SESSION 4A

PAPER 4

MEDICAL DIAGNOSIS AND CYBERNETICS

by

DR. FRANCOIS PAYCHA

BIOGRAPHICAL NOTE

Dr. François Paycha, born at Narbonne, studied medicine at the University of Montpellier. His first researches were concerned with the embryology of the eye, later using the distribution of radioactive phosphorus P32 to study the structure of the tissues and for the detection of tumours.

He was then appointed to the National Centre of Scientific Research. While in charge of a hospital clinic, he noted the considerable differences in the diagnoses of conscientious and knowledgeable practitioners and those advanced by the hospital. In view of the special need for exact diagnosis in medicine he made a study of the causes of these differences.

After theoretical research, he made the first "Medical Memory' in 1953 with the help of Bull and later of I.B.M. He studied the structure of a three-symbol logic which is applicable to medical problems and in general.

After a year in the service of Prof. G. E. Jayle, he abandoned pure research and entered industry.

(94009)

- 636

MEDICAL DIAGNOSIS AND CYBERNETICS

by

DR. FRANÇOIS PAYCHA

SUMMARY

I am going to analyse briefly, and describe, the logical structure of Medicine.

On the basis of this study, I shall show how the results thus obtained may be wholly applied to other subjects.

Then I shall state in detail how and why certain branches of activity recognize other forms of logic.

Lastly, I shall show how one may conceive a general system of logic, which is normative, but only in terms of the nature and development of each science, regarded as a special case of a general rule.

This form of presentation is necessary in order to make the nature of Medicine clear to those who have had treatment because the patient does not see things in the same light as the doctor.

HISTORY OF MEDICINE

The first man or woman to pour fresh water on a painful wound was performing the first piece of therapy by that act; and the first man or woman to become aware of the approaching demise of a fellow-creature thereby made the first prognosis.

The desire to relieve pain is probably as old as the world itself, and concern with suffering undoubtedly dates just as far back.

(94009)

Regarded in this way, on the basis of human suffering, Medicine is probably the oldest of the sciences.

In the beginning, its aims were unformulated, its activities undirected, but it has since become a discipline governed by the desire to relieve pain.

Medicine has gradually dissociated itself - though incompletely as yet from magic, voodooism and superstition; in short, from a series of practices - highly irrational, to say the least - whose existence was justified by the ineffectiveness of the drugs which the "doctors" (they must be given this name) used.

Some of the first practitioners turned their activities towards the making of drugs, but their work soon became out of date; the secrecy with which they surrounded their ridiculously ineffective recipes and the naive character of those which have been handed down to us - likewise very ineffective - now only have an anecdotal value. Nowadays our attention is directed ironically enough, much less to the drugs themselves than to the phials and bottles which contained them and which are the delight of archaeologists.

Others, more moderate in their aims wished to know about the diseases of man before endeavouring to cure him. Today, the nosological framework of their descriptions seems vast, tenuous and shapeless; but the slender thread of their clinical observation, made two thousand years ago, still remains valid today and is recorded in its entirety in the huge network of innumerable subjects and interrelationships forming our present knowledge.

We can already perceive the division which is going to take place. Even in the time of Hippocrates, it was difficult for one brain to know everything, for one man to do everything, diagnosis as well as therapy.

Gradually this tendency took hold, and nowadays we have two distinct branches, both equally indispensable: medicine and pharmacy.

In passing, stress must be laid on this process whereby a single discipline subsequently divides into two or sometimes several different parts, under the pressure of increasing complexity of the relevant data.

In this study, we shall consider Medicine and Pharmacy as a whole.

Medicine, then, is a discipline defined by its particular aim of curing the sick. It is this aim which governs the activities of the doctor in terms of opportunities for action, thus all methods and all techniques are justified.

It must be noted, however, that such definitions, made and presented "a posteriori", do not correspond to any logical arrangement within the discipline.

It is the aim which gives it its unity; the purpose of Medicine is to cure.

• • • • •

and the second second

HOW IS MEDICINE PRACTISED?

This ancient branch of knowledge is represented by the medical practitioner; we shall therefore establish the logical structure of Medicine by studying his activities.

The point where Medicine and pain come together is in the consulting room, where on the one hand we have the patient and on the other, the representative of Medicine, the practitioner.

What takes place during the consultation?

There are two indisputable facts: at the beginning of the interview the doctor knows nothing about his patient except that he is ill, and at the end of it the patient goes out provided with a prescription with which he obtains the medicaments to cure him, or intended to do so within the limits of our knowledge. If we confine ourselves to the traditional system, the consultation consists of various parts, as follows: the questioning, the general examination, palpation, inspection, examination with instruments. When these have been carried out, the doctor makes out a case-sheet which, above all else, must be complete. He makes his diagnosis, arranges for further examinations, perhaps, and prescribes treatment.

It must be stressed that in this description, the part devoted to establishing symptoms is fully developed, but the part leading to diagnosis, i.e. to the affirmation that a patient is suffering from such and such a complaint, is skimped. Much emphasis is laid upon the value of a proper examination, a complete record of symptoms, palpation carried out gently and correctly, but no indication is given of the way in which all this material is put together.

Thus is the point to which I would like to draw attention. To make the study easier, we shall transcribe the medical data into cybernetic language.

This we shall call all the particulars we have about the patient and the ailments "information".

We shall call all the actions by which the doctor obtains information about his patient the "acquisition of information", which thus comprises the general examination, palpation, questioning the patient, special examinations: in brief, all the semiological and laboratory techniques. In this connection, we should note that knowledge of a blow on the right side is just as much a bit of information as a laboratory report stating: inductance 45 Henries, or a detailed report from the heart specialist.

We shall call "information processing" all the mental processes whereby use of the information acquired leads to the affirmation that "this patient is suffering from such and such a complaint".

It must be noted that for the time being I have merely given cybernetic names to functions already known for a long time. One may therefore ask whether introduction of these new terms is justified, whether any new contribution is made by this simple change in vocabulary.

. More generally, we must prove the existence of a problem in diagnosis and of therapy - a problem which is far from obvious, especially to the medical practitioner.

The latter in fact regards diagnosis as a self-evident affirmation; in most cases he will remark that for centuries diagnoses have been made and treatments prescribed, without anyone giving their attention to the mechanism, but that the system has, nevertheless, worked. This view of the problem, which consists in ignoring it, is associated - paradoxically enough - with the high professional scruples of the doctor.

Let us suppose, in fact, that a practitioner has made a diagnosis L and prescribed treatment K for a patient; he has allowed for all contingencies and all the pathological and therapeutic possibilities before arriving at K and L. Thus in all good faith, he does not think that there can be any possible conclusions other than these.

However - and in this lies the justification for this study - it has never been shown that the nature of Medicine is such that the whole of it can be known by a single doctor.

Indeed, we have already seen, in the brief history given above, how Medicine, or the art of tending the sick, is already divided into two branches: Medicine proper and Pharmacy, and it has been so divided for a long time. Now during the last thirty years we have seen Medicine proper split up in its turn into ophthalmology, neurology, pediatrics, geriatrics, obstetrics, gynaecology, oto-rhino-laryngology, and so on.

And now a new tendency is becoming apparent, a kind of superspecialisation, the result of which is that within each special field, new, independent branches are tending to form, one making a study of and treating binocular vision, another, phonation and so on. Fragmentation of this kind is an excellent thing, in the sense that it leads to a good knowledge of the subject concerned; it is justified - and this is the important thing by the multiplicity of data applied.

