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Musculoskeletal Disorders

Studies and Research Projects

REPORT R-762



Study of Interventions to Reduce Musculoskeletal Disorders and Psychological Health Problems in 911 Emergency Call Centres in the Municipal Public Security System

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This Québec-based research project was the result of close collaboration between researchers, preventionists from the Association paritaire pour la santé et la sécurité du travail secteur des affaires municipales (APSAM, or joint sector-based association for occupational health and safety, municipal affairs sector), the managers of five municipal public security 911 emergency call centres (MPSECCs), representatives of the emergency call centre agents, and two IRSST knowledge transfer advisors, Laurent Gratton and Charles Gagné.

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ABSTRACT

This research project followed on an initial epidemiological study demonstrating the high prevalence of musculoskeletal disorders (MSDs), psychological health problems (PHPs), and physical and psychosocial risk factors among agents working in municipal public security emergency call centres (MPSECCs) in Québec, Canada. It sought to understand how these risks manifest themselves in this type of work in order to propose courses of action that would reduce the adverse effects on the agents' health. With that in mind, this project was based on the ergonomic approach to work activity, including physiological measures, and was supplemented by a study of the work psychodynamics.

The physical and psychosocial risk factors identified in epidemiological studies relate, in ergonomics, to the presence of work demands and musculoskeletal and mental workloads that are in turn associated with the presence of MSDs and/or PHPs.

The physical demands at the source of potentially harmful musculoskeletal workloads in the MPSECCs stem from computer work problems and are compounded by the demands specific to emergency communication. These demands are associated partly with accessibility problems relating to the number of pieces of equipment needed on the desk and partly to the prolonged maintenance of the seated posture required by the agents' obligatory presence at their workstations. To reduce the risk of MSDs related to this last type of demand, some MPSECCs have installed workstations that allow the job to be performed in sitting or standing position.

The mental demands stem from three processes: first, the workload per se, which in corporate contexts is defined as the number of actions to be performed during a specified period of time, and which here relates to the frequency of incoming calls and the number of searches required to answer them; second, the cognitive workload, which concerns the processing of information and in the present case means the complexity of handling calls; and, third, the psychological workload, which refers to the emotional dimension of handling emergency calls and the psychic¹ processes brought into play by the agent in order to deal with the demands present in the work.

The descriptions of the work situations with demonstrated regulation problems formed the basis for the development of courses of action aimed at reducing MSD and PHP risks. These courses of action were developed with the assistance of the follow-up committee and validated at a meeting with a group of agents.

The research was carried out with the participation of the five MPSECCs involved in the preceding study. It had two components: an ergonomic study involving the collection of physiological data and a study of the work psychodynamics. The ergonomic/physiology study was based on the participation of 11 agents, namely six men and five women, of whom nine were experienced employees and two were novices. The agents held generalist, call-taking, and dispatching positions. The following data were collected: description of the work and of the workstation layout; observation of work postures; use of the sit-stand workstation adjustment options; telephone communications; subjective evaluations of the mental workload,

¹ The term *psychic* is used here to refer to the theoretical construct in Freudian metapsychology used to explain the functioning of the mind, including both its cognitive (information-processing) and affective dimensions.

musculoskeletal pain, and fatigue; trapezius electromyography (EMG); heart rate or electrocardiography (ECG); and the agents' comments during self-confrontation interviews. Observations were made and measurements taken during a work shift, while heart rate was recorded over 24 hours. The work psychodynamics study entailed organizing four group interviews in four MPSECCs. The groups consisted of four to six male and female agents with between two and 25 years' experience. The interview content analysis was based on the work psychodynamics reference framework in accordance with current methodology.

The results of the ergonomic study show that, from a physical-risk prevention standpoint, introducing adjustable sit-stand workstations provides a greater margin of manoeuvre to agents for dealing with the work's various demands and with sensations of musculoskeletal pain or fatigue. However, the design of the workstations does not appear entirely satisfactory for reducing MSD risks. The design of the worktables should be rethought in light of the agents' activities and technological developments.

The ergonomic/physiology and work psychodynamics studies provide a clearer understanding of the presence of psychosocial demands. As measured by subjective evaluation of the mental workload, these psychosocial demands are associated with an increase in sensations of musculoskeletal pain. More specifically, pain in the upper back, neck, and shoulder region correlates positively with a higher perceived level of workload and call complexity, while low back pain is related to perceived negative emotions. This result is consistent with the increase in activity and decrease in rest time for the trapezius muscles associated with the increase in workload and call complexity. For negative emotions, none of these changes proved significant. The increase in activity and decrease in rest time for the trapezius muscles probably stem from more frequent actions involving the manipulation of equipment controls. For heart rate, a significant loss of variability was measured throughout the work shift for the experienced agents, a loss quickly reversed after the shift ended. This shows that experienced agents are prepared to react to stress situations. During the work shift, correlations between the heart rate (HR) or heart rate variability (HRV) and the responses on the perception rating scales were found in only a small number of agents, attesting to a dependency on the specific characteristics of the work shifts observed.

Observation of cognitive and relational problems in the telephone conversations monitored and the comments obtained through the self-confrontation interviews allowed the work situations with a high cognitive and emotional workload to be described. Analysis of the work psychodynamics completed the picture by describing how these demands are managed relative to the psychic dimension. This made it possible to determine how agents' work experience is developed over time and to identify the sources of pleasure and the defence strategies adopted to deal with the demands specific to this occupation.

The results brought a clearer understanding of various aspects of the work, which the follow-up committee used as a basis for developing courses of action. These courses of action form part of the development prospects for a profession that only began to be structured and organized in Québec relatively recently. Initial efforts focused on improving the technology. They took the form of purchasing computer hardware that supported the agents' work and furniture adapted to the demands of continuous operation in which agents take over from one another at the same

workstation. The results of the psychosocial risk study show that, in a subsequent phase, efforts should be focused on cognitive and emotional support. Such support requires the development of training based on the transmission and exchange of know-how regarding communication when taking calls. It also implies improving relationships with first responders², especially patrol officers. The follow-up committee developed courses of action with that in mind. More generally, this research project made it possible to develop an ergonomic study methodology for interventions aimed at reducing psychosocial risks.

