TOWARD A SYSTEMIC AND INFORMATIONAL THEORY OF MEDICAL DIAGNOSTIC PROCESS
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Resumen

La Teoría General de Sistemas de Bertalanffy creó la posibilidad de lograr la comprensión regular de una realidad y de los cambios que en ella ocurren, suponiendo que alguna parte de tal realidad pueda ser aislada como un sistema. Por su parte, Prigogine estableció que es posible asumir que sistemas complejos pueden mantener incrementos evolucionarios de orden y energía opuestos a la entropía creciente en el sistema. A su vez, Rimoldi definió el proceso diagnóstico como de tipo informacional para reducir incertidumbre.

Desde estos puntos de partida, se postula en el presente trabajo que un correcto proceso diagnóstico posee una equivalencia significativa entre la situación clínica de un paciente y la comprensión que el médico logra acerca de ella. También se postula que ambos comparten objetivos: reducir la incertidumbre - entropía en la condición del paciente.

Sobre estas bases se propone una clasificación general acerca de los pasos del proceso diagnóstico. Además, como ejemplo práctico, se realiza una aplicación de esa clasificación para cuatro de los procedimientos más generales utilizables para evaluar proceso diagnóstico.

Palabras clave: Teoría de la información - teoría sistémica - teoría de diagnóstico médico.

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Abstract

Bertalanffy’s System Theory created the possibility of regular comprehension of a reality and changes occurring in it, supposed some part of it is isolated like a system. Also Prigogine stated it is possible to assume that complex systems can maintain evolutionary increments of order and energy against the rising entropy. Further, Rimoldi defined medical diagnosis as an informational process to reduce uncertainty. Based on both, here is postulated diagnostic process as a significant equivalence among the patient’s clinical situation and the understanding that doctor has about it, also both share objectives: to reduce the uncertainty-entropy about the patient’s condition. On these bases, a classification is proposed about general steps in diagnostic process. Besides, as a practical example, an application is made for four of the more general procedures existing to assess diagnostic process.

Key words: Information theory - systemic theory - medical diagnostic theory.

Introduction

Since its enunciation by Bertalanffy on 1945 (Rapoport, 1978) the General Theory of Systems has deserved considerable attention by scientists. The model proposed provided both a regular comprehension of reality (nowadays it is called a systemic comprehension) and the possibility of understanding changes that occur in that reality, if one can isolate some part of it as a system. A system can be defined when are provided the following conditions in that part of reality:

a.- the existence of some kind of limits, plus
b.- a persistent, regular and active organization inside those limits, and
c.- a persistent activity for interchanging matter (or information) and energy with the environment that allows a sort of balance for matter (or information), energy, order and complexity.
The balance among order and functional and structural evolution, permit to preserve the system similar to itself as an entity, as opposed to the natural order loss inside the system, that is to say, as opposed to the rise of entropy into the system.

Obviously, there exist far more complex expressions to define a system. And there are several shorter statements to define it. By the case, it can be mentioned that definition for a system (an informational system) that state it is a mere group of related objects, some with others, in certain way. In this exposition it will be maintained the given initial definitions, because they points three proprieties almost present in biological systems, usually denominated respectively as:

a.- limits,
b.- homeostatic functions, and
c.- metabolic functions.

On the other hand it will be kept the very short definition, because indicates the more general propriety of an informational system, and (so it will be here considered) a basic characteristic of the process of gathering information to perform a medical diagnostic. Since Prigogine (1978, 1998), and Prigogine and Stengers (1994) it is possible to assume that complex biological systems can maintain an evolutionary increment of order, and energy, performing activities that include the interchange with the environment and the preservation of the stability into the own internal medium. It seems to exist a narrow parallelism between these previous statements and the clinical situation of a patient. The body of a patient can be easily understood as a biological system wit its own limits, its own interchange of matter and energy with the natural world, and a persistent and regular internal content, different of the environment.

