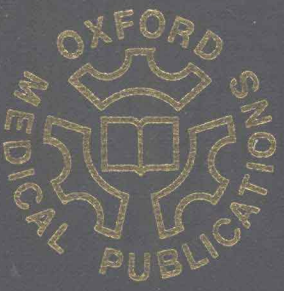

Medical Diagnosis

From Student to Clinician

Janet Gale and Philip Marsden

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from student to clinician

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Preface

Central to the effective delivery of health care by the physician is the complex skill of clinical problem solving.

(Barrows and Mitchell 1975)

This book is about the way medical students and doctors think when they are trying to make a clinical diagnosis. It is also about the effects that medical education and clinical experience have on that thinking, and about the ways in which we can help or hinder the development of an effective diagnostician. Traditionally, the process of diagnosis was left undefined, a natural art, or explained as a process of intuition. Despite recent advances, this is still too often the case. However, this book provides the basis for a fresh appraisal and new directions for teaching and learning with regard to diagnosis. It is intended for all those involved or interested in medical diagnosis. It is therefore relevant to those whose work entails either teaching or learning about diagnosis or who have responsibility for patient care themselves. The content of the book is designed to be relevant to the needs and clinical experiences of students, medical teachers, and practising doctors. It is also designed to make an analysis in terms of educational and psychological theory, to help understanding, and to further research in the area. Because of this dichotomy of purpose we expect that, according to their educational background, readers will find some parts of the book will be of more interest, and will be more pertinent to their needs than others.

The studies reported here add a new and significant dimension to previous formative work which had characterized the diagnostic thinking process in terms of hypothesis generation and testing. We have been able to define the range of specific thinking processes which underpin that general approach. We have also been able to show that these specific processes are shared by senior medical students, house officers, and experienced clinicians. The relative use of such thinking processes, however, is affected by the experiences of medical education and clinical practice. This finding has led us to propose pedagogical strategies which will be appropriate to the needs of both student and teacher in relation to the development of diagnostic skill. We have borne in mind the practical circumstances of teaching and learning in medicine and have put forward ideas which can be translated into realistic teaching and learning exercises. Our future work will concentrate on the development of practical teaching strategies. We are emphasizing practical, pragmatic approaches for reasons, and in ways, which are explained in this

book. Many medical teachers and students are interested to teach and learn more about the diagnostic thinking process, and yet find that opportunities for curriculum change are few. We have, therefore, taken the approach that individual teachers or departments, or small groups of students can begin to teach and learn in this area within the current curriculum arrangements.

We are happy that the original purposes of our work have been achieved. These purposes were fourfold:

1. To define the specific thinking processes which lay behind the general hypothesis generation and testing approach.
2. To identify differences between students and experienced clinicians.
3. To explain these differences in terms of the experiences of medical education and clinical practice.
4. To provide a rational educational analysis and suggest practical pedagogical developments.

We hope that in achieving our purposes and reporting our findings, we have presented information and discussion that will enable practising clinicians, medical teachers, and medical students to come to a better understanding of their own and others' diagnostic thinking processes and so to better monitoring of self and others with the intention of improving teaching, learning, and practice.

January 1983

J.G.
P.M.

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Note

Throughout this book the masculine pronoun is used. Although we do not like this convention, the English language has not yet evolved suitable replacement, non-sexist terminology.

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1 Diagnosis: what do we know?

INTRODUCTION

We are by no means the first to recognize and think about the problems of the relationship between medical education and clinical practice. But our analysis of that problem and of pathways towards its resolution seems to us to add new dimensions to the debate. The importance of this debate is reflected in the well-recognized and documented need to make the content and structure of medical education more appropriate to the student's future needs as a practising clinician. Many have considered that diagnostic thinking processes (which some have called clinical problem-solving skills) should be dealt with more conscientiously by undergraduate medical education:

> There is no more important field in medicine than diagnosis. Without it, we are charlatans or witch doctors treating in the dark with potions and prayers. Yet there is no field more difficult to teach. Strange that this art and science has not attracted innumerable theorists to make it more teachable! Thousands are studying membrane transfer, yet few strive to make a science of diagnosis (Cutler 1979).

Here are posed both sides of the question. The skill of diagnosis must be taught, and our assumptions underlying such teaching must be sound (Berner *et al.* 1974). The first major reason for understanding the diagnostic thinking process, then, can be stated quite simply. It is that if a subject is to be taught effectively, it must be understood by the teacher. Therefore, if the development of effective diagnostic thinking processes is to be facilitated by the undergraduate medical curriculum, those processes must themselves be understood. Yet Shulman and Elstein (1975) cite Hammond (1971) who makes the disturbing point that:

> . . . the teacher is frequently unaware of the real system he uses to make his expert judgments. He may even believe that he operates in a very different fashion from the way he actually does. Imagine the frustration of students who must learn to ignore what he says they should do and instead must infer the model of his judgments. Alas, claims Hammond, this is far more frequent in the teaching of clinical judgment than has been admitted or recognised (p. 28).

