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**Collective activities in a technology-mediated medical team.
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Collective activities in a technology-mediated medical team.

An analysis of epidemiological alert management

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Abstract

We conducted an exploratory study of a complex and dynamic medical activity, namely the collective management of an epidemiological alert situation. With a view to improving our knowledge of how this activity is managed, we set up simulated situations of epidemiological alerts. A multidisciplinary medical team was assisted by a decision-support system called ASTER and we recorded a set of systematized observations of human-human and human-machine interactions. Participants were physicians belonging to the Department of Epidemiology at the French Army's Institute of Tropical Medicine. After presenting the epidemiological domain and our theoretical approach, we describe the simulated situation and the communication dataset we collected and analysed, applying the EORCA method. Finally, in our discussion of the results, we suggest how communication could be enhanced between technology-mediated teams in complex and dynamic situations.

Keywords: complex and dynamic situations; medical decision-making; epidemiological alert management; decision support system; team activities.

1. Introduction

Epidemiological alert management **situations** which has not been explored until now, encompasses medical problem-solving situations, dynamic situations and team processes. It is undertaken by a distributed team of physicians whose job is to assess and control outbreaks of disease. From a public health perspective, the French Forces are particularly exposed to biological and medical risks, in various natural environments during their deployments. Epidemiologists must detect pertinent cues from the situational context in order to clarify their understanding of the current situation on the basis of their expertise. Once an outbreak has been identified (though not necessarily biologically confirmed), the experts build a set of medical countermeasures to prevent the outbreak from spreading. These medical countermeasures have to be reviewed with regard to the situation constraints (location, time, population, epidemiological agent, treatment, etc.), before they can be implemented. This situation requires teamwork between medical physicians with different specialities and may be mediated by technologies, as in the present study, where we focused on epidemiological alert management assisted by ASTER, a prototype technical system designed to deal with early warnings of biological threats occurring during military deployment. Alert management center may be regarded as a Command and Control systems including a decision center in which teams of experts work to reach shared objectives, assisted by technical systems and rules (Walker et al. 2006).

The use of an alert management centre raises several research questions. What, for instance, are the proportions of human-machine and human-human interactions during alert management? And what is their purpose? Does alert management take all the main characteristics of dynamic and medical situations into account? More specifically, which

1
2
3 cognitive processes are engaged in this activity? And how are they implemented? What kinds
4
5 of collective activities are performed by team members during alert management? By what
6
7 common purpose are the team members linked? What are the implications for the design of
8
9 the ASTER system?
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13 To our knowledge, complex situations **of this kind** have never before been analysed
14
15 from the perspectives of cognitive processes and team activities. The present study looked at
16
17 the way in which collective processes are carried out during alert management activities.
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19 More specifically, we sought to describe and categorise team activities during decision-
20
21 making processes undertaken in a complex, dynamic and medical situation. To this end, we
22
23 decided to adopt a formal method for describing collective activities in complex situations,
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25 known as Event Oriented Representation of Collaborative Activities (**EORCA**) (Pellegrin *et*
26
27 *al.* 2007, 2010b). After presenting the rationale behind collaborative decision-making which
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29 guided our research, as well as the particular characteristics of epidemiological alerts, we
30
31 describe the method and the material (ASTER system) we used and the results concerning
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33 alert management. Finally, we discuss how to enhance communication **within** technology-
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35 mediated teams.
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41 42 43 **2. Theoretical foundations**