There is an unfortunate corollary to it, however, and that is, the different specialists are obliged to ignore the rest of Medicine.

Now an ailment is never confined to a single organ, and such specialisation inevitably leads to a Medicine of organs, a therapy for organs, neglecting the essential indivisibility of the human being.

How could it be otherwise? The specialist has all his attention, all his faculty of memory, all his actions directed towards a tiny sphere of activity; he cannot multiply himself by a number corresponding exactly to the number of specialist fields.

We thus reach an impasse, with continued progress in the various branches of knowledge on the one hand, and our inability to use them all at once on the other, while they are all necessary for the proper practice of Medicine.

Although specialisation may be a means of study, it cannot be the best way to making cures.

After all, the problem would be a minor one if we could be sure that the specialist could now somehow or other link up the smallest details in his own field with the whole of pathology.

Now this is by no means the case; already, details are escaping the attention of the doctor within his own special field, and he is finding it more and more difficult to keep up with ideas in the wider field.

To express this more specifically, we can consider the fact that there are some 4,785 periodicals published in the world. If we allow for a monthly issue, with four articles of interest in each issue, anyone who wished to keep up to date would have to read - and remember - some 19,140 articles a month, or 638 a day. This assumes that by previous study he knows all the basic works and especially that there is no defect in his memory; in particular, that he never has to re-read a work in order to recall it.

The magnitude of these figures alone shows that a problem exists, but they are confirmed by experience as well. Errors in diagnosis occur, unfortunately; we all know of such cases.

The doctor is thus faced with the problem of diagnosis, and every day he sees the difficulties of his work increasing. The logician is faced with the problem, as well, when he is searching for rules and conditions.

Considered in this light, the problem is a very general one which, as we shall see, concerns Medicine solely because it represents a particular aspect of the problem and is really that of many different forms of knowledge.

INFORMATION IN MEDICINE. NOTATION SYSTEM

It seems that Medicine is "par excellence" a field undergoing continual change, and it seems difficult to reduce it to logical terms. Now it is in no way a question of reducing the very substance of Medicine, clinical observation and other factors, but very much the opposite procedure of adapting logical symbols to this complexity.

Here, logic is not conceived as a more or less arbitrary order imposed on facts, but as a way of transcribing these facts so that by considering them as a whole, it becomes possible to bring out laws and relationships between general opinions which have hitherto been hidden.

We can give an arbitrary number - any number - to each pathological symptom, provided there is a 1:1 correspondence. To simplify the question, let us suppose that we choose the following series of natural whole numbers:

(a) 1 2 3 4 5 6

Each of these figures then corresponds to a symptom, and once the conventional symbols have been decided upon, writing the figure 5 corresponds to writing, for example, "headaches in the vertex". On the basis of this conventional system, we can write an ailment M of which a headache in the vertex is one of the symptoms:

(b) M = 3, 5, 8, 17

Thus in this series in addition to a headache in the vertex we have other symbols, 3, 8, 17

But we can write this ailment M in another way. If we agree to make the symbol "1" (i.e. the binary symbol 1) express existence so that, for example, if there is a "1" underneath the number "5", the symbol "5" is by definition present, we can write series (a) and mark with a "1" underneath, the symbols which really are present, for example, in the ailment M:

 $(a) 1 2 3 4 5 6 7 8 \dots 17 18 19 \dots$

(b) M = 1 1 1 1

We can also agree to indicate with an O the absence of a symptom: hence we get:

(a) $1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ \dots \ 17 \ 18 \ 19 \ \dots$

 $(b) M = 0 0 1 0 1 0 0 1 \dots 1 0 0 \dots$

It is then possible to eliminate the (a) series (which can always be found again easily), the position of each 1 and 0 indicating the pathological symptom which they represent.

We then get

 $(c) M = 0 0 1 0 1 0 0 1 \dots 1 0 0$

With these conventions, which are very simple, if not childish, it will be easy for us to describe, with a code, all the ailments, in the form of relationships, such as (c):

 $N = 0 \ 0 \ 0 \ 1 \ 1 \ 0 \ 0 \ 1$

 $P = 0 \ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \ 1 \ 1$

However, we can describe the patients themselves, as well:

 $Mr. K.... = 0 \quad 0 \quad 1 \quad 1 \quad 1 \quad 0 \quad 0 \quad \dots$

 $Mr. H. ... = 0 0 0 1 1 1 0 0 \dots$

For example a person in good health will be represented thus:

 $X = 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0$

Are we entitled to write in this way?

Are we entitled to reduce to logical symbols entities as complex as pathological symptoms? Are we entitled to put on one and the same footing symptoms which are obviously not all of the same value?

It seems that we are not - at first sight; and this is one of the most important arguments put forward.

Now if we study the question more closely, we find that there are various criteria of the value of pathological symptoms. For example, it is perfectly legitimate for one to give an extremely limited prognostic value to the appearance of a pre-auricular ganglion during an ocular neoplasm, or to attribute great diagnostic value to photophobia in Weeks' keratoconjunctivitis. At the same time, however, it must be borne in mind that the appearance of the same pre-auricular ganglion in a case of Parinaud's conjunctivitis is perfectly normal; on the other hand, if revealed in syphilitic interstitial kerotitis, the same photophobia would be of no interest for the purpose of diagnosis.

Thus we see that the notion of the value to be attached to a symbol depends upon both the criteria envisaged and especially the clinical context of the symbols; and this context can only be arranged when the diagnosis has been made.

Now we have a strange inconsistency here: we would attribute a value to the pathological symptoms, knowing that this value depends upon the diagnosis, and we would use this value to make the diagnosis.

Such a procedure must be rejected, because it uses the unknown factor in proof: the assumption is not the symptoms expressed in terms of a diagnosis, but, of course, the symptoms alone.

For these reasons, therefore, it is legitimate to use the above system of notation.

Introduction of a symbol expressing the absence of information

In addition to the symbols 1 and 0 about which we have just spoken, mention must be made of the question mark '?'. This third symbol indicates the pathological symptoms about which we have no information at all.

If, for example, the number 6 is used by convention for the wave-recording system of the electro- encephalogram, and if we have not yet made the EEG examination of the patient K, we may write the following, if we already know of the existence or absence of the other symptoms:

(d) $K = 1 \ 1 \ 0 \ 1 \ 0 \ ? \ 0 \ 1$

Apart from the role of this question-mark, we shall see that its presence characterizes a logical structure which is peculiar to certain disciplines. The doubtful, non-informative nature of the ? enables us to do without studying the characters with logical validity further on.

Moreover, we shall see that this does not give rise to any logical operation, and that it therefore cannot lead to any erroneous conclusion. APPLICATION OF THE NOTATION FOR THE LOGICAL STUDY OF DIAGNOSIS

Conditions for the validity of positive diagnosis

Let us suppose that a doctor has diagnosed the complaint M for a patient A.

Let us study in detail the mental operations and actions which lead him to this affirmation.

When the patient enters the doctor's consulting room, the doctor knows nothing about him, which we may express as follows:

(e) A = ? ? ? ? ?

The doctor then examines his patient. Let us agree to use this term "examine" to designate the whole of the questioning, the examination proper, palpation, percussion, auscultation ... in short, the techniques currently employed by practitioners.

