Ergonomic Approach for the Conception of a Theatre Medical Regulation System

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Abstract. This paper is a reflection for the conception of an overseas operations' computerised medical regulation system. After a short description of problem-solving and human error cognitive mechanisms, these concepts are used for the conception of a human centred theatre's medical regulation system.

Keywords: Medical regulation, problem-solving, human error, human reliability.

1 Introduction

Medical regulation consists in matching the needs of the patient or casualty with the most appropriate medical capabilities, whether in terms of equipment, personnel or technical support centre.

The service de santé des armées (defence medical services) is currently developing a medical regulation concept for the management of troops injured in overseas operations. Such a concept cannot reuse existing solutions designed to handle a limited number of casualties (as "SAMU" type regulation software) or to a medical organisation that strongly differs from that deployed in overseas operations ("plan rouge" management software for example). Indeed, on an operational theatre, institutional armed forces, likely to conduct coercive actions, are deployed against institutional or non-institutional, controllable or non-controllable forces. Besides, this deployment occurs in a complex international diplomatic framework and under a media pressure that takes place in real time, since populations are reactive to it. Available means are at once limited and can only be adjusted via urgent political decisions under media pressure. Without these extraordinary decisions, available means are systematically degraded in an uncontrolled way by enemy forces. Stress and sleepiness rapidly add their effect to jeopardize a medical regulation that has to simultaneously consider a disaster situation and an emergency situation. Although it does have similarities with emergency medical regulations (SAMU) and "plan rouge" management software, medical regulation on an operational theatre is very unique and has to be considered as such as a complement to the previous two.

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2 Ergonomic Issue

The core of medical regulation lies at the level of information gathering, processing and integration required to its implementation. Quantitative and qualitative factors combined with the time factor determine the critical character of situations (need to make choices), decisions having to be made by vulnerable, stressable and fatigable men. Human decision in medicine cannot be replaced but the level of human performance is fluctuating, both naturally circadian and likely to be rapidly degraded under constraint. Man has thus to be employed for what he is irreplaceable, his abilities have to be conserved and he must be released from what only concerns automatism. In order to avoid the pitfall of a software program imposing an action not desired by the operator, we have thus wanted to put him in the centre of the system. To that end, we have searched for the information relevant to such a regulation and the links between them in order to propose consistent information to the physician in charge of regulation.

2.1 Cognitive Bases of Decision-Making

Medical regulation is part of problem-solving processes. The physician in charge of regulation has to make a decision in view of the coordination of the patient management means, based on data available to him, which is necessarily fragmentary and changes as the patient status evolves.

Rasmussen [3] described three levels of operator action: the skill-based level, the rule-based level and the knowledge-based level. The level concerned here is the rule-based level (assuming an experienced operator and a "simple" case: rescue organisation complies with specific rules based on the patient's status), but most often, actions are based on the implementation of declarative knowledge: the physician in charge of regulation makes his decision based on what he imagines of the patient's situation and of the capacities of the rescue teams.

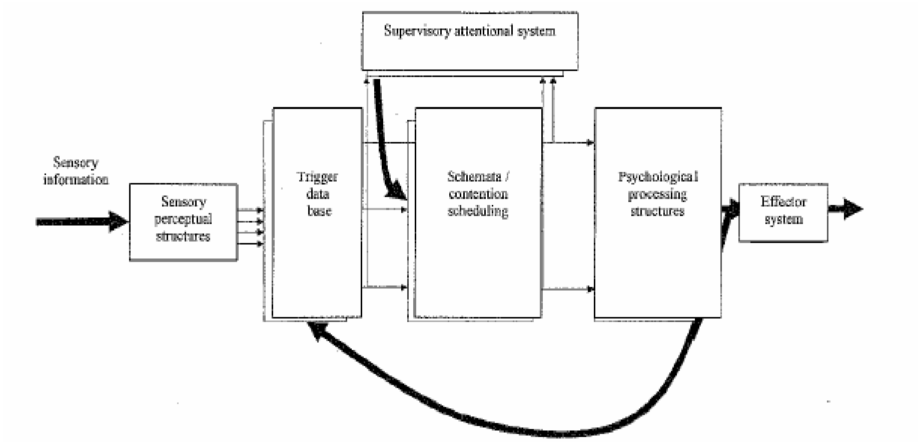

Fig. 1. Norman and Shallice's information processing model. Sensory information triggers an action after processing by psychological processing structures. These structures are activated by the schemata and contention scheduling system and the data base trigger. The supervisory attentional system handles the activation of these processing structures.

The information processing model proposed by Norman and Shallice [5] in 1980 reminds us that the implementation of that knowledge is done after sensory information have been processed by data base trigger and psychological processing structures, via a schemata and contention scheduling system, itself under control of the supervisory attentional system.