² In this text, *first responder* is used to refer to the emergency service providers who arrive first at an incident site, e.g. police officers, ambulance technicians, and firefighters.

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ABBREVIATIONS FOR PHYSIOLOGICAL MEASURES

- APDF: Amplitude Probability Distribution Function
- EMG: Electromyography
- HF: High frequency (component of the heart rate variation whose range of frequency is between 0.15 and 0.40 Hz, expressed in ms^2)
- HR: Heart rate
- HRV: Heart rate variability
- LF: Low frequency (component of the heart rate variation whose range of frequency is between 0.04 and 0.15 Hz, expressed in milliseconds squared, or ms^2)
- pNN50: Percentage of absolute difference between two successive heart beats (i.e. interbeat intervals, or IBIs) greater than 50 ms
- R: Statistical index that describes the intensity and direction (positive or negative) of the linear correlation between two quantitative variables and that ranges from -1 to +1
- R^2 : Coefficient of determination that measures, usually in percentage, how much the variability of a given variable Y depends on its relationship with another variable X
- RMS: Root mean square (statistical measure of amplitude)
- RVE: Reference voluntary exertion (sub-maximal reference contraction)
- SDANN: Standard deviation of normal-to-normal IBI averages calculated on successive five-minute segments during the work shift or a 24-hour cycle (expressed in milliseconds, or ms)
- SDNN: Standard deviation of normal-to-normal IBIs calculated on five-minute segments (expressed in ms)

1. INTRODUCTION

During the 1990s, the Québec government gave municipalities the responsibility of providing citizens with the 911 emergency service. The municipalities usually integrated this service into their municipal public security system. However, the tasks of taking and dispatching emergency calls were assigned to public service employees within the municipal administration's group of white-collar workers. In 2006, approximately 45 municipal public security emergency call centres (MPSECCs) employing approximately 1,000 telecommunications agents were identified. This dispersal of the agents and their assimilation into the white-collar workforce of the public service made it difficult to compile data on the status of their health and safety. Also, further to a request from APSAM (Association paritaire pour la santé et la sécurité du travail, or the joint sector-based association for occupational health and safety, municipal affairs sector), an initial study on the agents' musculoskeletal and psychological health was funded by the IRSST (Institut de recherche Robert-Sauvé en santé et sécurité du travail). That study brought to light the high prevalence rates of musculoskeletal disorders (MSDs) and psychological health problems (PHPs)³, as well as the physical and psychosocial risk factors present in their work (Toulouse et al., 2006).

As a sequel to the initial study, this new study sought to gain an understanding of how these risks emerge in the work, ultimately with a view to proposing courses of action that would reduce their adverse effects on the agents' health. It therefore fits into the framework of an ergonomic approach to work activity, including physiological measures, and is supplemented by a study of the work psychodynamics. This report describes the problem of the occurrence of MSDs and PHPs in the MPSECCs. It also presents the study's reference framework, objectives, and methodology, as well as its results and their concrete translation into courses of action. It ends with a discussion and conclusion.

2. THE PROBLEM

In ergonomics, the physical and psychosocial risk factors identified in epidemiological studies relate to the presence of musculoskeletal and mental demands and workloads that are in turn associated with the presence of MSDs and/or PHPs. The concept of workload refers to the efforts made by workers to cope with the demands they must meet to perform the work and fulfil their roles within the organization. Work demands and workloads are manifested in the physical and mental dimensions of the work activity. In this report, they will be detailed in the context of the work carried out by the MPSECC agents in relation to the MSD and PHP risks.

³ The musculoskeletal regions that are particularly affected are the neck (43%), shoulders (35%), upper back (33%), and lower back (43%). The prevalence rates of psychological distress and occupational burnout are 50% and 49% respectively. The physical risks are caused by the inappropriate layout of the workstations (e.g. work surface, position of the keyboard or screens, chair), and postural constraints. Regarding psychosocial risks, 70% of the call centre agents are exposed to high psychological strain, 90% report an effort/reward imbalance, 40% report low social support from coworkers, and 51% report low social support from superiors.

2.1 State-of-the-art review of knowledge of work demands and musculoskeletal and mental workloads associated with risk of MSDs in MPSECCs

The work demands and musculoskeletal workloads likely to generate a risk of MSDs result from the layout of the computer workstations, the mental workload associated with taking and dispatching emergency calls, and the agents' musculoskeletal health.

2.1.1 *Computer workstation layout and MSDs*

The MSD risks associated with the computer workstation layout arise partly from the workers' exposure to the constraining postures required to use hard-to-access equipment (Arndt, 1983; Bergqvist et al., 1995) and partly from prolonged seated postures (Andersson et al., 1987; Chaffin et al., 1999). In the MPSECCs, these risks stem from the number of pieces of equipment that have to be placed on the worktables and the obligatory sustained presence of the agents at their workstation.

Equipment accessibility depends on how the equipment is arranged, taking into account desk and chair design. Integrating all these factors poses a particularly tricky challenge owing to the quantity of equipment required on the desk. In fact, the workstations are equipped with several screens, keyboards, and mice, a telephone console, a radio console, and a printer, as well as other types of equipment, used, for example, to communicate with callers who are hard of hearing. It is impossible to place all this equipment within the agent's reach, making compromises necessary. Under these circumstances, the magnitude and number of postural constraints required depend on the compatibility of the desk and chair design with the work activity. A number of suppliers currently offer office furniture designed especially for communication centres.