When these actions are completed, if the doctor makes out a complete record, we find in it details of the facts which we write down using the values 1 and 0, according to a code of equivalence agreed on in advance:

The record for the patient will then be:

 $(f) A = 1 1 ? 0 1 0 1 0 1 ? 0 1 \dots$

- which is the same as saying that patient A shows the symptoms which we designate with the numbers 1, 2, 5, 7, 9, 12.... and that the patient does not have those which are designated by the numbers 4, 6, 8, 11.... the latter being those for which the doctor's search yielded a negative result. For example, he has looked for tenderness in the right iliac fossa, number 4: there is no tenderness there, so it is indicated by 0.

The question marks represent the symptoms which the doctor has not specified, either because he did not consider it worthwhile to do so, or because it has not occurred to him.

To simplify our reasoning, let us now suppose that the doctor is thoroughly acquainted with four ailments only. This is admittedly a surprising assumption, but it is perfectly valid. In fact the number of ailments is much greater; it could be put at 10,000, for example. But however great the number is, it is finite, which means that we can be sure of succeeding in drawing up a complete, exhaustive list of all the ailments. It is by regarding 4 and 10,000 as comparable in the sense that they are both finite, that assimilation becomes possible: the reasoning applied to 4 may by extension be applied to 10,000 and even more. The knowledge which the practitioner has about the 4 ailments (which we shall call M, N, P and 2) has been acquired from the books on Medicine, improved by the examination of patients and kept up to date by reading specialist reviews.

This knowledge is recorded in the doctor's memory. He knows, for example, that the ailment M includes a headache in the vertex, and that in the same ailment M there is no tenderness of the right iliac fossa.

(94009)

•• (a. j)

Confining ourselves to twelve symptoms, so as to make the reasoning easier, using the above conventions, in combination with a code, we may write:

(g) M = 0 1 1 0 1 0 0 1 1 1 1 0

- a relationship which represents symbolically the knowledge which the doctor has of the ailment M.

We shall see that, if it is suitable, the arbitrary limit (12) which we have imposed on the number of symptoms retains all the demonstrative value required for the argument.

In fact, it is easy to confirm that, although there may be a large number of symptoms, they are not infinite in number. However great the number is, we shall see that it in no way invalidates the argument below.

We may write three more relationships on the lines of (g).

(h)	N	=	1	1	1	0	0	1	1	0	1	1	0	1
(i)	Р	=	1	1	0	0	1	0	1	0	1	1	0	1
(j)	2	=	1	1	1	0	1	0	1	1	0	0	0	0

Let us take as an example the patient who goes into the doctor's consulting room. Some doctors, who are famous names in the short history of Medicine, had acute powers of observation which enabled them to see details normally overlooked. However, if we ignore these men - who after all, are exceptional - and consider the more common cases, then from the very beginning, after the first words spoken, after the first replies to his questions, the doctor will generally have some information - vague perhaps, but of such a kind as to enable him to direct his investigation along certain lines.

We shall dwell upon this first change in the doctor's attitude. At first, he is passive and contents himself with recording the data as he finds it, or which he may even obtain after a single question even though he poses it without any preconceived idea. During a second period, when a working hypothesis has already been formed, the doctor directs his questions and examinations along definite lines.

The length, difficulties and methods of the initial consultation period vary greatly. They depend upon two factors: on the one hand, the mental make-up of the doctor and on the other, the form of the ailment. This period, during which the doctor makes a very random search for indications which may restrict the field of subsequent investigation, we call the "semiological period". It is during this period that what is known as the "clinical sense" seems to appear. If the patient comes in with his head down, covering his eyes with his hand, and wiping them (they are covered in a muco-purulent secretion) with a handkerchief, declaring that there is a pain in his eyes, just as if he had sand in them, then the semiological period is reduced to the time taken by a simple thought

association reflex. The doctor immediately thinks of infectious conjunctivitis. If the patient has pains all over his head, in no particular part, and a general feeling of fatigue or asthenia - but still has a good appetite - further information will be needed before an exact diagnosis can be made.

Let us suppose then, that the doctor has just completed the semiological period. He thinks to himself: This ailment could be N, P or Q.

What has made him think of these ailments?

This is one of the essential points of diagnosis.

These ailments have occurred to him, because the patient has shown the symptoms which he knows to be part of the ailments N, P and Q.

That is, he has associated in his mind the constituents of patient A's ailment with the constituents of N, P and Q. We may write this mental process as follows: let us suppose that the knowledge which the doctor has of his patient at time t = 2 is such that:

(k) A t 2 = 1 1 ? 0 ? ? ? ? ? ? ? ? ? ?

That is, the patient has symptoms 1 and 2, but not those numbered 4 and 11. The same table applies to ailments P and Q and N as well.

As soon as the doctor has made a mental association between one or several ailments and the case of his patient, the search for symptoms is no longer carried out at random. On the contrary, the doctor makes a precise search for such and such a symptom which he knows to be part of the ailment concerned. His reasoning runs as follows: such a symptom belongs to this ailment, and my patient already shows these symptoms; let us see whether he has this one as well.

We can draw up a table showing these steps in the mental process:

No. of	symptoms:	1	2	3	4	5	6	7	8	9	10	11	12
Ato	2	?	?	?	?	?	?	?	?	?	?	?	?
At 1	2	?	1	?	?	?	?	?	?	?	?.	?	?
М	=	0	1	1	?	1	0	0	1	1	1	-1	- 0
N	=	1	1	1	0	0	1	1	0	1	1	0	1
P	=	1	1	0	0	1	0	.1	0	1	1	0	1
Q	=,	1	1	1.	0	1	0	1	1	0	0	0	0
At 2	=	1	1	?	0	?	?	?	?	?	?	0	?

Ato = the patient enters the consulting room; he is about to cross the threshold; the doctor is aware of his presence, but he has not seen him yet and knows nothing about him.

At1 = symptom No.2. is immediately apparent. Nevertheless, since it occurs very frequently (in the present case, it occurs with *M*, *N*, *P* and *Q*, i.e. in all the ailments), the doctor cannot draw any valid conclusion from it. At1 thus represents the state of his knowledge in the semiological period.

(94009)

 At_2 = the presence of symptoms 1 and 2. The absence of Nos. 4 and 11 connects this case with ailments N, P and Q. Ailment M must not be considered, because it includes symptoms No. 11, which the patient does not show. Comprising At_2 , N, P and Q, the doctor then looks for symptom No. 5 in the patient, for example. If it is present, the possibility of the ailment being P or Q must still be entertained; if it is absent, the doctor will have to consider ailment N.

This thought process - which utilizes the facts held in the memory, comparing them with the actual case of the patient, in order to direct the semiological investigation - we call the "differential diagnosis period". It is a period in which the doctor is guided by his knowledge of pathology.

I would emphasise that these different stages of diagnosis were never described by the classical writers. It seems that they were not aware of these mental activities. (This assumption is very probably true, since habituation to thought processes removes them from the conscious mind).

To revert to our example; let us suppose that patient A shows symptom No. 5, which we write as follows:

(l) At3 = 1 1 ? 0 1 ? ? ? ? ? ? ? ? ? ? ?

This means that the patient is suffering from ailment P or Q. In order to be able to make a positive diagnosis, the doctor then looks for symptom No. 12 in the same way. If it is present, the positive diagnosis is made, still by comparison: patient A is suffering from ailment P, because symptom No. 12 is present in this affection.