44 45 46 **2. 1. Team activities**

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48 It is important to analyse collective activities in complex and dynamic military organizations,
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50 as teams play a key role in these organizations and are often regarded as a factor of reliability
51
52 (de Terssac and Chabaud 1990). Thus, operators' activities need to be analysed not only at an
53
54 individual level but also at the level of their team (Dyer 1984, Salas *et al.* 1992, Leplat 1994,
55
56 Rogalski 1994, Canon-Bowers *et al.* 1995, Benchekroun and Weill Fassina 2000, Maggi
57
58 2002).
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3 Salas and Hendricks (2004) define a team as a group of at least two persons dealing
4 with multiple resources of information and working to achieve a common objective. In
5 addition, according to Cooke (2004), teams must perform several activities as an integrated
6 unit and co-ordinate numerous cognitive processes, such as the detection and interpretation of
7 information, remembering, reasoning, planning, problem-solving, acquiring knowledge and
8 making decisions. Several approaches (Leplat 1994, Karsenty and Pavard 1997) regard team
9 activity as a task requiring the coordinated intervention of several operators in order to
10 achieve common goals. This means that it is important to define a number of key concepts
11 related to team activity, such as “cooperation” and “collaboration” as seen in figure 1. In line
12 with several authors, we consider that these two terms correspond to different processes.
13 Cooperation occurs when operators perform different tasks but pursue common goals. Thus,
14 operators have to deal with interference and must also try to facilitate each other’s activity
15 (Rogalski 1994). In addition, cooperation requires neither unity of time and location, nor
16 direct communication (Maggi 1996). By contrast, collaboration occurs when the operators not
17 only pursue the same common goals but also work on the same tasks together in order to
18 achieve them. Thus, collaboration requires unity of time, though not necessarily a single
19 location, providing the team members have access to computer supported cooperative work
20 (CSCW) tools. For instance, during a complex heart operation, the anaesthetist or the nurse
21 cooperate with the surgeons. Conversely, the surgeons collaborate and perform together on
22 the bypass operation.
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50 *Insert Figure 1 here.*

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52 Both collaboration and cooperation processes between players require mental
53 synchronisation, which corresponds to the construction of a shared representation, as well as
54 the temporal synchronisation of actions. Therefore, information acquisition and the
55 development of a common ground or reference frame are essential in collective activities. A
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1
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3 reference frame is jointly constructed by the individuals involved in the preparation and
4
5 performance of actions. It is the result of team members coming together (de Terssac and
6
7 Chabaud 1990, Hoc and Carlier 2002).
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10 Coordination can be regarded as the set of rules that manage and control cooperation
11
12 and collaboration activities (Maggi 1996).
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15 Finally, communication is a tool for performing collective activities and, thus, a team
16
17 activity indicator (Savoyant and Leplat 1983) that can be used to examine and model team
18
19 activities (Benchekroun and Weill-Fassina 2000).
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23 **2.2. Alert management activities**

24

25 From a psychological ergonomics point of view, alert management activities can be regarded
26
27 as problem-solving situations. The identification of an epidemic agent may be routine in
28
29 common epidemiological situations, but it requires the activation of conceptual knowledge in
30
31 rare and complex cases (Rasmussen *et al.* 1994). The results of the diagnosis trigger decision-
32
33 making performed both to manage an alert, and to design epidemiological countermeasures.
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37 Operators involved in alert management must detect and characterize a health event as
38
39 early as possible and then assess the situation. These teams of experts need to perceive,
40
41 interpret and exchange a considerable amount of frequently ambiguous information, with the
42
43 aim of developing the high level of situation awareness required in decision-making activities.
44
45 Situation awareness (SA) refers to the perception of the key elements of a situation in a given
46
47 time and space, the comprehension of their trajectory and the projection of their status within
48
49 the immediate future (Endsley 1995). The generally ambiguous nature of the processed data
50
51 and the dynamic, dubious and complex nature of the environment call for an approach known
52
53 as “Naturalistic Decision-Making” (Klein *et al.* 1993). This approach seeks to understand and
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55 explain (1) how experts work individually or collectively in situations characterized by strong
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3 time constraints, (2) how they assess the situation, and (3) how they make decisions and
4 perform actions.
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8 Previous psychological ergonomics studies of medical situations have highlighted two
9 fundamental cognitive processes: diagnosis and decision-making. The diagnosis of the
10 situation (integrating real-time and forecast information) corresponds to the comprehension of
11 the situation required to reach a decision about what action to take (Hoc and Amalberti 1994).
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17 In the “Recognition Primed Decision” (RPD) model (Klein 1997), two types of
18 situations are described, in which the experts use their experience and knowledge to deal with
19 a situation that may be either routine or complex. Experts use typical responses and outcomes
20 in situations they identify as being similar to ones they have previously encountered. In these
21 cases, they recognize situations or scenarios and compare them with clusters of knowledge
22 concerning certain previously encountered situations. By contrast, when the situation does not
23 seem familiar, the decision-maker has to assess it before adapting his or her chosen solution to
24 it (Klein 1997). Decision-making processes have been the subject of several studies in the
25 context of military command, emergency services (Rogalski 2004), hospitals (Molenda *et al.*
26 2009), or a military training facility (Drillings and Serfaty 1997). However, none of these
27 studies tackled the collective dimension, focusing solely on the social, cognitive or situational
28 factors.
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45 In the context of alert management, our objective was to describe how
46 multidisciplinary teams, supported by a technological system, perceive information, assess the
47 current situation and make decisions during an epidemiological alert. To this end, we
48 designed and implemented simulated situations of alert management.
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3. Method