According to the prevalence study, the budgets available for the municipal mergers enabled four of the five centres to upgrade their furniture and some of their computer equipment. These MPSECCs are now equipped with desks that allow work to be performed in sitting or standing position. These desks come from different suppliers. It was therefore considered worthwhile to assess the advantages and disadvantages of these furniture items in relation to the placement and accessibility of the various pieces of equipment. It was also possible to study the use made of the sit-stand desk adjustment options. To date, few such studies have been conducted in companies, but laboratory research has shown that the possibility of varying postures reduces musculoskeletal workload (Hasegawa et al., 2001; Husemann, 2009; Karlqvist, 1998). The results of one study conducted in a bank pointed to a reduction in discomfort for work performed at adjustable sit-stand desks (Roelofs and Straker, 2002). However, another study showed little reduction in pain and infrequent use of the sit-stand adjustment options, despite user satisfaction (Wilks et al., 2006). In addition, a prolonged standing work position is recognized as being uncomfortable (Messing et al., 2005; Messing et al., 2004).

2.1.2 Psychosocial demands, mental workload, and MSDs

A number of laboratory studies have shown the impact of mental workload on musculoskeletal workload (Davis et al., 2002, Dennerlein et al., 2003; Holte and Westgaard, 2002a-b; Holte et al., 2003; Lundberg et al., 1994; Van Galen et al., 2002; Waerstad et al., 1991; Waerstad and Westgaard, 1996). Their results indicate that an increase in the quantity or complexity of the information to be processed during computer work is accompanied by increased neck muscle activity as measured by electromyography (EMG) (Holte and Westgaard, 2002 a-b; Holte et al., 2003; Lundberg et al., 1994; Van Galen et al., 2002; Waerstad et al., 1991; Waerstad and Westgaard, 1996; Westgaard et al., 2002). Another study cites similar results when sources of frustration are present (Dennerlein et al., 2003). Increased muscle activity would appear sufficient to induce pain (Westgaard, 1999). However, a recent study conducted in the workplace was unable to replicate these findings (Mork and Westgaard, 2007). Possibly the work situation studied did not involve sufficient stress to induce a muscular response.

2.1.3 Agents' state of health, musculoskeletal workload, and MSDs

The musculoskeletal workload also depends on the state of the agents' musculoskeletal health. This state of health relates to both the agents' physical health and the presence of a history of musculoskeletal injury or pain. In particular, from an ergonomic intervention standpoint, it is important to examine the opportunities available to the agents to control and manage pain during their work.

2.2 State-of-the-art review of knowledge of work demands and mental workload associated with risk of PHPs in MPSECCs

Work demands and mental workloads are manifested in cognitive and psychic dimensions of the work activity. While often studied separately, they are in fact closely integrated during the work activity (Clot, 2008). In fact, cognitive interpretations influence the emotions experienced, and emotions in turn have an impact on the workers' involvement in the performance of their cognitive and physical work (Ribert-Van de Weerd, 2002). The mental workload level has repercussions on physiological functioning; above all, it would appear to impact on heart rate variability (HRV). One study of air traffic controllers found that an increase in mental workload caused a loss of HRV (Collet et al., 2009).

The prevalence study carried out in the MPSECCs revealed the presence of psychosocial risk factors, which in turn underscored the magnitude of the cognitive and psychic activity involved (Toulouse et al., 2006). This high level of activity stems from demands imposed by the number and variety of tasks to be performed and calls to take, the complexity of handling the requests, the emotional content of the requests, and the lack of recognition or social support. The current knowledge in this regard will now be reviewed.

2.2.1 Number and variety of tasks to be performed and calls to take

The work of the MPSECC agents, particularly in the small call centres, is characterized by the wide variety of tasks that have to be performed. Not only must the agents answer 911 emergency calls, but they must also take calls from the police, operate the police station telephone switchboard, and perform certain administrative tasks such as entering data for the Centre de renseignements policiers du Québec (CRPQ, or Québec's police information centre). The number and variety of tasks to be performed and calls to take have repercussions on the work activity and can impact on the agents' mental workload and the quality of their work.

The number of tasks to be performed depends partly on the unpredictable number of calls received by the agents. A higher or lower volume of calls can come in at any time. The agents' workload can therefore fluctuate and include overload periods, which represent one of the psychosocial risk factors identified in the study on MSDs in teleservice centre operators (Hoekstra et al., 1995; Hurrell et al., 1996). Also, in a study on the transmission of information concerning emergency calls between 911 emergency call centre agents and paramedics, Rhoddenizer et al. (2000) observed that communication transmission incidents occurred during heavy workload periods. The authors found that incomplete information was transmitted during these periods. The 911 agents only transmitted to the first responders the information they considered important. According to the authors, the workload caused by the heavy increase in the number of calls was regulated to the detriment of the quality of the information transmitted. This situation has also been described in the context of mental workload regulation by air traffic controllers. Spérandio (1977) showed that controllers modified how they communicated with pilots according to the traffic load.

The number of tasks to be performed may also constitute a demand that increases the call centre agents' mental workload. This increased mental workload is due to possible interruptions in the performance of their various tasks. In fact, these interruptions cannot be handled solely by applying directives concerning order of priority in task performance. A study conducted in one institution showed that the receptionists, who were required to both take telephone calls and perform word-processing tasks, made errors when the two tasks overlapped. Given that each task was constantly subject to interruptions, the receptionists' mental workload was focussed on remembering the activities that had not been completed (David and Pretto, 1992). According to these authors, the managers' tendency to assign too many different tasks to these receptionists could be related to a lack of recognition of the complexity of the reception-desk tasks.