This procedure, and the various periods involved, is followed in its entirety in all consultations, and it is the basis of all diagnosis. Only the length of the various periods varies.

Certain points thus brought out should now be specified in detail. I shall ignore those conclusions which are of interest only to doctors, and dwell upon those which are of logical significance.

1. If we designate by Σ (K) the number of symptoms defined by 1 or 0 in an ailment K or in the case-sheet of a patient, we may write:

(m) Σ (At3) $\langle \Sigma$ (N) (n) Σ (At3) $\langle \Sigma$ (M) (o) Σ (At3) $\langle \Sigma$ (P) (p) Σ (At3) $\langle \Sigma$ (Q)

This means that, in actual fact, the doctor does not use all he knows about the ailment for making the diagnosis. The difference represents the symptoms which the doctor has omitted or neglected to specify, since the diagnosis appears to him to be decisively established without them. 2. This is the essential point which I emphasize; namely, that the diagnosis is the outcome of a series of comparisons between what the doctor knows about the ailments and what he knows about his patient. There is no fabrication at any time.

This conclusion is very important, and we shall see below its consequences and applications.

In all the above, we have reasoned about four ailments and eliminated three of them. It is easy to see that we could just as well have reasoned in the same way about five ailments, or six; in short, about any desired number of them, on the one condition that the number of symptoms characterizing the ailment increases at the same time. In passing, let us note that we may conceive the number of these symptoms being increased to thirteen, then to fourteen, and so on, in the same way.

In practice, the number of symptoms is much greater than the number of ailments, which enables the ailments to be distinguished unequivocally.

Conditions for valid diagnosis

With this ternary system of symbols, it will be easy for us to study the conditions to which the doctor must subject himself, if he is not to make an error in his diagnosis.

This does not mean that these conditions are essential for exact diagnosis, but that they are logically necessary. The diagnosis may, of course, be correct without all the conditions being fulfilled, but it may also be wrong.

If the police have a detailed description of an offender - if, for example, they know that he has a scar twelve centimetres long, pigmented, in the right lumbar region, and if they have some very good photographs of him as well - the offender may be arrested in the street, thanks to the photographs. There will not be sufficient identification, however, until it has been confirmed that he has the scar. Nevertheless, the diagnosis of the policeman who recognized him in the street will have been correct, even though it was not based on all the requisite data. On the other hand, it invalidates the arrests which others may have made, arrests which were not justified in the absence of the scar (wrong diagnosis).

Taking the above notations, we may write:

(a) $2\Sigma^{(Kt)} > V$

where Kt represents what the doctor knows about the patient at the time of the diagnosis, and V the total number of ailments.

This formula represents the minimum of knowledge which is necessary in order to ensure that no error in diagnosis is made.

It is also the mathematical expression of the two requirements illustrated by the following examples.

Let us suppose that a doctor has diagnosed the ailment M in patient A. He has studied, in all good faith, all the possibilities, all the hypotheses for symptoms, with which his memory has been able to furnish him. If, during this study, he had considered an ailment Q which perhaps appeared to him to be more closely identifiable with the case of his patient A, he would have ruled out the diagnosis M in favour of Q.

(94009)

However - and this is an important point - for any given patient, the search amounts to going through all the ailments together, since we are left in ignorance, if the very ones we rule out do not include just the one from which our patient is suffering.

How is it possible to satisfy these conditions, when for the cornea alone, the number of ailments may be put at 1,0007 Then again, as we have seen, and as happens in every diagnosis, the diagnosis is made with a relatively small number of symptoms.

In our example, we have put the number at 5. Here, it is easy to study the possibilities, because only four ailments are involved, M, N, P and 2, but when the number of ailments runs into thousands, it is difficult for the practitioner to answer this question. Would there not be a risk of the diagnosis which I have made with all these particulars about the patient, being invalidated, if I looked for such an such another morbid symptom?

We thus have a second condition. In order to be sure about his diagnosis, the doctor must look for all the symptoms.

Now some of them involve certain danger; how can they be attributed to the patient systematically.

Therefore to be sure about a diagnosis, it would be necessary both to consider all the possible affections and to look for all the pathological symptoms in the patient.

Formula (q) provides a solution for these requirements which is neat and simple, mathematically speaking.

It also defines a threshold, Δ , which we shall find in the further treatment of these applications below.

Value of the Diagnosis

Having thus specified the mental processes leading to the diagnosis, we should now study the value of the affirmation that the patient is suffering from such and such an ailment.

There is one point which must be brought out straight away: it is not a question of a probability here.

A patient would never allow himself to be left permanently in doubt. Of course, there are cases - and they are frequent - where a consultation cannot lead to a definite conclusion, even with searching examinations; cases in which further examinations are essential; and here the patient will readily allow the diagnosis to be deferred until the results are available. But once all the symptoms have been specified, a conclusion must be drawn, and it must be definitive. That is, the reply given must not be confined merely to probabilities; it must be absolutely positive. To give a patient who is anxiously awaiting a diagnosis a reply that "there is one chance in three that you have the complaint M, and two chances in three that it is N and finally one in ten that it is another complaint" invites the following kind of reply: "make the necessary

investigation to put an end to this ambiguity, then". If, for example, *M* is characterized by a shift to the left in Arneth's formula, let us let blood." I would stress this very special nature of medical diagnosis.

For a long time it has been thought that statistical studies could be of no little value in Medicine. This is true; statistics are an incomparable tool of knowledge in medicine: but not in the field of diagnosis.

Statistics are on a level different from the individual level of the patient.

When the statistical method has been applied in classifying groups of patients and studying correlations, it cannot give any answer to the question everyone asks: namely, "which group do I come under"?

Statistics are the tool of the public health specialist, who studies man as part of a whole, but they cannot give any help in the highly individualized branch of diagnosis.

However, it is certain that for some cases, though statistics cannot give a final answer, they can be a guide. We shall study below these special data which in actual fact correspond to a particular material state.

Diagnosis and Prognosis; the Conditions for Prognosis

Besides diagnosis, and subsequent to it, we have the development of prognosis, which consists of forecasting the course of a given ailment. Here, statistics attain their full value, being based upon the analysis of existing and comparable facts.

Thus it makes use of the diagnosis results and interprets them, sometimes with the aid of new facts which have nothing do do with making the diagnosis.

For example, we have here a patient who has had an accident. After the general examination, questioning and supplementary examinations - radiography, in particular - the doctor diagnoses open spiral fracture of the two bones of the leg.

At this moment, the diagnosis is made unequivocally.

In order to make the prognosis however; to be able to say to the patient, "we are going to reduce this fracture, put it in plaster, and in so many days' time you will be able to return home", further investigations have to be made; if the blood sugar level is high in a diabetic the prognosis will be less optimistic.

Thus, as far as the elements of evaluation are concerned, the rules for prognosis are the same as those for diagnosis, but instead of leading simply to an affirmation, all the data are together combined through a factor derived from the study of earlier cases, and lead to the statement of a probability.

PRACTICAL APPLICATIONS OF THIS THEORETICAL STUDY IN LOGIC

Once the conditions for diagnosis and the means of arriving at it have been studied, the applications are easy to conceive.

The most striking and simplest illustration of this is the use of punched cards.