Iansek and Balla (1979) strongly agree. Balla, himself a neurologist, speaks from a particular vantage point:

> The majority of doctors are well aware of the many diagnostic decisions they make in their daily practice. However, not many doctors are aware of the underlying mechanisms involved in the making of such decisions, except to attribute such an

ability to 'experience', 'art' or encyclopaedic knowledge. This nebulous attitude to their diagnostic ability is, of course, extended to an important facet of a doctor's responsibility: medical education. In this context, an incongrous situation is apparent in that the teacher is responsible for imparting to his students knowledge which the teacher does not fully understand or of which the teacher is unaware. Such an approach is obviously unacceptable, and requires rectification.

Such criticism of medical education has been echoed by many medical teachers and educationalists would agree:

> It seems self evident that the teacher should constitute an important variable in the learning process. From a cognitive standpoint it should certainly make a difference, in the first place, how comprehensive and cogent the teacher's grasp of his or her subject matter is (Ausubel *et al.* 1978, p. 498).

In planning our inquiry into the effects of education and experience on the development of the diagnostic thinking process, we concluded that the teacher's subject matter must concern the nature of both neophyte and experienced clinician. The teacher not only must know what state he is hoping to help the learner achieve, but must also know what current state the learner is likely to be in. We therefore looked at a developmental continuum of students, house-officers (i.e. new graduates with less than one year of clinical practice), and registrars (i.e. experienced clinicians). de Groot (1965) and Marton (1975) describe a number of good reasons for adopting this developmental and comparative approach:

> . . . the more 'experience' a person has collected in any field, the more difficult it becomes for him to understand the behaviour of have-nots. Thus, every teacher knows the following frequent brand of overestimating his students: opining that from the given problem situation his students can 'immediately' derive (see) some property or means that he himself finds quite obvious—whereas in reality, in order to 'see' it, much perceptive and abstractive experience is required. The teacher has had this experience for so long that he is no longer aware of it! (de Groot 1965).
>
> A necessary pre-requisite of ease of learning on the part of the learner . . . is that the teacher has a clear conception of what lack of understanding looks like and as regards the absence in the student of these pre-requisites on which it may depend . . . The idea is simple enough: in order to help the students understand, we must first understand their way of thinking about the topics with which we are concerned (Marton 1975).

We felt, and argue in this book, that, despite much work, knowledge of the diagnostic thinking process and its development had remained at a rather general level and that by this the development of teaching strategies that could be used by all and any medical teachers was hampered.

But the importance of this book is more than that, for the study of the development of the diagnostic thinking process in medical education and clinical practice has implications not only for the medical student's training (Schroder *et al.* 1967), but also for the efficiency and effectiveness of his subsequent practice. It is not suggested that the experienced clinician's

diagnostic thinking processes are without blemish. Hence, achievement of a better, more complete and accurate description of the process than was currently available might allow advantage to be taken of Abercrombie's (1960) hypothesis that 'we may learn to make better judgments if we can become aware of some of the factors that influence their formation'.

Knowledge of their own thinking processes should enable clinicians to modify them according to the demands of each individual clinical situation. Such knowledge may also stimulate a constructive questioning of established applications and a more rigorous self-evaluation.

We have tried to do work and produce a book that is practical, relevant, and sound. We have tried to unite good research practice with appropriate, interpretative theoretical constructs from psychology and education. But we have tried not to stray into extremes of academicism, while maintaining academic integrity.

Thinking about thinking processes is never without its difficulties and problems. When the content of the thinking process under study is also especially difficult, then thinking about thinking becomes even more complex. This is particularly the case for the diagnostic thinking processes of doctors and medical students.

The problem of diagnosis is especially difficult because there seem to be no 'rules' and no boundaries, no defined beginning and no pre-established end to aim for. It begins with whatever the patient presents, it ends when the clinician judges that he has enough information and understanding on the basis of which suitable action can be taken. The problems of diagnosis are not neat and tidy problems. Each one is different. Each one requires judgment. There are no externally set criteria against which 'accuracy' of diagnosis can be measured. A difficult problem such as the Rubik's cube or *The Times* crossword, has, at least, a defined starting point, end point, and set of relevant or possible elements. But the diagnostic problem has no such boundaries, parameters, or systematic ways of deciding when a proposed solution is acceptable. Barrows (1976) describes the clinical problem as an 'unknown problem'. Reitman (1964) terms such problems 'ill-defined'.