2.2.2 Complexity of call-handling process

A number of ergonomic studies report the fairly-often underestimated complexity of the work involved in service relationships. This complexity becomes apparent when one looks at the handling of service requests formulated by clients. One of the complex aspects of the process is the need to clarify the unclear or confused requests sometimes formulated by service users. In addition, in some instances, the caller's request has to be reformulated to correspond with the receptionists' response script file (Duhamel, 2000). This request clarification process obliges the worker to analyze and diagnose the request so as to understand what the person is actually asking (Duhamel, 2000; Pochat and Falzon, 2000), an activity that is more or less arduous, depending on the quality of the relationship established with the service user. The receptionists have to learn

to manage these situations with difficult callers (Duhamel, 2000). Such skills can be acquired with experience. The receptionists thus learn to anticipate the callers' requests for explanations and to infer what the latter understand of the explanations provided (Pochat and Falzon, 2000). To do so, they must be vigilant and attentive, memorize large quantities of information, and constantly keep up with changes taking place within the organization (Pochat and Falzon, 2000). The emergency nature of the context adds further complexity to the communication with the caller (Grosjean, 2008; Tracy, 1997; Zimmerman, 1984 and 1992). In these situations, the agents have to obtain information quickly, while the callers are not always in a condition in which they are able to express themselves clearly or to accept the agent's directive questions.

The prevalence study conducted in the MPSECCs also brought to light other problems faced by the agents when handling calls. The agents emphasized notably the problems associated with the technology interfaces and the unavailability of first responders. Moreover, they sometimes have to utilize first responder skills themselves, particularly in regions not covered by a specialized emergency telephone service such as Urgence santé or Prévention suicide. For example, we identified one case in which the agent was able to save a life by guiding the caller through the steps of cardiopulmonary resuscitation (CPR) while awaiting the arrival of first aiders (Roberge, 2002).

2.2.3 Emotional content

The emotional content of the call centre agents' work concerns various aspects: the relational dimension of emergency communications, the responsibility for responding quickly and appropriately to emergency calls, exposure to descriptions of dramatic situations, and the need to control their own emotions.

When handling 911 emergency calls or during police interventions, the agents have to cope with dramatic situations in which human lives are at stake. Handling these calls is therefore particularly demanding on the emotional level. Working in contact with individuals who are subjected to traumatic events, who are sometimes in a state of shock, and the outcome of whose requests can turn catastrophic (for example, when a caller commits suicide) can induce unusual physical and emotional reactions in the agents (Mercier-Leblond, 1994). This phenomenon is known as "critical incident stress" and is defined as follows: "any event which has a stressful impact sufficient enough to overwhelm the usually effective coping skills of either an individual or a group. [They] are typically sudden, powerful events outside of the range of ordinary human experiences" (Mitchell and Everly, 1993).

Although critical incident stress is reasonably well documented in first responders, our review of the literature did not reveal any scientific articles on this problem as experienced specifically by 911 emergency call centre agents. However, the phenomenon is discussed in professional journals, notably in articles by Francis X. Holt (1989), a specialist in this field. Critical incident stress can generate post-traumatic distress. Our study of call centre agents identified two cases of elevated post-traumatic distress, while 55.6% of the agents reported having had a traumatizing experience in the course of their work.

These traumatizing experiences attributable to the dramatic situations faced by agents when handling calls represent one of the specific aspects of the service relationship work performed by

911 emergency call centre agents. However, they may also encounter other problems involving emotions. These problems pertain to the interface role they play between citizens calling for 911 emergency services and first responders. They concern the challenges of reconciling the emergency service needs perceived by citizens with first responders' roles and expectations. The difficulties encountered with citizens requesting emergency services but whose needs do not always correspond clearly to 911 services can result in discontent citizens. First responders can also react negatively to requests for intervention that they regard as unjustified. Their reactions range from simple casual remarks to more outright rudeness. Faced with these situations and knowing that the conversations are being recorded and that citizens can file official complaints with the organization, the agents are obliged to control their emotional reactions. This disconnect between the emotions experienced by the agents and the emotions they are able to express demands emotional control on their part, which Hochschild (1983) defines as "emotion work." This need for emotional control is a factor present in the work of 911 emergency call centre agents (Shuler, 2001; Tracy and Tracy, 1998). However, the impact of this control on psychic workload and health is unclear. According to some studies, frequent and intense emotional work generates anxiety and frustration in workers and a feeling of being overextended (Maslach and Jackson, 1981; Perlman and Hartman, 1982, Zapf, 2002). On the other hand, recognition of this emotional work may serve as a factor that protects psychological health. In fact, workers have reason to be proud of their ability to handle this emotional work (Zapf, 2002).

2.2.4 Social support and recognition

The demands related to the agents' work, whether the quantity and variability of the tasks to be performed and calls to be handled or their complexity and emotional content, are particular in nature given the content of the service rendered by the agents and the major responsibility associated with it. From this perspective, it appears that social support from peers is a crucial factor in the preservation of the agents' health. In fact, social support and recognition can help agents develop self-assurance, self-confidence, and a feeling of control over their work when dealing with the inherent work demands and uncertainties. Yet the prevalence study showed that the agents lack social support and recognition. Ergonomic and work psychodynamics studies can provide us with a better understanding of the form this problem takes for agents working in the MPSECCs.

Ergonomic studies have shown that, given the variations and contradictions inherent in any task, it is impossible to anticipate everything. There is always a gap between the prescribed work that can be anticipated and the real work (Daniellou et al., 1983). Regardless of the precision of the prescribed procedures and work methods, the real work also involves a degree of the unforeseen, a grey zone that obliges the worker to reinterpret instructions and procedures in order to cope with a given situation. Work never boils down to a mere activity to be performed, and even less so for agents who are faced with a variety of tasks and varying volume of relatively complex calls that have an overlay of more or less intense emotional content.

This work of reinterpreting instructions and procedures is subject to doubt and interrogation, such as "Did I make the right decision? Did I pass on all the necessary information?" To eliminate these uncertainties, the agents require access to feedback about their work, from both first responders and their coworkers and superiors.