For each symptom we have a corresponding place on the card, determined by the row and column (on an IEM card there are 80 columns and 12 rows). There is a card for each ailment, with perforations for each of the symptoms present. In machine language, all the cards together form a "library".

We ourselves can read the contents of these cards, thanks to the code, as well: but a simple sorting machine handles them much more rapidly.

The cards are made out, in holes, according to the data contained in the medical treatises, old and new, none being left out; and they are punched according to the latest data given in the most recent works. That is, the cards constitute a complete, up-to-date library.

We have a patient before us and we find that he has certain symptoms, Nos. 78 and 115, say, while those numbered 513 and 587 are absent.

We then send the cards through the sorter, having all the cards without perforations 78 and 115, and those with perforations 513 and 587, rejected in four successive passes.

We are then left with a number (N') of cards. Let us pick out one of them at random; it has, say, perforation 432. We see whether the patient has this symptom, and find that he does in fact have it; so we then use the sorter to eliminate from the cards left after the first four passes all the cards without this perforation. Thus by successive passes - each one of which reduces the number of remaining cards, we are eventually left with only one card, representing the diagnosis.

If we analyze this procedure, we see that we have satisfied the theortical conditions which we have shown to be desirable in the logical study, i.e. we have allowed for all the possible cases; in fact, all our cards together represent all the existing medical knowledge on the subject concerned. We are sure that looking for a further symptom cannot invalidate our diagnosis, and in fact, we have already eliminated them all but one. It is easy to make a check, by seeing whether the patient has or has not the symptoms entered as present or absent on the card.

Lastly, this mechanical system enables us to calculate by practical means the value of Δ the threshold - which we defined above. Thus this threshold corresponds in practice to the number of sorting passes needed to obtain one card only.

I have given this example of the operation of a punched card sorter, because it enables the processing of the information to be followed easily. However, this example is surpassed in the field of applications by machines using magnetic tape and quick-access memory drums. Combination of the two memory systems allows more flexible and rapid operation, which I cannot describe in detail here.

Before I conclude this passage on the practical systems, I would like to stress two points - which I consider essential - in the use of machines: on the one hand, the subordinate role of the machine, which cannot be thought of as making the diagnosis by itself; the machine assists the doctor, who remains the prime mover in Medicine, - without whom the machine could not function; on the other hand, the quality of the service given by the machine: its memory is tireless and infallible.

Study of the General structure of the Machine

From the particulars given above, one can easily derive notions enabling one to state precisely the structure of medical knowledge.

We shall only give a brief glimpse of this structure, since a complete study would require technical treatment falling outside the essential point of this paper.

If we consider equivalences of the (g), (h), (i) and (j) type:

(g) M = 0 1 1 0 1 0 0 1 1 1 1 0,

we find that they are presented in the books and publications in the $c \in c$ sequence of M followed by the symptoms which it covers.

In fact, the name of M, of N etc. is the chapter heading under which the details which we denote by 1 or 0 are listed. However, we see that conversely, in making the diagnosis, the movement is in the opposite direction, from the symptoms to the name which is the diagnosis.

To denote this double use of the (g)-type equivalence, we can use a double arrow thus:

 $(r) \ M \longrightarrow 0 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 0$

This is important, in my opinion, because it emphasizes symbolically the changes brought about in our mode of learning by progress in technology.

In fact, if we consider the development of information processing techniques, we see that for thousands of years the problem of storing information has been solved fairly successfully - Nebuchadnezzar had libraries even in his time; and printing has multiplied this means of storage, but so far there have been very few means of converting information and, above all, they have been ineffective. We have only had the information, in a form like that of the (r) formula, but following only one direction in use: from M to the constituent elements of M.

The only information-processing machine which we had at our disposal was our memory and intellect: a very flexible machine, with infinite resources (many of which escape us), it is true, but one with a serious defect in that its storage capacity is inadequate and it is not absolutely reliable.

(94009)

Modern techniques have given us punched card machines, magnetic tape memory machines, magnetic drum memory machines in short, a set of units capable of processing information, of operating in both directions, as in (r).

This notion of two-way utilization clearly appears in the study of the application, but the principle of it is used in the mental process. I think that it is important to emphasize that the operations which we can follow easily in their material form on punched cards exist, except for a few details imprinted on the mind when a diagnosis is made.

The only reason why they do not become apparent is that we are too much accustomed to carrying them out and they therefore remain in the subconscious.

We only have to see what happens in a difficult case which, owing to the difficulty, demands all the doctor's attention. He reasons the matter out as follows: This is not the ailment P, because there would have to be different pigmentations; nor is it R, which is characterized by a rise in the maximum humeral pressure. In short, in any unusual type of case, the doctor has consciously to think over the stages of diagnosis, and then these successive comparison are made with the eliminations, finally leading to identification.

Moreover, it is very probable that the practitioner has short cuts (still unconscious), which quickly lead him to the diagnosis, and that organizational structure of the data in his mind is less rigid than the equivalences of the (r) type.

However that may be, and with the reservations mentioned, we see that he remembers information in the (r) form.

Medicine does not consist only of diagnosis and prognosis, however; it includes - and this is the most important point - therapeutics, as well.

Now the latter is linked to the name of the ailment in a more complex way.

We shall not study the logical details of therapeutics, because they are questions involving medical explanations which would make this paper too long if included here.

I shall merely state that, in the decision "you must have such and such a treatment", one can see the same logical basis as in diagnosis - with the reservation that here, as in prognosis, probabilities must be allowed for.

If we try to tabulate these various data for each ailment we get a group of relationships in the following form:

(s) ailment M _____ 0 1 1 1 0 symptoms (Z)

ailment N _____ treatment

Prognosis for ailment $M \xrightarrow{} 0 1 1 0 \dots$ symptoms (not necessarily the same as in Z)

(94009)

13

This set of relationships forms a large part of the sections on the ailment M.

During the consultation, the doctor's mental processes follow a path leading from the symptoms to the diagnosis whence they spread out towards, the treatment and prognosis.

If we try to generalize this structure and derive a logical system from it, we find that the basic element is the diagnosis. It is the diagnosis which forms the focus of all the doctor's efforts; from it, he draws his conclusions for treatment and prognosis. The term "diagnosis" is the "turntable" for the dynamic logical structure of medicine.

It is interesting to note how general this structure is. I believe it can be found - more or less in its entirety - in all the disciplines.

In fact, Medicine is a science combining knowledge and action: action in the prescription of treatment, and surgical action. The knowledge classified under a term which defines it very often only includes the element of acquisition of information.

If we consider botany, for example, we can easily see that this science consists essentially of the logical part which corresponds to diagnosis. The botanist observes a plant, picks out its particular features, compares them with the classification tables in his memory, and when he has identified the plant under observation with a plant already known, he is able to name it.

Other forms of activity include both diagnosis and action, however. For example, if we consider the logical work done by a lawyer preparing his speech as counsel, we find that it includes (a) a diagnostic element: acquiring information on his client's case, followed by comparison of these particulars with the precedents set down in legal texts (the diagnosis may be said to be made when the lawyer can say "Here is the precedent which applies to my client's case"; (b) an action element - strangely distorted here, but which in actual fact would have to be confined to reading the text of the precedent which applied to the client's case.

The same reasoning is followed, moreover, by the judge in charge of the case.

The very same structures are to be found in administration. All the administrative regulations are founded on one and the same logical model: the first part defines the groups, and the second, the measures applying to these groups.

