge activated by the contextual information in the 32 cases covers a broad range of subject-matters; from disease-distributions to side-effects of drugs. Generally, in the training of medical students to become diagnosticians much attention is paid to complaint-exploration and physical examination. This is mainly due to the fact that most of the time training occurs in clinical settings like hospital wards. Moreover in medical education emphasis lies on anatomic and pathophysiological knowledge in order to let the students understand the patients symptoms and signs. The results of this experiment, however, indicate that in a critical phase of the diagnostic process another kind of knowledge is used namely that needed to understand the context of a patient.

This finding needs further exploration. For instance, there are good reasons to believe that the importance of contextual information in medical problem solving varies with the kind of context of the diagnostician (e.g. specialist versus general practitioner).

In conclusion, the data provide support for the notion that experienced physicians make an extensive use of contextual information while attempting to solve diagnostic problems, at least when no additional information regarding the present condition of the patient is available. They confirm the assertion of Feltovich and Barrows (1984) that enabling conditions form an essential part in the construction of a mental representation of the patient's problem and help the physician to reduce the number of alternatives he has to take into consideration. The results also indicate that this skill is acquired only through years of clinical practice.

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