3.1. Participants

Seven experts took part in the experiment, forming a team that was representative of a real-life epidemiological context: two physicians specialising in epidemiology (one from the Epidemiological Research Unit in Djibouti and one from the Medical Intelligence Unit in France), three physicians (one from a medical unit in Djibouti, one from Djibouti Hospital and one from a French hospital) and two medical officers (one from the Djibouti unit and one from the French one). The experiment lasted two hours. By the end of this exercise, the epidemiological team was expected to have identified the syndrome and come up with countermeasures.

3.2. Outbreak simulation scenario

To analyse the alert management situations, we built a Wizard of Oz experiment, in which the scenario involved a natural outbreak within French forces deployed in Djibouti. The scenario consisted of a natural epidemic of pertussis affecting military personnel in Djibouti (about 20 medical cases, where patients first presented with a bad cough). The experimenter piloting the simulation communicated surveillance data at a “naturalistic” medical pace corresponding to the realistic development of an outbreak in this specific situation. We also took spatial, temporal, geographical and military constraints into account: players were in different locations; we simulated time pressure; the population affected was representative of a real epidemic; the epidemiological agent we choose was realistic; and the medication was present in real quantities. Thus, this scenario was realistic and matched recent real-life cases within the French army.

3.3. Materials

ASTER is a groupware application designed to support a team of physicians engaged in the surveillance and management of epidemic diseases as seen in figure 2 (Chaudet 2006, Chaudet *et al.* 2006). It allows the consultation of both epidemiological surveillance and medical intelligence data. ASTER is designed to detect and assess any epidemiological event that risks impacting on military operations.

Insert Figure 2 here.

The ASTER system is based on two main sociotechnical networks, which support team activities related to alert management.

- ASTER's declaration network is responsible for the notification of the case, the management of the individual patient data and the conducting of an alert procedure in each theatre of operations. Military unit physicians and the theatre's medical officer all belong to this local network, their respective roles being to save and transmit the medical information (medical cases, syndromes, location and time) and to oversee the medical situation.

- ASTER's analysis network (based on specialised Web services) takes information from the declaration network and performs a specific automatic analysis, in order to detect an epidemic alarm. In the event of an alarm notification, the epidemiology experts have to interpret the health situation, confirm the epidemic alert and manage it by submitting health countermeasures to the medical officer. Other physicians (medical intelligence unit, medical entomologists and other specialists) may be asked for specific information or advice linked to the situation's medical, environmental, geographical or sociopolitical constraints.

The medical officer is responsible for the definition and implementation of the countermeasures, with the unit physicians who are present in the theatre of operations and

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2
3 with the epidemiologists who remotely monitor the epidemic spread. These different players
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5 can coordinate their actions via ASTER, which allows for information sharing between
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7
8 declaration network physicians and analysis network epidemiologists.

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10 Other tools may also be used by the team, such as phones, maps, Internet services, electronic
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12 mail services, phonebooks, and logbooks.

13 14 15 16 **3.4. Method for observation and analysis**

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18 Observations were manually recorded by two ergonomists applying the EORCA method
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20 (Pellegrin *et al.* 2007, 2010a). This is a task-analysis tool for observing and modelling
21
22 collective medical activities. It was designed to highlight the collective dimensions of
23
24 healthcare, as well as the human factors involved in decision-making in medical conditions.

25
26 The EORCA method was implemented in three steps:

27 28 29 30 *Step 1: Observation recording.*

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32 This step consisted in collecting sequences of events through direct observation. The
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34 recorded action could take the form of either a physical act or verbal communication between
35
36 health professionals (e.g. explicit decision-making requests or questions). Events were
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38 recorded in chronological order with nonsystematic timestamps. This step yielded an event-
39
40 oriented written description in natural language of the management of an epidemiological
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42 case. For example, (1) *Player 1 logs onto the ASTER system to search for new medical*
43
44 *information* or (2) *Player 2 asks the military unit's physician, "What kind of symptoms does*
45
46 *Case 2 present?"*