It is absolutely the same structure as that in legal texts. In some cases, a group is so defined that it is impossible to be mistaken - the problem does not exist - for example "no-one may plead ignorance of the law". In other cases - the most numerous - the definition - of the group is complex: and besides this, the definitions themselves are numerous. Classification thus involves the same problems as those involved in making a diagnosis.

(94009)

654 🔅

For example, "when the injury heals without permanent disablement, or if there is permanent disablement at the time of healing, a medical certificate showing shall be made out in duplicate" (Act of October 30th 1946).

In this passage, which states the law for accidents at work, the diagnostic element may be distinguished. Does this case, this victim of an accident have an injury which has healed without disablement, or not? If so, he belongs to the group defined by the act, and from this, the action element comparable with the therapeutic element in Medicine - is derived: a certificate is made out in duplicate.

In most cases, however, the problem in Law is not such a simple one. Indeed, whereas in Medicine there is only one diagnosis, in Law there may be several answers.

In Medicine, a patient may for example be suffering from sciatica and a gastric ulcer. We shall make two easy diagnoses - separately, because in this case the indications and symptoms of the two ailments are distinct from one another. But if we examine a patient suffering from cardiac insufficiency with a chronic emphysema complication, it will be difficult for us to distinguish between the symptoms of the two ailments.

In Law, such intricacies are common, and it is these that the reasons adduced in the judgements specify. Each reason involves a separate "diagnosis". Later on, we shall study very briefly the consequences of this.

In passing, let us stress here the existence of a threshold - comparable with the one we defined for Medicine; a threshold which, derived from formula (q), indicates the presence of necessary and sufficient conditions, as I have defined them for making a diagnosis.

Although this structure of knowledge may seem over-simple, it must be borne in mind that this elementary simplicity is the rule in our mental processes.

I would like to demonstrate how general the diagnostic process is, by means of a short example.

This mode of thought is in fact so general, so common, that we are not consciously aware of it. When we look at the picture below, the name of the object occurs to us immediately; it is a pair of spectacles.

This recognition - which is really only a diagnosis - must be studied in detail, however. To do this, let us complicate the data of the problem; the difficulties which we shall find will bring out the mental steps taken. Let us say that an object - unknown to us - is placed underneath a cloth by another person.

If we try to guess what the object is, without raising the cloth, we may be surprised when we reason as follows: It is a small object, hard to the touch, in the form of a rectangular parallelepiped, with its longest side about three centimetres long. But it is not a rubber because it is not flexible, it does not bend; on the contrary, it is crumbly, like sugar; yes, it is a lump of sugar.

Here, we can easily recognize the steps which we have already described for making a diagnosis.

Thus we see that this logical form of thought is very general; we find it not only in most of the disciplines but in the processes of everyday life, as well. The process is very rapid in its usual form, so rapid and so common, in fact, that we are not consciously aware of it.

For concluding our study, let us take the following general logical formula.

(r) $M \xrightarrow{\longrightarrow} 0$ 1 1 0 1 0 0 1 1 1 1 0 with two-way utilization, and the deductive type of conclusions attaching to the notion of M.

It is useful to study, on the basis of these forms of knowledge, the logical validity of various structural relationships found in disciplines of this kind - disciplines and unorganized forms of knowledge as well. Critical study of the validity of relationships of type

 $(r) M \xrightarrow{} 0 1 1 0 1 0 0 1 1 1 1 0$

There are a very large number of relationships of this kind in all the disciplines; they are all valid by convention. In most cases, in fact, M corresponds to a fact or to a notion of the "entity" type.

In geology, for example, it may be said that oolithic limestone has such and such distinguishing features. Conversely, such and such characteristics found in a rock enable one to state that the rock is oolithic limestone.

This is in the case where M corresponds to a fact, an object. Another example, this time of an entity: the notion of "stress" corresponds to a set of defensive reactions in the body against some cause tending to disturb its equilibrium.

We see that these relationships are conventional relationships; they are postulates, convenient postulates, but postulates which cannot be challenged. In fact, their nature is not such that they rule out the co-existence of other conceptions.

(94009)

656

We find these types of conventions, this type of structure in the descriptive sciences, such as botany and natural history.

They represent the initial, early form of a discipline, the latter in fact requiring efforts of comparison, observation and description, and today sciences which are confined to these functions are rare. We are turning more and more to action.

This is written for Medicine as follows:

(t) ailment M = treatment T

This relationship is valid, generally speaking, for all the sciences in which an action is an extension of knowledge:

 $(t') M \Longrightarrow A$

Critical study of the validity of relationships of the type

 $M \Longrightarrow A$

This is the essential point of the present study; the action consequent on a piece of knowledge is in fact all the more effective, the more specific the knowledge is.

Expressed in such general terms, such a law seems quite meaningless. One must consider specific examples, in order to be able to judge its value better.

The therapeutic action may vary very considerably. In France there are some 9,000 drugs, without counting surgical intervention. This means that if taken at random, a prescription will have one chance in 9,000 of being effective. The difference between this 1/9,000 chance and the cure effected through the doctor's diagnosis emphasizes the importance of precise knowledge.

Relationships of the (r) type are only modified slightly or at least gradually - because they represent basic concepts, "generally recognised ideas", frameworks for nosological classification. These ideas, which may only be contested by other ideas, have a reliable reference value. They are the basis of mutual understanding.

The (t)-type relationships, on the other hand, are always being questioned owing to technical progress. In Medicine, for example, they are overthrown by the appearance of a new anti-biotic.

It is the (r)-type relationships which determine the degree of complexity of a science. When the number of the values 0 and 1 corresponding to each relationship increases, the discipline becomes more complicated: after a certain point, it divides, and this is what has happened in Medicine.

It is the (r)-type relationships which indirectly underlie the notion of a threshold - from a diagnosis point of view, as well, because one must not lose sight. of the fact that the threshold varies with V, the total number of ailments.

Certain objections must be considered. The principle of a fixed number of diagnostic hypotheses surprises one because we cannot readily conceive the

limits to our intellectual capital - which are hazy, even more so than those of books on pathology; and it is conceivable that putting pathology into the material form of (r)-relationships, then, for example, punched cards, will at first seem an arbitrary limitation.

Now the existence of a finite number of symptoms - however large the number may be - is the medical expression of determinism, a determinism, which is absolute, both for living bodies and for inorganic matter (cf. BERNARD).

The basic postulate of science is that "in Nature there are no contingencies, no capricious occurrences, no miracles, no free-will" (GOBLOT).

This postulate is the profession of faith of all science, and if it sometimes seems to us to fall down in the face of unexpected facts, it invites us to admit that our knowledge is still imperfect.

Determinism is not obvious in Medicine, because it expresses itself in a complex way, involving above all a very large number of factors; consequently we do not readily attribute to Medicine the same logical forms of knowledge as we do to the other sciences. In Medicine, Σ (*N*), the quantity of knowledge is exceptionally large, as is *V*, the number of ailments.

In sciences other than Medicine, the value chosen for Σ (M) is lower; but in Medicine this quantity is forced on us by the very complexity of the object of our study: Man. In the patient we have a complex whole, the different elements of which need to be specified separately, but which must be regarded as indivisible, as far as interpretation of it is concerned.