The internal stability of this system is maintained thanks to the activity of an extensive kind of functions performed by the internal organs. That stability (and the functions and organs engaged in) are named homeostasis. That is the resultant of various biochemical and biophysical transformations called metabolic functions. When metabolic functions are regular and correctly performed, the whole system, and its more probable evolution, are predictable for a diagnostician. The whole system is ruled by an order well known by the physician. These elements operating under the mentioned conditions configure what is called the healthy state and constitute a referent condition, or, perhaps, a cognitive general map, a physician uses to detect changes out of the biological order, caused by any illness.
When the patient’s system is just not able to preserve his own order, its functionality becomes progressively unpredictable and hazardous, configuring some sort of clinical pathological situation. Between the health state, and the illness state, there exists a sometimes long step of compensatory reactions. These compensatory reactions are accomplished by homeostatic metabolic functions trying to bring back the patient biological system to the previous healthy state. From a theoretical point of view, this correspond to the above mentioned Prigogine’s (1978) assertion when a system is performing interchange with the environment and so preserving of the stability into the own internal medium. Sometimes, those compensatory reactions constitute by themselves all the illness, like happen in various types of allergies and autoimmune abnormalities.

The diagnostic process is a process to confirm which of the various areas of the patient’s biological system works correctly. Or, in the other hand, to detect which of that areas are performing out of order, either by primary illness or by a compensatory reaction. The diagnostician manages an informational system built up with his theoretical, and factual knowledge about human biological systems. When diagnosing, a doctor is operating his own informational system to recognize at what degree the patient’s system is able to produce the known order or it is failing to maintain it. And at the same time he is applying his informational system to orient the gathering of valuable data about the patient clinical state.

The physician is also identifying which of the various areas of the patient are generating disorder, and which of the remaining areas are affected by it. He is estimating too, the point in what the system could not be returned to the normal level of functioning. One of the relevant aspects linked with the diagnostician factual knowledge is the correspondence between his own knowledge and the facts he is finding out from the patient’s clinical situation. And it requires of building a clear hierarchy of that kind of theoretical knowledge that permit him to get an actual comprehension of the physiological, and pathological conditions of the patient.

So a physician can develop a neat interpretation of the significance, it is to say the importance, of the founded facts and, so far, to build up his factual knowledge about the patient’s clinical situation. This process of assigning differential importance to the data, will be here denominated as organization of contents of the diagnostic process. One of the highest goals of this classification is to get a reliable, and -if it is possible- quick recognition of what abnormal process can introduce more disorders, or unpredictability and gaining of entropy, in the patient’s system. That is to say, to recognize
what could cause an abrupt declination of the level of survival potential of a patient.

Information theory gives a frame, that here will be considered as appropriated, but not sufficient, to understand and, to a certain degree, to measure the process of gathering information about the patient. Medical diagnostic process may be understood, formally pointed by Rimoldi (1988) and clinically in a Bayesian approach by Elstein (1999), like a sequence of decisions that diagnostician takes for gathering data in order to reduce uncertainty, meaning the lack of knowing about the actual clinical situation of a patient. To overcome this condition an adequate diagnostic process is required.

Here it is considered that an appropriated diagnostic process, and its correct ending, constitute a significant symbolic equivalence between the patient’s real clinical situation and the understanding that a doctor has about it. At this point, diagnostic process is defined as a cognitive process that generate various cognitive products. The decision of consider diagnostic process in terms of his cognitive products and not in terms of mental or brain functions is, surely, arbitrary, but it seems wide feasible and do not make assumptions on that kind of activities that frequently present some difficult to be measured.

From this initial considerations it is discussed here the possibility of enunciating a systemic and informational theoretical approach to medical diagnostic process, assuming that: diagnostic process can be described as a cyclical informational process that includes four clearly different steps, that have different cognitive products, and that are finally integrated in the fourth last level:

a.- First Step: To collect valuables data selecting them form all (raw) data available in the clinical case. This step requires a diagnostician strong sense of, and skill for, differentiation between valuable and non valuable data. It is the level of data evaluation. Moreover, here the physician recognize the probable limits of the entropy dissemination in the patient’s system. The understanding of those probable limits is the relevant cognitive product of this diagnostic step.

b.- Second Step: To build up a coherent comprehension of the clinical meaning (it is to say, clinical importance) of gathered valuable data. In this step a diagnostician has to integrate data collected in the previous step, and recognize, deduce, define or suppose, which areas are affected by disorder and, or engaged in, compensatory reaction processes. Now, valuable data gathered in first step have clinical meaning and it
seems preferable to denominate them *information*, to denote their new status. When performing this way a physician can understand the clinical condition of a patient and can also reduce his own uncertainty about the patient biological system, in other words, he can comprehend the levels of entropy the patient system is gaining and reaches the second level. The cognitive product of this second step is recognizing the basic, or the more troubling, syndrome or illness in the patient system.