Work psychodynamics studies on the role and importance of work collectives have shown that to assist workers in coping with the uncertainty and doubt associated with decision making in real-life work situations, workers need to be validated and to verify and discuss their choices and practices (Dejours, 1995a and b). Coworkers involved in the same process thus become points of support essential to recognition of their strengths and weaknesses and their development of competencies. The possibility of discussing their practices with coworkers leads to the development of occupational rules and guidelines and the building of a work collective. These rules are built through a process of regulation and normative agreements that provide a framework for the way in which each person manages his or her relationship with the realities of the work and that support decision making in difficult situations. Self-assurance, self-confidence, and the feeling of having control over the task at hand are supported by others' looks and by peer recognition and social support.

In contrast, when coworker support is absent, workers may develop psychological defence strategies to cope with the anxiety caused by doubt, for fear of making errors that prevent people's lives from being saved or of putting first responders' lives at risk. These psychological defence strategies can help workers combat anxiety and thus stay in their jobs when adequate social support is missing. However, these defence strategies also have their downsides as they allow dysfunctional situations to persist at the expense of individual and collective efforts that camouflage certain aspects of the work reality.

2.3 Conclusion

Based on our review of the literature on musculoskeletal and mental workload, we were able to specify both the nature of the demands present in terms of the technical, organizational, social, and human characteristics of the work and the problems that can arise concerning the regulation of the musculoskeletal and mental workload associated with MSDs and PHPs. This issue is a complex one involving various dimensions of the work as a whole and the activity per se. A presentation of the conceptual framework should therefore provide a clearer picture of all the elements involved.

3. CONCEPTUAL FRAMEWORK

The conceptual framework for this study was an adapted version of the ergonomic model of activity analysis (Guérin et al., 1997) (Figure 1). This model was supplemented by the occupational health and safety intervention concepts developed by Baril-Gingras (2004).

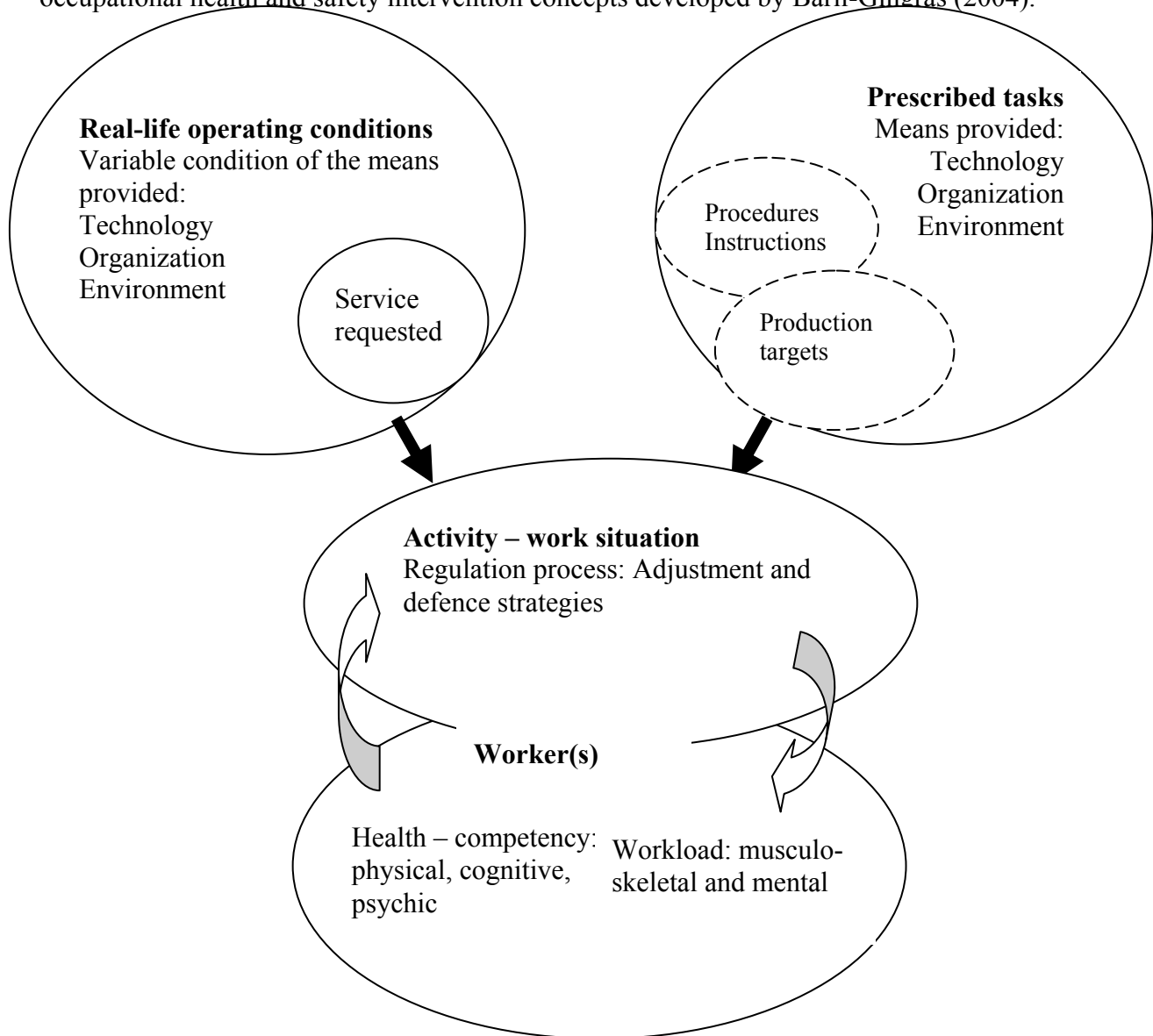


Figure 1: Adaptation of the activity analysis model (G. Toulouse)

In this model, the work activity is developed by the workers in light of their competencies and state of health (e.g. musculoskeletal pain) and according to the objectives set and means available for performing the prescribed tasks, taking into account the operating conditions that arise during work. This leads to a mental and musculoskeletal workload for the workers, which in turn, modifies their physical, cognitive, or psychic condition. The prescribed tasks encompass all the objectives sought as well as the organizational and technological means available. They

are designed on the basis of representations of the real-life operating conditions and the activity in order to combine the service mission with economic and regulatory criteria.