47 48 49 50 51 *Step 2: Action codification.*

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53 This step consisted in analysing the epidemiological case in order to extract the event's
54
55 components and sequencing. Actions and agents were identified and coded on the basis of
56
57 EORCA's domain-oriented ontology, which formalises and organizes observations in terms
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3 of concepts (Gangemi 2002). A number of concepts belonging to this ontology were adjusted
4 or supplemented for the purposes of our research. For example, we distinguished between
5 objects (physical and social), locations and events (Pellegrin *et al.* 2010b). EORCA allows
6 observations to be divided into two main categories of actions: human-human interactions
7 (oral or written communication between humans), and human-machine interactions, such as
8 information acquisition via ASTER or other tools. Thus, Action 1 would be classified a
9 human-machine interaction, because the operator uses ASTER to acquire information, and
10 Action 2 as a human-human interaction.
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22 As EORCA's formalisation can be compared to theoretical models such as the one
23 developed by Rasmussen *et al.* (1994), we decided to distinguish between five categories of
24 cognitive processes drawn from Rasmussen's model. Accordingly, each type of observed
25 action could be coded as a perception action, a diagnosis action, a planning action, a decision-
26 making one or an information transmission one. Actions 1 and 2 would both be classified as
27 perception actions, as they are both aimed at acquiring information about the epidemiological
28 situation.
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38 Finally, actions could be coded as either cooperative or collaborative. Our two
39 examples would both be deemed to be cooperative actions: one with human players, the other
40 with ASTER.
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45 *Step 3: Event representation.*

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48 This final step consisted in giving the coded epidemiological case an event-oriented
49 description (Chaudet 2006), taking the form of a graphic representation of the observed
50 scenario. For this purpose, we defined generic graphic concepts for building the final
51 representation sheet of the medical management activities (Pellegrin *et al.* 2007, 2010b). The
52 goal was to represent all the main components of the team members' management of the
53 medical situation on a single template.
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6 Like other methods such as “Event Analysis of Systemic Teamwork”, developed by
7
8 Stanton *et al.* (2005), which allows for the analysis of distributed team activity in complex
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10 sociotechnical systems, EORCA provides a means of formalising the players involved in the
11
12 situation, their actions, the information relating to time and place, and the tools used by the
13
14 players. Its objective is to formally describe collective actions performed by operators in
15
16 complex and dynamic medical situations. In the present study, our objective was to identify
17
18 and characterize human-human interactions and human-machine interactions. EORCA allows
19
20 us to make systematic field observations illustrating human-machine and human-human
21
22 interactions. It also helps us to identify cooperation and collaboration processes, as well as
23
24 cognitive processes such as perception of information, diagnosis, planning, decision-making
25
26 and information transmission. EORCA also provides an accurate means of describing human-
27
28 human interactions and identifying those players in the social network who are genuinely
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30 involved in alert management.
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39 **4. Results**

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41 The data presented in this section were yielded by the EORCA analysis. The observed actions
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43 are therefore divided into two main categories: human-machine and human-human
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45 interactions. We also present an analysis of these actions with regard to the main cognitive
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47 processes involved in a dynamic and complex medical situation. Finally, we describe results
48
49 on the social network and team activities identified in this situation.
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53 We identified a total of 221 actions during the two-hour simulation (density: 1.84
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55 actions per minute). Table 1 shows the frequency of these actions according to each category.
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58 *Insert Table 1 here.*
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Thirty-one percent of the actions corresponded to human-machine interactions and 69% to human-human interactions. This was not a random distribution (chi-squared test for given probabilities: $\chi^2 = 58.73$; $df = 2$; $p\text{-value} < 0.01$), as we found that human-human interactions predominated, thereby highlighting the importance of communication between team members during alert management activities.

4.1. Human-machine versus human-human interactions

As seen in table 1, human-machine interactions were performed with the assistance of various tools. A large majority (68%) concerned the ASTER system, which was used to examine the epidemiological information (e.g. consultation of epidemiological curves and medical records), while 16% corresponded to searches for relevant information in a logbook. Other actions included searching for medical information in phonebooks, textbooks, on the Internet, in databases, maps, and so on.

In addition, we were able to identify several subcategories of human-machine interactions (31%). These corresponded to the intentions associated with each human-machine interaction. Thirty percent of them consisted of information-selecting actions and 27% of information-recording actions, 19% corresponded to situation assessments and 14% to situation monitoring, 5% dealt with system failures and 5% corresponded to the simulation design.