To study the diagnostic thinking process, then, is to study a complex phenomenon, and to present the results of that study in some digestible form means either resorting to some kind of representation or model, or presenting a descriptive account. Both approaches have been tried by a variety of researchers and authors. We might best begin our journey into the process of making a clinical diagnosis by looking at the terrain as it has already been mapped by other travellers. So we must look at statistical and other models, and at the descriptions of the thinking processes that result in a diagnosis. On the basis of this initial survey, we can go on to define other lines of inquiry which are necessary to our full and useful understanding of the mind of the diagnostician. We can then also examine related current and possible teaching and learning strategies.

1.1 MODELS

1.1.1 Statistical models

Early work on characterizing the clinical problem solving or diagnostic thinking process concentrated on the production of models which seemed best to fit the apparent relationship between 'input' (clinical information) and 'output' (diagnosis). Such models, not surprisingly, turned to established statistical theories. They were not based in any psychological study of the clinician's thinking but rather on an input–output relationship with little regard to what might, in fact, happen in between.

Goldberg (1968), traces the development of statistical modelling of the diagnostic process from early research on the accuracy and validity of clinical judgments in clinical psychology. Such investigations progressed to consider the process of clinical inference and to attempt representation and simulation of clinicians' cognitive processes. The statistical models which have been, and are being, developed predictably fall into the two broad categories of linear and non-linear. In turn, the studies can be subdivided into two groups as indicated by Hoffman *et al.* (1968); those which focus upon outcome, reliability, and accuracy, and those which focus upon the judgment process itself especially upon the manner in which cues (items of information) are weighted and combined by the clinician. It is clear, then, that statistical models have had different purposes.

Linear models have been based on the statistical methods of linear regression, analysis of variance, and conditional probability theories or Bayes' theorem. The purpose of regression models has been to discover which combination of pieces of clinical information best indicates the actual diagnosis. This involves the assignment of relative numerical weights (or predictive importance) to those pieces of information. It is worth looking more closely at this process so that we can see exactly what these models do and are.

In regression models, the dependent (or criterion) variable is the clinician's diagnostic judgment, and the independent (predictor) variables are the values of the cues (test scores, symptoms, signs, etc.). The result of such an analysis is a set of regression weights, one for each predictor. In such studies, clinicians are asked to estimate some criterion (i.e. make some diagnosis) on the basis of given values of several predictors (i.e. pieces of clinical information). It is then possible to compute the relationship of each predictor variable to the decisions of each judge across a group of test protocols. The results, stated in terms of 'relative weights' indicate the relative importance of each predictor in contributing to the decisions of each clinician and to the diagnoses made. Hammond and Summers (1965) cite more than a dozen studies of clinical judgment in which the accuracy of prediction derived from linear regression analysis was great enough, for them, to suggest that

clinicians are primarily linear in their mode of combining cues. That is to say that clinicians tend not to use groups or configurations of cues but merely combine individual items in some weighted manner. Such a conclusion seems naïve at best! Yet similar inferences of some pseudostatistical form of thinking have been drawn on the basis of models using the statistical method of analysis of variance (Hoffman *et al.* 1968).

Perhaps the most powerful and popular of all the statistical models are those based on conditional probability theory or Bayes' theorem. The prevalence of this model demands that we look at it more closely. According to Bayes' theorem, in relation to medicine, accurate decision making depends on the prior probabilities of the possible diagnoses and the observed signs and symptoms, and on their probability of joint occurrence. The strength of an association is indicated with probabilities also. Bayes' theorem allows mathematical revision of opinion about possible diagnoses in the light of new information.

The earliest, and probably most formative paper on the use of conditional probability models in computer-assisted diagnosis is that of Ledley and Lusted (1959). Taylor (1971) gives a comprehensive review of conditional probability models of diagnosis. Both Taylor (1970) and Card (1970), consider that in clinical practice the doctor collects data sequentially, guided at each stage by a mental estimate of the probability of diseases under consideration. Although Taylor's own Bayesian model showed a success rate of 93 per cent, the model had to select between only three possible diseases, which introduces a certain element of unreality into the process; firstly, by having the possibilities designated and provided, and, secondly, by limiting them to only three. This element of unreality is present in all such studies. Taylor's solution of developing a system with more tests (88), nine diagnoses and eight treatment possibilities does not necessarily reduce the unreality of being 'given' possibilities from which to select in the first instance. The technique still demands a closed set of symptoms and possible diagnoses (Lindberg 1968), and it is in this that the unreality is seated, not in the magnitude of that closure.