The service delivered is the result of the workers' regulation of the prescribed-task requirements and the operating conditions, taking into account their own characteristics. The regulation process occurs at two levels: both individual and collective (psychosocial support). The first level is characterized by adjustment strategies, which correspond to work practices aimed, where possible, at meeting the prescribed-task requirements and protecting the workers' health and safety while taking the real operating conditions into account. Their effectiveness depends on the leeway available. These strategies are individual or collective, depending on the type of cooperation possible. In cases where insufficient leeway is available, adjustment strategies may be implemented at the expense of the worker's health and safety. In these circumstances, a second level of regulation appears with the implementation of defence strategies. These strategies are used to ensure psychological protection against risks. They camouflage, minimize, or create a psychological distance from the demands potentially endangering health and safety. These defence strategies evidenced in the work psychodynamics are collective in nature (Dejours, 1993-b). They constitute a type of support focused more on the emotional and affective dimensions of the work.

Risk-reduction interventions involve implementing a mechanism that brings together the different stakeholders in prevention. These stakeholders participate in the various steps of the process, including the conducting of the study, discussion, interpretation of the results, development of courses of action, and implementation of solutions. The implementation of solutions depends on the intervention context, as well as the predispositions and capacities of the stakeholders involved (Baril-Gingras et al., 2004).

In ergonomics, the intervention process includes the following steps: developing (planning and carrying out) the intervention, factoring in the organization's context, diagnosis, and change (Guérin et al., 1997). During intervention development, the external parties and the organization's participants identify the problems to be tackled and define the intervention's general objectives, as well as the steps required to bring about changes. Such was the aim of this project. The fact of taking into account both the organization's context and the intervention participants' predispositions and capacities supports the development of courses of action for improving occupational health and safety. Diagnosis corresponds to the step in which work situations are analyzed, and is carried out by the researchers together with the organization's participants. From a change perspective, the purpose of diagnosis is to describe and help the organization's participants understand the demands or resources that hinder or facilitate regulation of the musculoskeletal and mental workload. Discussion of the diagnosis helps to modify participants' representations of the work situation, which in turn paves the way to changes in the work with respect to occupational health and safety (Daniellou, 1998; Garrigou, 1992).

4. OBJECTIVES OF THE STUDY

The study had three objectives:

- I. To describe the processes used by 911 emergency call centre agents to regulate their musculoskeletal and mental (cognitive and psychic) workloads.
- II. To identify the work characteristics facilitating or hindering regulation of the musculoskeletal and mental (cognitive and psychic) workloads that are likely to constitute physical and psychosocial risk factors for MSDs and PHPs. However, given the MPSECCs' recent investment in furniture to reduce the physical risks, the study focused more on analyzing the psychosocial risks for the purpose of developing courses of action.
- III. To propose, with the follow-up committee, possible courses of action, taking into account the work sector context and the project participants' predispositions and capacity to act.

Objectives I and II were based on the following general hypotheses:

- The MSDs and PHPs present derive from the MSPECC agents' difficulty in regulating their musculoskeletal and mental (cognitive and psychic) workloads in a way that obviates the physical and psychosocial risk factors.
- The difficulties in regulating the musculoskeletal load that are associated with workstation layout are manifested as postural constraints. The presence of sit-stand desks offers the possibility of being able to regulate the musculoskeletal load according to the mental demands of the work being carried out and the pain or fatigue sensations experienced. The difficulties in regulating the mental workload are accompanied by an increase in muscle activity, shorter rest periods for the trapezius muscles, and the presence of musculoskeletal pain, and have an impact on the loss of heart rate variability.
- In order to cope with these regulation difficulties, the call centre agents form a representation of their work that focuses on its complexity, the sources of pleasure present in the work, and specific collective defence strategies.
- The difficulties in regulating the musculoskeletal and mental (cognitive and psychic) workloads stem from the fact that the agents have no leeway. This absence of leeway is attributable to the current gap between the prescribed work, the real-life operating conditions, and the agents' experience.

Objective III is based on the following general hypothesis:

- Changes in work situations for the purpose of reducing the prevalence of MSDs and PHPs result from the possibilities of reconciling the predispositions and abilities of the participants involved in the MPSECC intervention, taking into account the sectoral context and the changes necessitated by the difficulties of regulating the musculoskeletal and mental workloads as identified during the diagnosis.

5. METHODOLOGY

5.1 Overview of the method

The research project described in this report used a case study (Yin, 1994) and activity analysis (Leplat, 2002) methodology, a methodology that is warranted when the research issues involve seeking to understand a phenomenon occurring in its real-life context. The researchers ask questions about the “how” and “why” of the phenomenon and generally have little control over the events surrounding it (Yin, 1994). The term *case* is defined in different ways, depending on the phenomenon under study. According to Leplat (2002), a case can be defined as an object, event, or situation constituting a unit of analysis. This unit is taken from reality and fits into a context that must not be overlooked. The choice of case to be studied depends on the research objective and its theoretical framework. According to the model presented, the case studied here is that of the work situations faced by MPSECC agents. These situations were described with a view to analyzing the musculoskeletal and mental workloads, on the one hand, and to proposing means of reducing the MSD and PHP risks on the other.

The empirical nature of a case study is determined through the construction of internal validity, external validity, and reproducibility (Yin, 1994).

Internal validity is constructed by using several data sources and establishing links among them. This project was therefore conducted on the basis of several complementary data sources: observation, recording of the conversations held during 911 calls, administering of perception rating scales, recording of trapezius muscle and cardiac activity, self-confrontation interviews, and group interviews.