Concerning human-human interactions, we identified various communication modes, according to the participants' location. Participants mainly engaged in indirect, phone-mediated communication when they were some distance apart (57%) and direct communication when they were in the same place (42%). Only 1% of speech action was based on electronic mail services.

Human-human interactions could be divided into various categories. Human-human interactions predominantly corresponded to information requests (28%), decision-making

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2
3 (22%), discussions and debates (20%), replies and feedback (16%). Information transmission
4
5 (7%) and information acquisition (5%) were less frequent. Finally, we observed a few
6
7 information validation actions (1%) and action requests (1%).
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9

10 In addition, we were able to identify a number of recurring themes among the topics
11
12 broached in the human-human interactions. These themes related mainly to the medical
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14 situation (32%), countermeasure planning (22%), assessment of the epidemiological situation
15
16 (18%) and the military situation (13%). Other communication themes concerned
17
18 communication tools (6%), medical actions, such as medical examination and health checks,
19
20 and medical test results (5%). Finally, a few speech actions corresponded to non-replies /
21
22 failed replies (2%), administrative information (1%), and information requests about the
23
24 simulation design (1%).
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30 ***4.2. Cognitive processes engaged in an alert management situation***

31
32 Based on descriptions of cognitive processes in various decision models, we set out to
33
34 identify the processes to which the observed actions (human-human and human-machine
35
36 interactions) corresponded as seen in table 1. Human-machine interactions, but also some
37
38 human-human interactions (information requests, replies and feedback, and information
39
40 acquisition), involved information perception processes. This category represented 56% of all
41
42 actions: 30 human-machine interactions with ASTER and 77 human-human interactions. We
43
44 also identified 37 actions that corresponded to diagnosis (20%). This category essentially
45
46 contained situation assessments during discussions or debates (30 human-human interactions)
47
48 and human-machine interactions leading up to a situation assessment (seven actions). In
49
50 addition, 10% of actions were related to planning, 8% to decision-making and 6% to
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52 information transmission (e.g. 11 actions concerning the transmission of the selected
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54 countermeasures).
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3 We pinpointed several process sequences. Most of the actions comprised the following
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5 sequence of cognitive processes: information acquisition, diagnosis, planning, decision-
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7 making and information transmission. However, a few sequences only comprised two kinds
8
9 of cognitive processes. For example, some sequences were composed solely of diagnosis and
10
11 decision-making or of iterative information acquisition and diagnosis.
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14

15 16 **4.3. Cooperation versus collaboration**

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18 When we distinguished between different kinds of team activities, especially cooperation and
19
20 collaboration, we found that 53% of actions corresponded to collaboration between the team
21
22 members and 47% to cooperation (Table 2).
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24

25
26 *Insert Table 2 here.*
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28
29 More specifically, during information perception processes, essentially supported by
30
31 ASTER, more actions were performed in a cooperative mode than in a collaborative one
32
33 (60% vs. 40%). With regard to diagnosis, planning and decision-making, we observed the
34
35 opposite results: the number of collaborative actions was higher than that of cooperative
36
37 actions. Thus, 62% of diagnostic actions, 90% of planning actions and 81% of decision-
38
39 making actions were performed in a collaborative mode. By contrast, 54% of information
40
41 transmission actions were performed in a cooperative mode.
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44

45 46 **4.4. Social network**

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48 Our observations, supplemented by interviews, allowed us to describe the social network
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50 involved in the alert management situation. The epidemiologist in charge of the alert
51
52 management interacted with six interlocutors or team members. He initiated most of the
53
54 speech actions (57%) and was therefore at the centre of the social network. Some team
55
56 members were called upon more than others, as in the case of the medical officer. The latter
57
58 was the source of approximately 21% of all speech actions (direct communications),
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3 compared with around 10% for the medical unit physicians . Some team members intervened
4
5 only once, such as the medical intelligence unit physician. We also noted a pattern in the
6
7 distribution of cognitive processes across team members. Communication between the
8
9 epidemiological physician and the medical unit physicians consisted of medical information
10
11 requests. By contrast, interactions between team members corresponded to phone
12
13 communications, but also to cooperation via ASTER. Interactions between the
14
15 epidemiological physician and the medical officer took the form of direct communication and
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17 mainly concerned diagnosis and decision-making.
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5. Discussion