These various information processing and decision-making mechanisms generate risks of errors by the physician in charge of regulation. These errors can be fatal to the patient but also, on a theatre of operations, to the rescue teams.

2.2 Error-Production Mechanisms

Reason [4] showed how a system could allow or limit the production of errors by operators. Thus, in the specific case of problem-solving, errors can be due to the application of erroneous rules (the rule used by the operator is incomplete or incorrect: get a psychological casualty to a surgical structure for example) or to the erroneous application of right rules (the operator chooses to implement a solution that, although it works in other situations, is not adapted to the particular case of the current problem: it may be disastrous for a casualty suffering lung damage to be evacuated by air because although aeromedical evacuation is much faster, it may worsen the problem).

According to Amalberti [1], these errors are linked to bounded rationality phenomena: an individual cannot apprehend all the environment information, and all the consequences of current actions. The operator has to make choices based on his fragmentary perception of information and consequences of his actions. To that must be added the time constraint, as in many other situations, that forces the physician in charge of regulation to act "under emergency" and not wait for the situation to stabilize.

However, in spite of his weaknesses, the human operator makes the decision-making process more flexible. Indeed, he is able to make choices, bets, in spite of fragmentary and even erroneous information, while a computer system, more rigid, will request complementary information before proposing a solution. The information automatic processing by systems can only be based on a structured (form) and well formed (e. g.: XML format) piece of information corresponding to a pre-established meaning (codes). The use of metadata does enable automatic cross-check and interpretation actions that offset the lack of consistence or the gaps and fuzzy logic techniques make the algorithmic process more flexible but the man maintains an edge on computer systems. He is able to exploit the implicit information contained in any communication and to use his metaknowledge (the knowledge of his own abilities). This exploitation is immediate, even if the interpretation entails risks. It has the advantage of saving time even if the postponement of a rational decision would not necessarily be better since only built on explicit information that is incomplete and sometimes wrong.

For us, rule making does not consist in forcing the physician in charge of regulation to follow a pre-established algorithm but in assisting him to balance entities he will have to use to make his decision. Balance the relevance of upstream information, balance the useful availability of deployed means, balance the risk-taking calculated based on known elements.

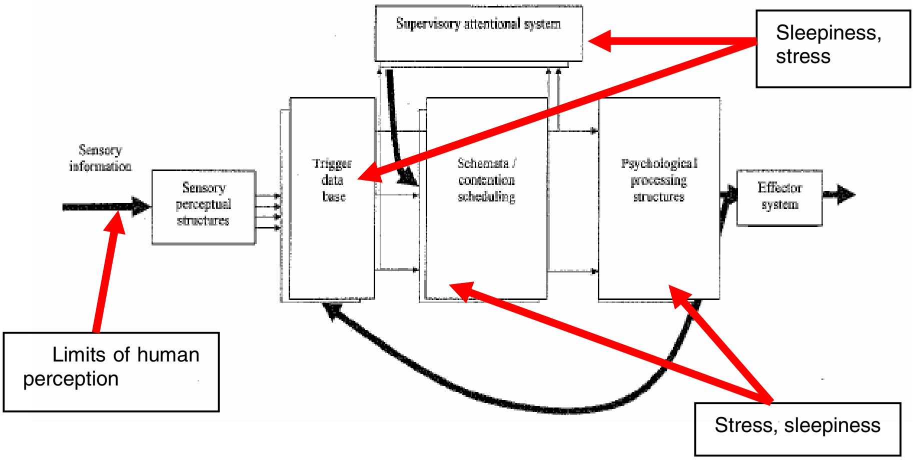

Fig. 2. Error-production mechanisms based on Norman and Shallice's information processing model

Thus, designing a theatre medical regulation system as we imagine it does not aim at developing a software program imposing ready-made solutions to an operator who will just be a mere executant. It aims at implementing an information system that lets the man carry out the noblest tasks (genesis of information and decision-making process). Everything else is just organisation and automatism, whether the transmission of messages themselves, their addressing in structured data bases or their processing via cross-checks in view of a relevant contextual graphical presentation.

Following Hoc [2] and Amalberti [1], we will define such a concept as an ecological system. In this system, cybernetics takes on intangible automatisms, and man takes on the contact with the patient and the critical decision making.

3 The Design of a Medical Regulation System in Practice

The action of the service de santé des armées has to fall within the scope of the new Forces information and communication system that contributes to battlespace digitisation, whilst preserving the fundamental values of medical practice and in particular ethics. Human constraints such as the vulnerability of combatants, medical operators and decision-makers have thus to be taken into account to be able to contemplate the design of an information system compatible with the autonomy required for medical decision-making in degraded contexts.