The interest of this study, of the ternary notation (0, 1, ?), lies both in the fact that the symbols describe the mental steps taken in the diagnosis, in the fact that they specify certain notions relating to the necessary and sufficient conditions for diagnosis, in the fact that they show the structural complexity of Medicine, but above all, in the fact that they make it possible to use machines.

The machines give us their power and above all, their reliability, their reliability in memorizing data which - as we find every day - is sadly lacking in the human mind.

Consequently, we can be certain that we cannot foresee the developments which this mechanization will bring to the problems very frequently encountered in diagnosis.

In conclusion, we may make the following assertions (and I think that these are the essential points of the present study):

(1) In an action as complex 'a priori' as diagnosis, embodying and utilizing all the facts of medical knowledge, and apparently an art in itself, it is nevertheless possible to describe a logical process.
(2) The principle of this logical process is amazingly simple, because it comprises a series of comparisons between what the doctor knows about ailments and what he knows about his patient. By successive eliminations, following comparisons which reveal differences, the diagnosis is made

when the case of the patient is found to be identical with that of the ailment M; we then say that the patient is suffering from ailment M. (3) The simplicity of the process enables it to be mechanized without difficulty.

(4) However this simplicity must not be allowed to hide the difficulties already stressed by CARREL: "The very volume of the facts which we know about Man is itself an obstacle to their use."

(5) Mechanization can solve the difficulties arising from the inadequacy of our memory, and is the sole means of utilizing the whole body of know-ledge.

(6) Diagnosis is a very general process, and strangely enough, it very frequently takes place in our sub-conscious, which explains why it is often uncontrolled and therefore a source of possible error.

2

DISCUSSION ON THE PAPER BY DR. F. PAYCHA

DR. F. A. NASH: I enjoyed reading Dr. Paycha's paper. I agree with many of the points he makes in his clear exposition of his views on the nature of the diagnostic process.

Whatever is asserted, especially in print, tends to be taken as fact unless it is questioned. I notice it is claimed (in the forenote to Dr. Paycha's paper) that he "made the first medical memory in 1953 with the help of Bull...". I should be foolish, perhaps, to try to establish with Dr. Paycha as to which of us has the greater right to unpopularity with our colleagues for inventing the first medical memory. However, 'it must be recorded that, in 1953, I constructed an apparatus to assist the logical faculties in differential diagnosis called "The Grouped Symbol Associator" (G.S.A.), and the patent applications were lodged officially with the Patent Office in London on 14th October. 1953 (*ref. 1*). It is fully described in The Lancet (*ref. 2*) and the Mark III Model is commercially available.

Perhaps we can avoid any argument by distinguishing apparatus that remembers by serial operations from apparatus like the G.S.A. that not only "remembers" but associates what it remembers, and that instantaneously.

The G.S.A. makes visible not only the end results of differential diagnostic classificatory thinking, it displays the skeleton of the *uhole* process as a *simultaneous* panorama of spectral patterns that coincide with varying degrees of completeness. It makes a map or pattern of the problem composed for each diagnostic occasion, and acts as a physical jig to guide the thought processes. *Figure 1* is a general view of the G.S.A.

I agree with Dr. Paycha that the diagnosis will always remain the decision of the doctor: but the machines can help with their infallible memories. I do not agree that the statistical approach is useless in differential diagnosis. It can help to reduce errors resulting from overfrequent diagnosis of rarities if one knows the frequency of occurrence of different diseases. Again if, as White and Geschickter state, 98% of death and disability in U.S.A. is caused by only 200 of the total of

REFERENCES

1. British Patent No. 28388/33.

2. NASH, F. A., The Grouped Symbol Associator. The Lancet, 1954, April 24, 874.

Figure 1.

2,000 diseases, obviously the doctor who knows which these are will, in the long run, make a better over all performance, other things being equal, than the one who does not.

In Cecil's Medicine, a standard American text book of medicine, there are described something in the order of 800 diseases.

DR. GREY WALTER: I should like first to congratulate Dr. Paycha on his presentation of a bold attack on a very controversial position. There are some general aspects of this work that I should like to bring into the discussion, as a physiologist, and not as a medical man.

It seems to me that we scientific workers in the medical field have rather neglected the way in which physicians go about their business; they are one of the few classes of people who are forced to appreciate complex patterns in human beings and build up from them notions of syndromes. This is rather a peculiar intellectual exercise and is very heavily weighted in the case of medicine with success or failure, since it deals directly with human lives. As scientists in the laboratory, we are reluctant to think in this way because the traditional statistical methods on which we rely so much do not help us to recognise complex individual patterns; they tend to efface individual differences rather than to emphasise them. But there are now available statistical methods which would help us to recognise syndromes in the more general sense, including those configurations of signs in normal people such as we generally call personal character or type.

These methods, whether clinical or statistical, are based, presumably, on the recognition of diagnostic signs, and I should like to ask a general

question of those skilled in this art whether the use of the adjective "diagnostic" is the same in medicine as it is, for example, in zoology, where I seem to remember that a diagnostic sign is found always and only in association with a certain genus or species. In medicine it is rather rare. I think, for a diagnostic sign to be so explicitly defined, but the application of the sort of methods Dr. Paycha has suggested might help us to recognise truly diagnostic signs. I think I am right in saying that Dr. Paycha's method was first applied to ophthalmology; that is, a group of organ diseases rather than organism diseases. Here the situation is considerably simpler than, for example, in neurology, where the problems are essentially of organism disease. Disturbance of the nervous system tends to affect many organs and hence the behaviour of the whole organism. This may raise rather special problems. I am not sure of this - it is a question I want to put to the meeting - as to whether methods which I suppose one can call cybernetic may be specifically adapted to the recognition of syndromes in organism behaviour. Consideration of an organism as opposed to an organ introduces special difficulties - not only difficulties of the same type but of a higher order than those obviously encountered in the application of this method to the diagnosis of organ disease. In neurology, one has an overlap and interaction of functions so that a similar type of functional disorder may result from a large number of central disturbances, because of the compensatory action of the nervous system. This seems to me where the word cybernetics may be justified, because one is bound to consider interaction between several systems of control. I would query whether the term cybernetic in Dr. Paycha's title is justified in this particular application. It might be justified in studying a system such as the nervous system, in which the interrelations of the components are as rich as possible, both between nominal inputs and nominal outputs and within the system itself. There the truly cybernetic methods might be essential in order to identify diagnostic signs and syndromes even including normal variations.

PROF. J. Z. YOUNG, CHAIRMAN: Are you suggesting from the general point of view that there are different systems of pattern recognition necessary, or different forms of classification? For example, you mentioned zoology or diagnosis. I was not clear what your general point was.

DR. GREY WALTER: There are two words that seem to be used rather freely statistical and diagnostic. Dr. Paycha said that, for example, statistics interested the Medical Officer of Health but not the doctor. This statement can be true or false, according to how you define statistics; obviously statistics interest the doctor in the sense that his probabilistic judgment of a diagnosis is a statistical statement. There are tables of vital statistics drawn up by registrars that may not interest him vitally, but

they obviously influence his behaviour, for example, if he knows an epidemic is going on. It seems to me that "statistical" is used rather loosely in this sense and "diagnostic" is also used loosely. I know many of my own deeply respected medical colleagues will speak of a diagnosis or diagnostic sign in a sense that seems to me a good deal looser than you or I might approve in relation to the identification of a species or genus; should the usage be tightened up in application to medical diagnosis, or should we allow them freedom and not bother to reprove them if they use it loosely? It seems to be a useful word to have - it has a clear etymology and a strict usage in the basic sciences. It seems a pity that it should be used more loosely in medicine, because it confuses scientific workers who are trying to relate objective measurements of some kind to diagnostic signs and symptoms.