The EORCA analysis we performed allowed us to classify a high proportion of the human-human (69%) and human-machine interactions (31%). Human-machine interactions were mainly performed via ASTER, in order to gain information about the epidemiological situation (number of medical cases, case characteristics, geographical location, etc.). Human-human interactions mainly consisted of information requests (28%), decision-making (22%), discussion (20%) and replies (16.34%). The main cognitive processes involved in the alert management situation we analysed were organised in the following sequence: information perception, diagnosis, planning, decision-making and information transmission. This kind of complex and rare situation requires the activation of conceptual knowledge (Rasmussen *et al.* 1994). In addition, the different kinds of cognitive processes we observed were performed in either cooperative or collaborative mode and were distributed across the team. Information acquisition occurred essentially during phone- or ASTER-mediated communication with the medical unit physicians and was performed in a cooperative mode. ASTER cooperation enabled team members to develop and fine-tune a common frame of reference (de Terssac and Chabaud 1990, Hoc and Carlier 2002). They could follow the situation virtually in real time, despite a lack of unity of time and place and the frequent impossibility of direct communication (Maggi 1996).

By contrast, diagnosis and decision-making occurred mainly during interactions between the medical officer and the epidemiologist, and were performed in collaborative mode, supported by direct communication.

Experts engaged in alert management situations have to call upon other experts, such as medical intelligence unit physicians in this instance, and make use of various systems in order to obtain new information and adjust their problem representation. Thus, each team

1
2
3 member searches for information. Cooperating during information searches enabled our
4
5 participants to collect a considerable amount of new information. The epidemiological
6
7 physicians and the medical officer then assessed the situation and made decisions together.
8
9
10 Collaboration allows the various players to create a common mental representation of the
11
12 situation as it evolves and to discuss and compare their situation assessments. This
13
14 collaboration continues until the final process of decision-making (Gaudin *et al.* 2009).
15
16

17
18 *Insert Figure 3 about here.*
19

20 Based on overall results, we came up with the notion of “team flexibility”, whereby
21
22 some team members were called upon to acquire specific information and others to assess the
23
24 situation. Moreover, team members engaged in either cooperation through direct
25
26 communication (or supported by ASTER) or collaboration, depending on the task objectives
27
28 as seen in figure 3. Thus, the team members adapted their collective activities and the tasks
29
30 they performed in order to manage this complex situation. Computational systems,
31
32 particularly the ASTER prototype system, need to take account of important team activities,
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34 such as cooperation and collaboration, as well as the existence of team configurations.
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36 ASTER essentially permits team members to cooperate during the information acquisition
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38 step. Medical unit physicians record medical data, to which epidemiological physicians then
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40 refer via ASTER in order to assess the situation and make a diagnosis. Systems must allow
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42 team members to perform individual tasks and pool resources. Team members must also have
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44 an opportunity to perform the same task together (e.g. diagnosis or decision-making), even
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46 though they may not be in the same place. Multidisciplinary teams supported by
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48 computational systems have already been described elsewhere and researchers have also
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50 highlighted the importance of informal discussion and interaction (Kane *et al.* 2005, Kane and
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52 Luz 2009) for improving medical situation management (Groth *et al.* 2008).
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3 Some limitations have to be mentioned concerning the representativeness ~~or otherwise~~
4 of this study. As the experimentation only lasted two hours, it would be difficult to generalise
5 the results we obtained. However, ours is the only study so far to have looked at both
6 collective activities and cognitive processes during complex and dynamic situations. Our
7 results reveal that experts are able to use both cooperative and collaborative processes,
8 depending on task goals and team members. ASTER's design should allow team members to
9 engage in both these kinds of collective activity and give them an opportunity to choose
10 which one they want to perform during alert management. We believe it would be useful to
11 build some additional functions into ASTER, such as a "chat" function or a voice calls over
12 the Internet allowing distributed team members to discuss and exchange ideas. ASTER should
13 feature a phonebook database and an intelligent decision-making system such as "Gideon"
14 (Global Infectious Diseases and Epidemiology Online Network) that helps diagnose
15 infectious diseases. Finally, an electronic logbook would allow team members to create and
16 share a common mental representation of the situation as it evolves.
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Figures

Figure 1.