c.- Third Step: To *build up a coherent comprehension* of what parts of the clinical facts respond to the basic illness and what parts become from compensatory reactions acting as pathological factors modifying, or not, the original clinical case. The valuable cognitive product of this third step is the differentiation among basic illness and compensatory reactions, that can better or no the clinical condition of the patient. When there is an appropriate correspondence between the comprehension made by a physician, and the actual clinical situation of a patient, one can say the physician has built, or has depicted, a valid *cognitive map* about that clinical condition. The diagnostician has moved from the raw data level to the *making of clinical information level*, it is to say that now the physician knows what are stable points of order and of lack of order in the patient system, which are the constants of illness and health in it.

d.- Fourth Step: When things work in this way, a physician is able to integrate the previous step and integrate the clinical information to *built up* a prognosis on which he can base treatment indications, or can develop a strategy for a treatment, to restore, or at least to better, the patient health. Of course, each step of a treatment may require, and usually does, a new cycle for gathering new data to perform new evaluations of data. This is a knowledge level about the overall clinical condition of a patient and it is reached when a physician knows the clinical meaning of data and can predict further evolution for the clinical case. This level is defined to differentiate the mere cognitive map depicted in the second level, from its projection into future, that is a basic characteristic of this *prognostic level*. The projection of the existing clinical condition or the patient into the future is the valuable cognitive product of this fourth step.

It seems convenient to think of diagnostic process as the process of making a scientific knowledge about the clinical condition of a patient,
somewhat similar to the assertion made by Barrows and Tamblyn (1980) when described the process of clinical reasoning. It seems also convenient to think of diagnostic process as an applied experimental process that begins exploring (first step), goes on describing (second step), after what correlates clinically and finally reaches the biological constants in the patient system that will permit the physician to make and adequate prognosis. The similarity with the so called non experimental study types are narrow.

Example of an application of the four level theoretical approach

There exists several kind of instrument, perhaps it would be better to describe them as procedures, for evaluating, teaching or training in medical problem solving. Giving some comparative examples applying the previous theoretical approach, we will briefly mention: the Test of Diagnostic Skills, the Initial Problem Based Learning, the Patient Management Problem, and the System of Staging Model.

1.- The Test of Diagnostic Skills (TDS) was developed by Rimoldi in USA, early in 1954 (Rimoldi, 1955). This test supplied us the basic experimental support and the desirable acquaintance with the empiric scene, needed to get records and obtain a general impression about the interaction between a diagnostician and the data contained in a diagnostic problem, during the process of getting it solved. The TDS was built following a different model of that classic in Psychometrics, that is: given a stimulus, it is observed a response, this is the $S \rightarrow R$ model.

In the TDS a diagnostician receives a set of enough written medical data extracted from a real clinical case, and the observer only records the sequence of decisions the diagnostician (that has free access to the whole set of clinical data) make to collect data for performing diagnosis. In this way, TDS satisfy the first level (data gathering) assessing the diagnostic sequence, to make clear if the diagnostician was able to differentiate between valuable and non valuable data, collecting exclusively the former.

The diagnostic sequence the diagnostician developed contains also the second level (making information from valuable clinical data). This second level is exposed comparing the obtained sequence against a criterion sequence obtained from those sequences developed by a
group of expert diagnosticians when solved individually the same
diagnostic problem. The mathematical procedure to quantify each
sequence applies informational theory of Shannon, and Weaver (1949),
modified by Attneave (1959), and Rimoldi (1988), and measures the
sequences in bits of information. This procedure permits to perform
various comparisons between subjects and groups of subjects, meas-
ured against the criterion (Rimoldi, & Raimondo, 1998).

The third and fourth levels do not receive more attention at TDS
than asking diagnostician to write the final diagnostic of the case. Of
course, the observer always can ask compensatory reactions, and
prognosis, and can asses the answer diagnostician gives.

The Rimoldi’s procedure (TDS) is really not a test but a technique
for evaluation and training, is not a simulation but an informational
clinical setting with enough medical information about a medical case
to perform a diagnostic process and to record the sequence of decisions
a diagnostician makes when developing a diagnostic process. Primarily can be understood as a cognitive training on applied diag-
nostic theory.