MR. G. B. NEWMAN: I consider that statistical considerations are an essential part of the diagnostic process, for much will depend on the relative detail of the diagnosis. Certain cancers are susceptible to their hormonal environment and before treating some patients it is necessary to know if the patient's cancer is of the "hormone dependent" type. Whilst it may be possible to say from observed signs that a patient obviously has Cancer of the Breast, it will not be possible to say with certainty that her cancer is "hormone dependent". Whether the patient is given treatment directed at the hormone dependent type of tumor must, therefore, be based on the a priori probabilities of "hormone dependence" in the type of patient concerned.

As a practical point, the patients case histories are far from being as complete as Dr. Paycha states and this, while presenting the great problem in the investigation of this subject, will also mean the more frequent use of probability considerations.

DR. A. REMOND: I have admired Dr. Paycha's work in France for several years and have often wondered how to apply it to my own practice. I understood then that it was a method for the future. I was not able, in the way I had been educated, to make use of it. In the neurological diagnosis at least, we are dealing with symptoms which are never entirely present or absent and which cannot be represented by either zero or one - they are always in between these extremes and we are seldom sure that they are present or not. They can be there once and when we look for them again they have disappeared or they are only half there. Take for instance, the Babinski symptom.

REFERENCE (by Mr. Newman)

BROADMAN, K., ERDMAN, A. J., LORGE, I., WOLFF, H. G., Cornell Medical Index, Health Questionnaire, *Journal American Medical Association* 1949, 140(6), 530 and 1951, 145 (3), 152.

Every morning, in a neurological department each patient is examined. At first when the interne looks for evidence of a pyramidal syndrome he may find it, it is "obviously" there; then, when later in the morning the "patron" comes to review the new cases, the interne says "This patient has a paralysis of such a kind, he has a babinski on the left". The "patron" looks for it ... it is'nt there any more. It is not the place here to discuss why it is so. In many instances we should rather deal with probability, instead of pure, clear cut observation. To come back to Dr. Paycha's work and before trying to make a medical diagnosis, a process often very difficult, we should dissect what we now call symptoms in more minute elements taken as bits which surely are there or not. But no clear definitions of these elements have been given as yet in medical books. Symptoms are too often complicated entities. The difficult question for me would be to redescribe every disease in terms of suitable code words being part of the language of a diagnostic machine.

DR. R. EFRON: As I understand the speaker, he is making a distinction between "prognosis", which he feels is a statistical element, and "diagnosis", which he feels is a more specific and individual act of decision. Speaking as a clinician, as a neurologist, I feel that this distinction is rather artificial. I think we make a probabilistic diagnosis because we are constantly checking back against the unfolding course of the disease. There is a distinction, therefore, between the speaker's concept of "diagnosis" that is set in time - at a particular instant, and the manner in which diagnoses are usually made. They are, in practice, more fluid things, taking place over a period of time and therefore there is always a feedback into the system of new information derived from observation of the patient's course.

There is one other point about which I am confused, and this may be because the teaching of medicine in Anglo-Saxon or English speaking countries is different from the way it is taught in France. We distinguish "signs" from "symptoms". A sign is something which is an observed phenomenon - observed by someone other than the patient. A symptom is something subjective - something which is complained of by the patient. In relation to Dr. Grey Walter's point of diagnostic signs, may I recall that one of the games which medical students often play is to think of socalled "pathognomonic signs". This is a special category of sign, only one of which permits the absolute diagnosis of a specific disease. An example: red teeth permit you to make a specific diagnosis of a certain metabolic disease. These are such striking signs that a medical student remembers them easily. Certainly, if there were more pathognomonic signs the probability of making a machine for medical diagnosis would be much higher. DR. D. M. MACKAY: The argument that 10 signs are sufficient if you have z^{10} possibilities from which to select is valid only if the signs are logically and statistically independent. Is it not essential to do some factorial analysis on the two hundred signs mentioned to find out what groups of signs are logically independent, before one can argue that ten or even many more could be sufficient?

DR. F. PAYCHA (in reply): I thank Dr. Nash for his remarks. But the part . played by statistics in diagnosis must be bounded.

For a doctor, the use of statistics in diagnosis is, in fact, a solution of facility. If about 200 diseases can cause 90 per cent of mortality, I find it is quite immoral to neglect the remaining 10 per cent.

It should be very easy for a practitioner to limit his diagnosis to 200 diseases. But, when a patient enters his consultation room, he may be afflicted with any disease, even one of this 10 per cent. And the doctor does not know if this malady belongs or does not belong to this 200 diseases which cause 90 per cent of death.

If the doctor assumes that there is more probability for a certain disease to have occurred, then he is making an a priori hypothesis on his patient; and so, he eliminates them without any reasons.

Statistics are of interest to the Minister of Health, but they do not interest the practitioner. Statistics only have a part to play in the prognostic and therapeutic side. Statistics, of course, apply to a group of individuals, but the patient is a unique, a sole case; and the question is then to know to which group of the statistics this patient belongs.

(To MR. G. B. NEWMAN): The first consideration is very interesting in two points:

1. Because it contains in itself its answer: Mr. G. B. Newman says that statistical considerations are essential part of the diagnosis; and immediately, he takes an example, and he speaks of treatment. So, he demonstrates the part of statistics in therapeutics, but not in diagnosis.

2. Because such error is frequent; often one blends diagnosis and therapeutics.

This example is therefore instructive: if now the treatment of certain cancers is based on probabilities of hormonal dependence, it is because we do not know, before testing the action of the hormones, how to recognize hormone-dependent type of cancer. When we know a sign or a symptom to distinguish this type from the other, we shall be able to give more chance of life to the patients.

The second remark is very true: seldom, the patients' case histories are complete. But, in this eventuality, the interest of the Medical Memory is

that it gives more than one answer, and the comparison between these answers shows the missing signs and symptoms.

(TO DR. EFRON): It is true that, for one patient, during a malady, the doctor may give several diagnoses. As Dr. Efron says, in practice, there are fluid things, taking place over a period of time, and therefore there is always a feedback into the system of new informations derived from observation of the patient's course. But, every diagnosis is done by a series of comparisons.

As regards the difference between signs and symptoms, French semiology is not very clear on this point, and that, of course, I am sorry about.

It is true that every medical student knows the sets of pathognomonic signs, special category of signs, only one of which permits the absolute diagnosis of a specific disease. But the practitioner may think that every disease may exist without these pathognomonic signs.

(To DR. MACKAY): There are two points of view in this contribution:

1. Logically 10 signs are sufficient, for there are about 1,000 diseases of the cornea, and $2^{10} > 1,000$.

2. Statistically signs appear not independent: certain groups of signs and symptoms appear together more frequently than alone or than other. In these conditions, it should be possible to study statistically, and by experiments, and also by factorial analysis every combination of the different signs. But, we do not forget there are about 200 signs: so there are 2^{200} combinations and this study should be tedious enough. So, it is easier to try, with punched cards for instance how many

sortings are necessary to obtain one card only: the number of sortings is about 10 in this case.