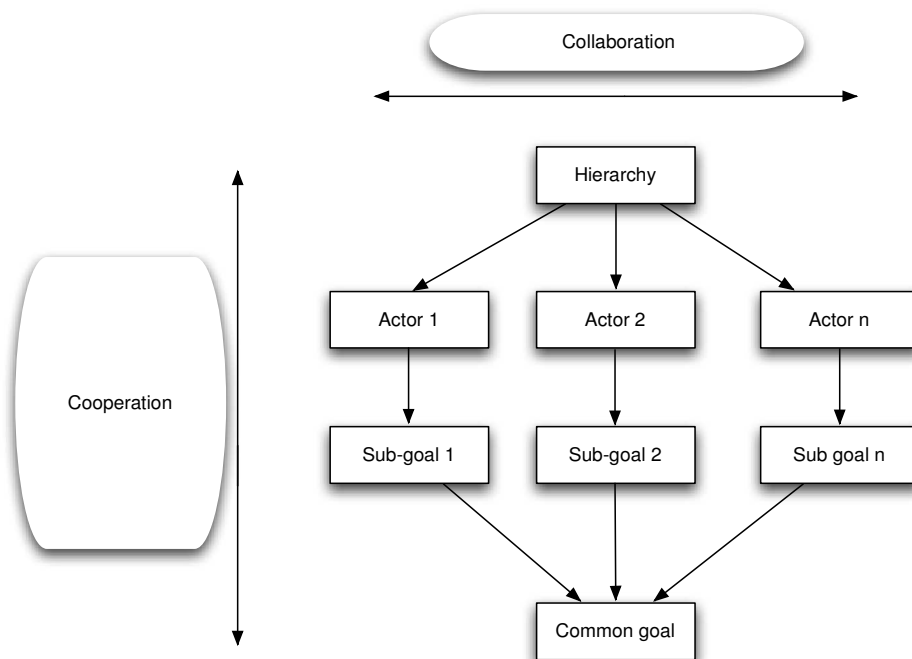


Figure 2.

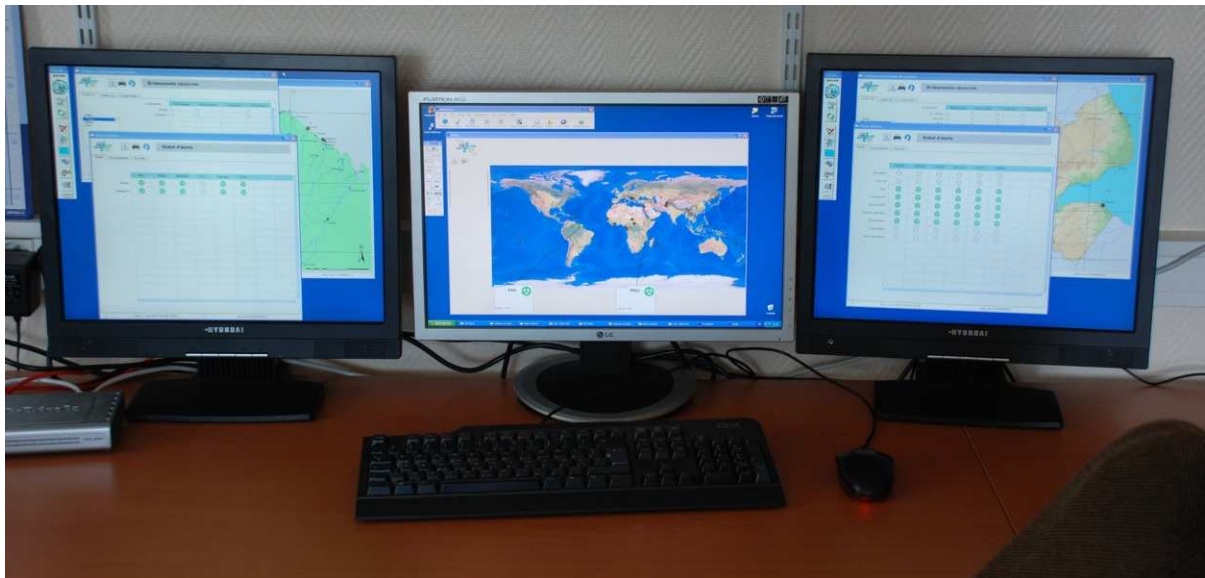
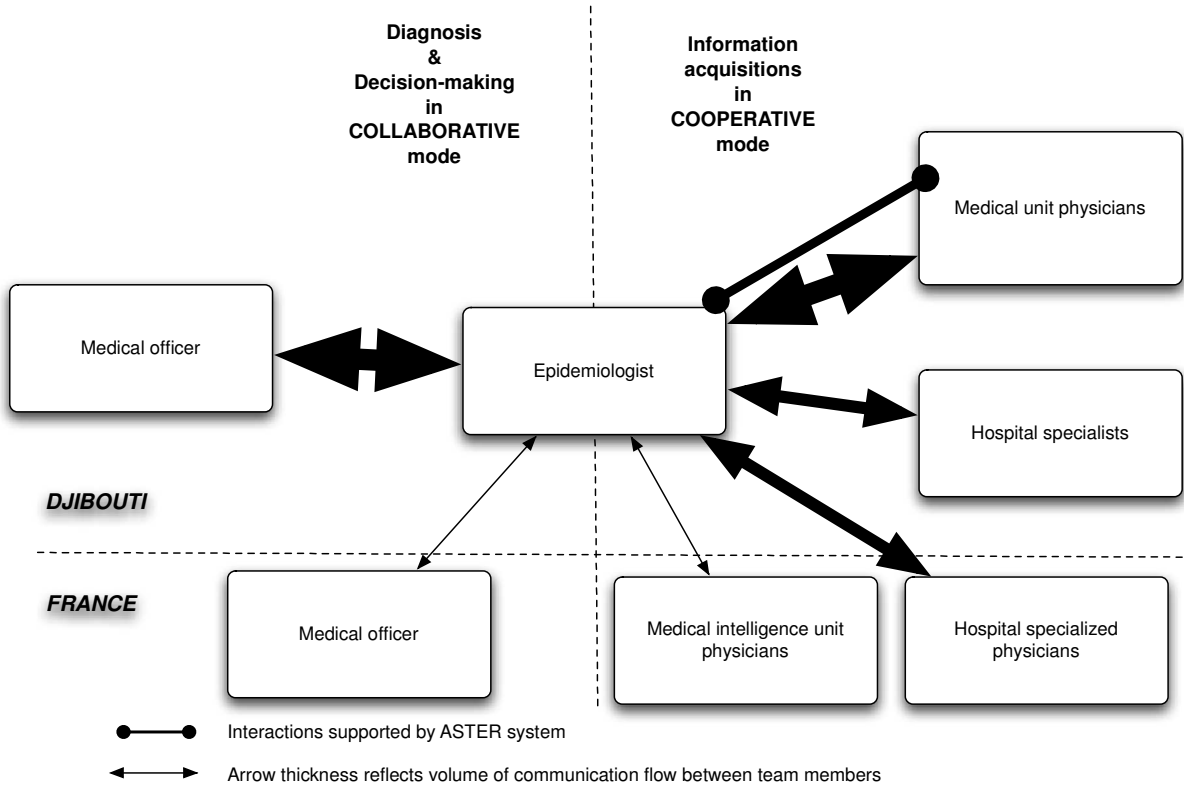


