Abstract

Diagnoses are perhaps the most complex and crucial decisions within the modern healthcare enterprise. Models for complex healthcare decisions must incorporate consideration for the usual multiplicity of important factors, interacting feedback loops among these factors, and the dynamic nature of the full diagnostic arena. A diagnoses modeling technique that has the requisite variety of relevant considerations is presented. The technique has the potential to overcome mandatory time criteria, while considering the competence and robustness of high importance diagnostic decisions. In this study, descriptive narratives dictated by examining physicians who were directly involved in the diagnosis and treatment of patients were examined in detail not only to extract key factors involved in medical decision making processes, but also to illustrate the wide ontological origin of key decision making factors. Important factors in the narratives were identified and mapped with a new System Dynamics methodology that incorporates a Zachman Framework for establishing the overall scope and context of the full medical decision making context within the modern medical enterprise. The two techniques produce a synergy that addresses the debilities of the techniques in isolation, allowing enhanced comprehension of diagnostic processes, and their improvement.

© 2011 Published by Elsevier B.V. Open access under CC BY-NC-ND license.

Keywords Medical decision making, diagnosis, system dynamics, Zachman framework

1. Introduction

Substantial documentation about experts making judgments unsupported by rational analysis exists in the field of medical decision making. Groopman and Montgomery have described ‘How Doctors Think,’ or the narratives and ideas that doctors personally employ during medical decision making. Redelmeier and Shafir (while noting that much medical decision making is seemingly simple and supported by a confirmatory environment of medical colleagues) noted that in decisions with multiple alternatives, physicians:

“do not always resolve medical decisions by analyzing benefits and harms in a reliable manner. Instead, people may resort to intuitive judgments that render them prone to cognitive biases. Psychological theory

Bharath Dantu. Tel.: 915-240-7571
E-mail address: bbdantu@miners.utep.edu

1877-0509 © 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
doi:10.1016/j.procs.2011.08.016
predicts that these cognitive biases will appear when people have difficulty deciding between conflicting alternatives, face situations of substantial uncertainty, or consider outcomes that have long-term consequences. …

“Thinking harder will not eliminate a cognitive bias any more than staring intently will make a visual illusion disappear. Instead, physicians need to recognize specific biases and consider possible corrective procedures” (p. 302).

Redelmeier and Shafir go on to describe how a technique such as considering each alternative in relation to the status quo is more effective than considering all alternatives at once and only in relation to themselves. More biases that result from the consideration of alternatives exist, and are presented below. We encourage pairwise comparisons, as in the Analytic Hierarchy Process (AHP) (although intransitivity can sometimes result). Also, alternatives should always be compared to the status quo.

Specific de-biasing techniques have been shown to be effective under specific circumstances. Principally, such techniques involve increasing the decision maker’s awareness of possible cognitive biases, and then mandating a procedure that has been shown to reduce the particular bias. However, in practice, few professionals remember the presence of biases, and almost none implement proven de-biasing processes. What is needed is a single abstract model of biasing, and the ability to apply the model generally.

2. Attribute Substitution

In this example, the target attribute, Happiness, is assessed by mapping the value of another attribute, Number of dates last month, onto the target attribute scale. Figure 1 illustrates the top-level, ill-defined attribute of Happiness, and the well-defined sub-level attribute of “Number of dates last month.”

![Figure 1: Happiness attribute substituted by “Number of dates last month”](image)

This process of attribute substitution “will control judgment when these three conditions are satisfied:

(1) The target attribute is relatively inaccessible [Happiness];
(2) A semantically and associatively related candidate attribute is highly accessible [Number of dates last month]; and
(3) The substitution of the heuristic attribute in the judgment and the immediacy of the response is not rejected by the critical operations of System 2” (p. 54).

System 2 is defined by Kahneman as being composed of those mental operations that are “slower, serial, effortful, more likely to be consciously monitored and deliberately controlled” (p. 698). In general, System 2 consists of explicit cognitive processes, as opposed to mental operations that are automatic, effortless, associative and implicit, which are performed by what Kahneman calls System 1. The division between System 1 and System 2 is typical across mental operations research. The extension of the mental process of attribute substitution to many other heuristics and decisions is quite straightforward.

Figure 2 illustrates attribute substitution with a hierarchical tree of attributes. When erroneous attribute substitution holds sway, and a person is asked a question about a top-level attribute, they are likely to substitute the top-level attribute with a lower-level attribute that is less inclusive and more definitely and specifically defined.
Concomitant with the move to a lower-level attribute is the construction of a more easily answered question about the lower-level attribute.

![Figure 2: Attribute substitution illustrated with hierarchical decomposition](image)

Just as ‘the map is not the territory,’ a heuristic attribute is not the target attribute. Recognizing the ‘super-heuristic’ of attribute substitution quickly leads one to question what other mental constructs must be differentiated from the reality they represent. Decision making models, for example, are only abstract representations of real systems. It is interesting to note that the process of attribute substitution involves two steps that reduce complexity:

1. Representation of the real system by the formation of an abstract model with a more definite and possibly reduced set of attributes, and,
2. Attribute substitution, or choosing one of the sub-attributes to represent the abstract model under examination.