There is great temptation to believe that decision-making can be optimised if human errors are removed and man enslaved to the system since compelled to apply procedures. The human factor has long been considered the primary cause of any error. In the interhuman "adversity" situation characterising the operational theatre situation, human will and the meaning of committed, or not committed acts, have as much weight as the reality of their consequences. The cognitive workload weighing on decision-makers has thus to be alleviated in order to preserve their ability to take on their technical and ethical responsibility.

3.1 The Context: Medical Management on a Military Operational Theatre

Medial regulation in overseas operations is characterized by the extremely variable number of potential casualties likely to be managed by medical teams on an action zone that may be vast (several units can simultaneously suffer casualties) and in a non stabilised space-time context (combat operations may continue over time and space, which limits the action capabilities of medical teams or compels them to a quick management of casualty/ies).

The physician in charge of regulation, the system's cornerstone, has thus to be able to remotely build a reliable representation of the casualties' status, the context in which medical teams will have to act, the dispatching in the field of the latter, etc. Besides, he shares information with the people in charge of logistics, conduct of operations and health resources on the military theatre to develop a strategy compatible with conditions of medical management. It is important to note that the context in which the regulation activity takes place will strongly impact the regulation process. As a consequence, analogies made with civil situations encountered by the services d'aide médicale d’urgence (SAMU) and those acting in a disaster situation will have to be cautiously analysed.

3.2 Technological Environment to Support Action

The material support of regulation activities is all the information and communication technologies that are more and more an everyday reality for the troop and the civilian population as well. An optimized medical management will require resorting to "mobile" computer technologies (personnel digital assistant, storage and digitisation of information on a physical medium) and to the organisation of information exchange through centred networks. In absolute terms, these concepts allow the combatant, as a basic tactical unit, to work in network with the higher hierarchical echelons. Medical management on an operational theatre involves the same principles. The current stake is that health actors in the field can communicate in a unique "information infrastructure" to develop a shared representation of the situation.

For a few years, tests have been carried out to approach the issue of medical information digitisation in the field, in France and overseas. Those various contexts of use allow us to identify the opportunities opened by digital technologies to meet our requirement for military regulation.

3.3 Variety of Actors and Levels

The variety of actors (from the paramedic in the field to the physician commanding medical service elements on the theatre of operation) and the distance between these various actors (an isolated paramedic may have to manage a casualty few hundreds kilometres away from the physician) are what makes our system unique.

The system under development will ensure medical regulation at the local level (the chief medical officer of the medical team on site) as well as at higher levels. Available information is not the same and only some pieces of information, that will have to be clearly identified, will be useful to the medical regulation. Its role will consist here in sending a team of varying medicalization level according to the patient's state, or only in guiding the paramedic on site in the actions to be taken.

For example, an analysis of the use of existing regulation software (SAMU regulation software, "plan rouge" monitoring software, etc.) allows us to identify the relevance of the information gathered and their exploitation during an intervention. This work is supplemented by interviews with the various actors of medical regulation in overseas operations (physicians commanding medical service elements, resuscitators in surgical team, surgeons, etc.). The library of characteristic activities thus built allows us to extrapolate a need for relevant information, whether medical (concerning casualty/ies) or operational (concerning logistic and more strategic data).

3.4 Purposes: Assistance and Advice on the Design of an Information System

The analysis of the results gained at the end of the usage studies on existing systems and of our interviews with operators in order to formalize the need shall allow us:

- to determine the information used during medical regulation by medical actors
- to identify the information exchanged that is necessary to the development of a shared representation of a given situation
- to understand a part of the problem-solving and decision-making processes by the operator in charge of regulation.

All these elements are essential to determine the information architecture required to manage a patient or a war casualty, or, in more practical terms, to decide on the organisation of data on the screens of the medical regulation system. The aim is to design an information system that allows the physician in charge of regulation to get a very good picture of the situation in order to make the decision that seems the most adapted to him based on his knowledge of tactical data, teams present in the field and their skills.

4 Conclusion

The purpose of this paper was to share our thoughts on the design of an operator-centred software program, which aims at enabling him to make a decision he will be able to follow and modify over time, based on the representation of the situation he has built, but which also takes account of his own abilities. This design compels us to reuse decision-making and error-production theoretical bases, in order to accurately identify the pitfalls we may encounter that will be challenges to be addressed by the end user. Thus, the software program that will be designed will have to include an ecological interface making the representation of the situation easier, proposing a decision support for the physician in charge of regulation but not imposing a rigid solution that could be a source of difficulty for the operator and entailing a risk of causing him to lose control of the situation.

This analysis will have to be faced with the field reality in order to evaluate a prototype that will be validated by future users during different exercises simulating various and realistic employment conditions.

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