None the less, Bayesian conditional probability models of the diagnostic process have been widely used. Taylor (1971) quotes studies in which Bayes' theorem has been applied to problems in haematology, gastroenterology, cardiology, primary bone tumours, psychiatric diagnosis, and Cushing's syndrome, in addition to his own work on thyroid disease. Knill-Jones *et al.* (1973) used a Bayesian model in diagnosis of jaundice, and Knill-Jones (1977) reports its use in calculating the prognosis for severe head injury patients. Lusted and Stahl (1964), however, point out that Bayesian models have greatest diagnostic accuracy when used in areas such as thyroid disease and congenital heart disease in which diagnostic data are drawn mainly from laboratory tests rather than the clinical history and physical examination which is difficult to present in quantitative form. Lusted and Stahl (1964)

conclude their paper with the suggestion that perhaps the Bayesian model does not entirely account for the clinician's thinking process. The view that clinicians do not think in terms of exact probabilities, is held by other workers (Albert 1974) and substantiated in other fields (Anderson and Shanteau 1970).

These, then, are the major linear models of the diagnostic process, and reference to the papers cited will evidence an associated consistent and considerable degree of predictive accuracy. Despite this, linear models have been the target of criticism. Hoffman's (1968) discussion mentions some of the points of controversy. First, adoption of a linear model would imply that individuals do not alter their mode of 'weighting' the dimensions of information, regardless of their pattern or configuration. Secondly, clinicians report in fairly emphatic terms that judgment involves a sequential consideration of many dimensions (symptoms, signs, or cues), and that the interpretation of a given dimension is conditional upon the values of other dimensions. This subjective assessment is supported by Goldberg (1968), and mentioned by Meehl (1954, 1960). Elstein *et al.* (1978) found the very diagnostic accuracy of the linear models which they applied to their data reason enough to reject the linear principle:

> Thus to the extent that a linear model resulted in increased diagnostic accuracy without changes in the data base, its adequacy as an account of human performance may be questioned (p. 104).

In clinical psychology, Nystedt and Magnusson (1975) quote five studies between 1968 and 1970 alone which indicate that clinicians use cues in a configurative way. In view of such factors, a few workers have addressed themselves to the development of non-linear models, considering that the interpretation of symptoms and signs is conditional upon the presence, absence, or nature of other symptoms and signs. Such studies as there are, however, are within clinical psychology rather than medicine where it remains for a non-linear statistical model to be developed.

1.1.2 Other models

Prominent among other models has been the use of decision trees, decision analysis, and decision theory. Schwarz *et al.* (1973) discuss the nature and use of decision trees and associated probabilities and values. They give an example of a decision tree describing possible actions by the physician, and their potential consequences, in a patient thought to have either essential hypertension or functionally significant renal artery stenosis. The tree consists of nodes and branches. At decision nodes the physician must choose one from a set of actions and proceed to travel down the consequent branch to the next node. Although Schwarz *et al.* (1973) suggest that 'most physicians will find the diagrammatic representation . . . quite in keeping

with their thinking about medical problems', there is no experimental or research evidence of such a thinking process. Some decision trees and flow-charts, such as those of Essex (1976), do not purport to represent a thinking process, but are merely an aid to diagnosis. Kleinmuntz (1968) has used logical decision trees not to model, but to study diagnostic behaviour of clinical neurologists.

Studies using the theoretical framework of decision theory and decision analysis have been completed by Garland (1959) with radiologists, comparing the effects of lax and strict decision attitudes and Aitchison (1970) in relation to treatment allocation. Aitchison and Kay (1973) interpret the clinician's diagnostic behaviour in terms of decision theory and the reduction of uncertainty. However, to what extent each of these represents a formal model of the diagnostic thinking process is not always made abundantly clear by the authors.

The only remaining major interpretative framework is that based on set theory. Feinstein's (1967) book has been formative in this area, and makes it clear that a model is being proposed:

> Like the character in Molière's 'Le Bourgeois Gentilhomme', who was astonished to learn that he spoke in prose, clinicians may be startled to discover that they *think* in mathematical sets. The thinking occurs during every act of diagnosis, prognostic estimation, therapeutic decision, and corrrelation of clinical and laboratory data. As exercises in deductive and inductive reasoning, these acts can be described in mathematical terms (p. 156).

Such an attempt to describe the clinician's thinking processes had been made previously (Feinstein 1963), yet the discussion of the application of set theory shows that a clinical taxonomy, or an objective organization and classification of clinical data, is being achieved, and not a description of a thinking process as is claimed. Set theory and Venn diagrams were attractive in this endeavour, because of their ability to identify and construct overlapping collections of items. As Bashook (1976) suggests, 'the logic Feinstein presents is reasonable and attractive except that it represents what we would like to see in physician thinking and not what our present knowledge suggests as reality'. The Royal College of General Practitioners (1972) also has used set theory as an interpretative framework, but without suggesting that clinicians actually think in this way.

1.1.3 An evaluation of models of the diagnostic thinking process

The models so far discussed do not provide a *description* of the clinician's thinking processes. They do, however, demonstrate other ways in which clinical information can be manipulated to yield the most likely diagnosis. Such models are of use to support the clinician or in certain situations where a finite number of diagnostic choices can be presupposed or identified in advance. But they show a clear lack of congruence with the realities of