Step (1) involves the structuring of the decision space, and is reminiscent of Newton’s replacement of a naturalistically ambiguous world of causes and effects with a world of distinct variables and mathematical relations among them.

3. Zachman Framework

The Zachman Framework was originally an enterprise modeling tool. It is essentially a 6x6 matrix which defines 6 levels relevant to any enterprise, as well as 6 aspects. The structuring provided by the Zachman Framework provides that attention is placed on all the relevant scales, as well as on all relevant aspects, of any situation under consideration. Any Zachman Framework should be calibrated so that all relevant scales occur within its boundaries. A Zachman Framework with an added level for the full medical enterprise is shown in Figure 3.

![Figure 3: Zachman Framework for the medical enterprise](image)
The circles in this particular depiction of the show the enterprise areas that were involved in the diagnosis of Anne Dodge, a patient whose particularly difficult story of finding health is narrated by Groopman (pp. 1-9). The number and variety of enterprise areas involved in one diagnosis is surprising, and indicates that medical professionals need an expanded awareness of the entire medical enterprise in order to serve patients.

4. Diagnostic Interviewing

Doctors interface with patients through three principal means, interviews, observation and testing. While testing based on scientific principles is highly useful, first hand information based on the patient’s perspective is often available on through interviews with the patient, and, for this reason, medical interviewing has been described and developed by Coulahan and Block, Enelow, Forde and Brummel-Smith, Newell, Bernstein and Bernstein, and Froelich and Bishop. Interviewing and observation is of course balance with quantitative evidence-based medical practice. Complementary balance in medical decision making is described by Seedhouse in “Values-Based Decision-Making for the Caring Professions.”

An abridged and edited example based on a diagnostic interview from Newell (pp. 89-98) follows:

Doctor: Please tell me in general terms the issues that brought you here today.
Patient: Well, it’s about my inhaler. They say I use it far too much.
Doctor: What do you think yourself?
Patient: I know the amount that I’m using it has increased just of late.
Doctor: It sounds like controlling its use is a problem.
Patient: Definitely. Every time I go anywhere, I have to have it with me just in case.
Doctor: What symptoms do you get before attacks?
Patient: Tightness in my chest, wheezing, and my heart starts thumping …
Doctor: And that makes you say certain things to yourself?
Patient: Yes, it’s very frightening.
Doctor: And then what do you do?
Patient: I take maybe three puffs, and wait and see if the breathlessness will pass.
Doctor: When does this happen?
Patient: Particularly when I am driving and the kids are in the car.
Doctor: You say you have had asthma for 20 years …
Patient: Yes.
Doctor: Our approach will be for you to relax.
Patient: Ok …
Doctor: … and when the attacks come on, delay reaching for the inhaler for just a few seconds, to give you a better idea if you can cope with the anxiety that accompanies an attack.
Patient: Ok.
Doctor: This goes along with helping you reach some of the goals you are setting for yourself in life.
Patient: Yes, I want to get to where I enjoy life.
Doctor: Gradually, you will lessen the frequency of puffs, and the need for prescriptions.
Patient: Sounds like a good plan.

5. System Dynamics

Systems Dynamics (SD) is a methodology used to define the influences and relations among many factors that contribute to directed effects and feedback loops. System Dynamics was developed by Forrester, and has been adopted widely as a visualization of complex systems. SD drawings can be used to visualize the many attributes pertinent to a medical diagnosis, as obtained in a medical interview. Additionally, the directed arcs of SD show attributes drew the attention of the interviewing doctor, and which causal attributes were deemed to contribute, either positively or negatively, to affect attributes.

The diagnostic interview quoted above can be shown with an SD diagram. As a first option, the SD diagram could show the temporal order of attributes as they arose in the interview, but this would produce a rather tangled diagram. As a second option, the SD diagram could try to sort out the causality among the attributes, as depicted in Figure 4.
6. System Dynamics within the Zachman Framework

System Dynamic elements, within pure SD diagrams, have no guarantee of being arranged in an intuitive fashion that shows the classification of attributes according to their levels and aspects. The use of a Zachman Framework with an overlaying SD diagram accomplishes the purpose of clarifying the inherent differentiations and relative scales of all factors used within an SD diagram. Note how the SD diagram for the medical interview is clarified with the backdrop of a Zachman Framework in Figure 5.

Conclusion

Medical decision making quality is critical throughout the modern medical enterprise. Despite the availability of analytic techniques, most decision making is done sole with the human mind. Mental decision making is subject to many mistakes of a great variety, which can be abstractly described as the mistake of attribute substitution. A diagnostic process modeled with system dynamics shows that humans are susceptible to a collapse of attention in which they focus on only a few attributes and the relations among them. In fact, excessive focus on the degree of relation among the few attributes can lead to amnesia as to the full spectrum of relevant attributes. The principal amelioration for attribute substitution is a widening of attention to a degree where awareness of the entire enterprise is maintained. The Zachman Framework can form the backdrop for a decision making process, ensuring that no mistaken collapse of attention occurs.
References