2.- The Problem Based Learning Set (PBL) (Barrows, & Tamblyn,
1977, 1980) is another clinical information data set, as it was original-
ly developed by Howard Barrows, at Mc Master University. Initially it
was designed to teach and train medical students in neurology diagnos-
tic process. Each problem is a complete set of medical data about a
clinical case or a clinical situation, that is supposed the student uses (if
necessary, repeatedly) to diagnose the case and to get a better compre-
hension of the valuable clinical data. All the process requires some
teacher’s supervision and does not requires necessarily to register the
data gathering.

As PBL almost can include the complete information, it is possible to put in it typical clinical cases. Here the PBL will be considered
as a procedure that emphasizes on the first step: data gathering level.
In hands of experienced medical teachers, this PBL can permit to reach
easily the other three levels, that originally were not considered. The
best of PBL probably is this characteristic of letting to medical stu-
dents a non restricted access to clinical data, and have their own expe-
rience, out of any situation of recording decisions and diagnostic
process. Finally it must be consigned that PBL has progressively con-
ceived a wide, intense and persistent attention by medical educators,
and it has experimented various changes from the initial design here
considered. Those changes and transformations have converted PBL it in a tool for training along all the medical career. Furthermore, PBL has been, and actually is, one of greatest impulses and challenges to improve medical teaching.

3.- Patient Management Problem (PMP) (Mc Guire, Solomon, & Bashook, 1976) is a procedure developed by Christine Mc Guire, in USA, as a written simulation to built clinical problems to be solved by students. One can say that PMP clearly emphasizes on the second step (that corresponds to the making of clinical information level) as the data gathering level (first step) is strongly restricted, and the main sequences of decisions to make a correct problem resolution, or to perform an erroneous problem resolution, are predefined in each problem. It seems that a diagnostician solving a PMP simulation really decides about meaning of given clinical data and better solves when better understand them as clinical information. This kind of clinical decisions is here considered the core of evaluation that PMP uses. PMP has a historical value too: put a well practical problem solving technique in hands of medical teachers and demonstrate them that tool of problem solving may be used in all levels of medical education. Furthermore, PMP maintains its practical value, as it is an acceptable way to evaluate the comprehension a diagnostician have about a set of clinical information, and this is yet a valid educational objective.

4.- The fourth procedure to consider is the Staging System of Diseases (SSD) developed by Gonnella, Hornbrook, and Louis (1984), at Jefferson Medical College, in the 80’s. The procedure in SSD presented a brief summary about a clinical case and asked to the diagnostican to indicate management, treatment and prognosis. Dr. Gonnella was urged to train his students on obtaining an early diagnostic of each case for the welfare of patients and, secondarily, for the economic health of medical care institutions. A very interesting point of view.

Here will be considered that the SSD emphasizes strictly, and practically exclusively, on the fourth step (prognosis level). In SSD there is not nothing about of data gathering first level, almost there is not information level comprehension from clinical data. Practically always, all the clinical information is given to the diagnostican and it is expected he/she will make and adequate clinical prognosis and treatment indications for the case. The SSD is another information clinical setting that does not proportionate raw data, not demands linking of
decisions about data, but only clinical information to be projected as treatment and prognosis. That is, clearly explores mainly the fourth step, the knowledge level, trying to make evident the integrated knowledge the diagnostician has about the clinical information given, how it could affect in the next future to the patient and how diagnostician can better clinical situation given.

SSD explores the general comprehension a diagnostician can reach about the overall clinical condition of a patient (or of a clinical given situation) and its probable clinical evolution. It is to say that SSD asses the making of final diagnostic decisions for a clinical case or situation, and how the diagnostician can predict the future clinical evolution.

Conclusion

Here finish the applied comparison using the theoretical approach earlier mentioned. It should be clear, for all of us, that the given statements and assumptions about the four mentioned instruments (or procedures) are not a complete description of them, and that not a formal comparison among them was performed.

Those statements and assumption were given here, we repeat, only as a practical example of application of the mentioned approach, to show how the three theoretical levels woks when are used to asses the process of getting medical knowledge applied to clinical cases.

Otherwise, there is a general coincidence among the four instruments here depicted: all of them strongly depend on the clinical validity (and the educational value) of data putted into. Besides, there is another, rather surprising, coincidence among the four: with different words, and procedures all of them accept that understanding in a medical diagnostic process, occurs when for a diagnostician, the valuable data, the clinical information and his prognosis or projective knowledge about a clinical case, make coincidence with the actual patient’s clinical condition.

Finally this paper was written with the purpose of facilitating the construction and evaluation of processes to teach and to learn the medical matters, for that which, to define cognitive products seemed an acceptable way.
References