Figure 3.

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3 **Figure captions**
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6 Figure 1. Typology of team activities (Gronier 2006, adapted from Rogalski 1994, Savoyant
7 1992).
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10 Figure 2. The ASTER system.
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14 Figure 3. Social network and communication flow during alert management situation.
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3 **Tables**
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11 Table 1. EORCA classification of observed actions.
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Main action categories	%	Tools used	%	Action subcategories	%	Communication themes	%	Cognitive processes	%				
H-H Interactions	69	Phone	57	Information requests	28	Medical situation	32	Information perception	56				
				Measure planning	22								
				Discussion /Debate	20	Situation assessment	18						
				Decision making	22	Military situation	13						
		Direct communications	42	Responses	16	Tools	6	Diagnosis	20				
				Transmission	7	Medical actions	5						
				Information acquisition	5	Failed reply	2						
				Mail service	1	Administrative informations	1						
				Action requests	1	Information validation	1			Simulation design	1	Planning	10
						Information selection	30						
H-M Interactions	31	Aster system	68	Information recording	27	Decision-making	8						
				Situation assessment	19								
		Log book	16	Spread monitoring	14								
		Phone book	5	System failure	5			Information transmission for action	6				
		Internet	3	Simulation design	5								
Maps	3												
Simulation design	5												

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Table 2. Distribution of cognitive processes across team activities.

Cognitive Processes	Cooperation	Percentage	Collaboration	Percentage
Information acquisition	64	60%	43	40%
Diagnosis	14	38%	23	62%
Planning	2	10%	17	90%
Decision-making	3	19%	13	81%
Information transmission	6	55%	5	45%
Total	89	47%	101	53%