External validity refers to a determination of the generalizability of the case study results. It is the crux of the case study approach. In fact, in this type of study, it is more difficult to properly situate the sample relative to the reference field. For the project documented here, the problem was all the greater given that there was no prior study or report providing a comprehensive profile of the MPSECCs. Therefore, to ensure that the work was as representative as possible, the preferred characteristics of the MPSECCs were determined with the help of consultants from APSAM. As a result, the study concerned work situations occurring in five emergency centres (Table 1) that encompass several characteristics present in the 45 MPSECCs operating in Québec in the fall of 2005. These characteristics are as follows: coverage of urban and rural regions; varying sizes; technical characteristics; working hours; and the agent population.

Reproducibility involves describing the methodology as precisely as possible so that it can be replicated. This description concerns the process and equipment used as well as the type of analysis performed. However, when a qualitative methodology such as interviews is involved, it cannot be substituted for researchers’ experience.

Table 1: Description of five emergency call centres within municipal public security system (MPSECCs) involved in study

	MPSECC-1	MPSECC-2	MPSECC-3	MPSECC-4	MPSECC-5
Population served	255,000	320,000	600,000	63,000	170,000
Number of agents	38	41	69	14	32
Workstations	8 workstations: 1 team leader workstation 2 call-taking workstations 2 police-dispatching workstations 2 firefighter-dispatching workstations 1 CRPQ* workstation	8 workstations: 3 call-taking workstations 3 police-dispatching workstations 2 firefighter-dispatching workstations	17 workstations: 2 supervisor workstations 6 call-taking workstations 4 police-dispatching workstations 2 firefighter-dispatching workstations 1 public works-dispatching workstation 2 deferred complaint-taking workstations	3 generalist call-taking, and police-, firefighter-, and public works-dispatching workstations	5 generalist call-taking and police-, firefighter-, and public works-dispatching workstations
Duration of shift	9 h	12 h	8 h	8 h and 12 h (weekends)	8¾ h
Number of calls in a year	440,023 (94,100 calls to 911)	300,000 (120,000 calls to 911)	400,000 (280,000 calls to 911)	45,000 calls to 911	66,606 calls to 911

*CRPQ: Centre de renseignement policier du Québec

The use of a multidisciplinary approach allowed for clearer identification of the risks through physiological measurements and the use of perception rating scales. It also allowed the risks to be situated within the work activity by means of ergonomic analysis and for the subjective experience to be understood through the work psychodynamics. The physiology study performed to identify the risks had an exploratory purpose, as few studies of this type are carried out in workplaces.

The sectoral participation structure, i.e. the follow-up committee, was formed during the prevalence study. In addition to the research team, the follow-up committee comprised one advisor from APSAM, one knowledge transfer advisor from the IRSST, and one employer and one union representative for each of the five MPSECCs. The members of the follow-up committee reviewed and ratified the proposed intervention process. They then took part in the organization of the project's logistics, and later, in the results interpretation and courses-of-action development steps. In addition, the results were presented and courses of action discussed and validated with the agents in three of the five MPSECCs. For logistical reasons, this meeting could not be held in the other two MPSECCs.

The methodology of the ergonomic/physiology and work psychodynamics studies is discussed in the following sections.

5.2 Ergonomic/physiology study

5.2.1 Workstations and participants

The selected workstations focused primarily on call-taking and police-dispatching tasks, the two permanent tasks forming the core of the agents' activity.

The agents were chosen from among volunteers comprising both women and men who were either experienced or novices in this occupation. The selection process was supervised by a committee made up of the centre manager, the union representative, and researchers. Volunteers were recruited following the distribution of information pamphlets and posters explaining the conditions that would prevail during observations and the collection of physiological data. To finalize the choice, a telephone questionnaire on the person's state of health was administered to each of the potential participants. In fact, the population selected had to be in good cardiopulmonary health and not have been diagnosed with a musculoskeletal disease, notably low back pain or neck pain.

A total of 15 agents divided among the five centres were recruited for the ergonomic/physiology study. The chosen sample allowed data to be collected on the call-taking and -dispatching tasks performed by both women and men, including novice employees, in the five MPSECCs. They were all permanent employees. Due to technical problems with the data-recording process, it was possible to analyze the physiological data for only 11 agents in the electromyography (EMG) of the trapezius muscles and for only nine agents in the heart rate study, or electrocardiography (ECG).

5.2.2 Data collected and collection methods

The collected data concerned various aspects serving to describe, evaluate, and identify the work activity components that could impact on the musculoskeletal and mental workloads. These data were the following: the postural and dimensional constraints pertaining to the workstation layout, the description of the communication activity, the subjective evaluation of musculoskeletal pains and mental workload, the physiological EMG and ECG measurements, as well as the description of the work situations in connection with the musculoskeletal and mental workloads.

Data collection took place from December 2007 to June 2008.

5.2.2.1 Postural and dimensional constraints associated with workstations

The description of the postural and dimensional constraints related to the workstation layout was based on the adapted use of computer workstation evaluation criteria from guides existing in that field, notably the Canadian Standards Association guide (2000) and the SuvaPro guide (2003). The workstation layout was described by a single observer using a chart that allowed the same type of data to be collected systematically for each workstation. The chart is shown in Appendix A. The work was filmed as it was carried out. The camera was positioned in such a way as not to hamper people from moving around, and its position varied from one centre to the other. Consequently, the agents' postures were not always totally visible.

5.2.2.2 Description of telephone call activities

The telephone call activities were described in terms of the type of incoming line, nature of the call, type of operation, and difficulty of the call. They were defined in light of the preliminary observations and meetings with the agents during the physiological test sessions. The observables investigated are presented in Table 3. The telephone calls were recorded using each call centre's recording system.

5.2.2.3 Subjective evaluation

Data on the agents' evaluation of their workload; call complexity; positive emotions; negative emotions; efforts expended to control emotions; low back pain; neck and shoulder pain; and elbow, wrist, and finger pain were collected by means of Borg's CR-10 scales (Appendix B). Used in ergonomics, these scales are well-validated for evaluating perceived musculoskeletal pain and physical efforts (Borg, 1998). However, they have not been validated for perceived workload, call complexity, or emotion.

Inasmuch as possible, the scales were administered approximately every 30 minutes during the workshift. The 30-minute period was a compromise to prevent overly frequent interference in the agents' work and to benefit from a period of time that would allow for the most accurate measurements possible of the subjective indices during the workshift.

5.2.2.4 Physiological measurements

The physiological measurements recorded were trapezius muscle activity and heart rate. The indices of trapezius muscle activity concern the measurement of fatigue and level of activity (Amplitude Probability Distribution Function (APDF), Jonsson, 1978) and the analysis of muscle rest times determined in a manner similar to that used by Samani et al. (2009).

Heart rhythm is measured by the heart rate (HR) (number of heartbeats per unit of time) and primarily heart rate variability (HRV) indices. HRV reflects the activity of the autonomic nervous system. Three different methods of HRV analysis exist: time-domain analysis, spectral analysis, and the Poincaré plot. The different types of measures, or indices, have their own specific characteristics that influence them. Measurement and analysis standards have been established by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996). A recapitulation of these standards is provided in Table 2. Generally speaking, except during sports activities, a healthy HRV is irregular and correlates with good cardiac muscle tone and efficient regulation of nerve activity. Frequent reference is therefore made to "loss" of HRV when it becomes regular. The HRV indices that will be analyzed here concern the parasympathetic nervous system (pNN50, HF), sympathetic nervous system (SDNN), parasympathetic and sympathetic nervous systems (LF), and sympathovagal balance (LF/HF) (Table 2).

Table 2: Heart rate variability (HRV) indices analyzed

General	
HRV	Heart rate variability
Time-domain analysis	
SDNN	Standard deviation of normal-to-normal (NN) interbeat intervals (IBIs) calculated on five-minute segments expressed in milliseconds (ms). Normal values (over 24h) = 141ms (SD = 39)
SDANN	Standard deviation of normal-to-normal interbeat interval averages calculated on successive five-minute segments; evaluated over the work shift and over the 24-hour cycle measured; expressed in milliseconds (ms). Normal values (over 24h) = 127ms (SD = 35)
pNN50	Percentage of differences between two successive heart beats greater than 50 ms; expressed as a percentage (%).
Spectral analysis	
LF	Low frequency, component of the heart rate variation whose range of frequency is between 0.04 and 0.15 Hz; expressed in milliseconds squared (ms ²). Normal values (over 24h) = 1170ms ² (SD = 416); normal values (over 24h) = 54 n.u.* (SD = 4)
HF	High frequency, component of the heart rate variation whose range of frequency is between 0.15 and 0.40 Hz; expressed in milliseconds squared (ms ²). Normal values (over 24h) = 975ms ² (SD = 203); normal values (over 24h) = 29 n.u.* (SD = 3)
LF/HF	Ratio of low frequencies to high frequencies, represents sympathovagal balance; no unit. Normal values (over 24h) = between 1.5 and 2

* To calculate LF in normalized units: $LF_{n.u.} = LF / (P_{tot} - VLF) \times 100$. To calculate HF in normalized units: $HF_{n.u.} = HF / (P_{tot} - VLF) \times 100$; (P_{tot} = total power).

More detailed information on normal HRV values can be found in an article by Agelink et al. (2001).

Installation of equipment on participants

The EMG signal of the right and left trapezius muscles was recorded using two pairs of differential electrodes pre-amplified at source (gain: 1000) with a bandwidth of 20 Hz to 500 Hz (Delsys, Boston, Ma.). The surface electrodes (DE-2.3, DelSys Inc., Wellesley, United States, two 1-cm bars spaced 1 cm apart) were positioned on the participants in accordance with the recommendations made by Jensen et al. (1993), i.e. 2 cm lateral to the midpoint between the seventh cervical vertebra (C7) and the acromion. The signal was recorded at a frequency of 1024 Hz using a Myomonitor IV system (DelSys Inc., Wellesley, United States).

The ECG was recorded using seven thoracic electrodes placed to obtain the V1 and V5 precordial derivations as well as the bipolar DIII derivation. These electrodes were connected to a portable recording device, or Holter monitor (3-channel Rozinn® RZ153+). The ECG and EMG recordings were synchronized. The EMG was recorded from the beginning to the end of the post-observation measurement-taking period, while the ECG was recorded over a 24-hour period. The Holter device was removed the following day before the self-confrontation interview.

Taking of pre- and post-observation physiological reference measures

Physiological reference measures were taken before and after the work shift. These measures were taken in three positions. The first measure was recorded with the participant sitting on a chair with back supported and hands on thighs. The recording of the useful signal lasted 30 seconds for the EMG and five minutes for the ECG. The EMG signals were presented as feedback to the agent, who was instructed to reduce the amplitude of the signal from the two muscles as much as possible. The second measure was recorded while the agent was lying down for 10 minutes. Lastly, the third measure was recorded with the agent in standing position with arms abducted to 90°, while holding a one-kilogram load in each hand (RVE: sub-maximal reference contraction). Once the agent had properly adopted the reference posture, the signal was recorded for a period of 15 seconds. A one-minute pause was given before this reference contraction was repeated.

After the work shift, the EMG and ECG signals were recorded again for each of the reference postures, starting with the standing posture with arms abducted, followed by the lying posture and then the sitting posture.

5.2.2.5 Description of work situations in relation to musculoskeletal and mental workloads

The description of the work situations in relation to the musculoskeletal and mental workloads was based on self-confrontation interviews. This method currently encompasses a variety of practices (Theureau, 2000). In the present study, the agents were interviewed in order to gain an understanding of the sequence of events that had an impact on their regulation of their musculoskeletal and mental workloads during work. The interview was guided by the agent's responses on the perception rating scales and by the researchers' direct observations of adjustments made to the sit-stand workstation, the layout of the workstation, the handling of certain calls, and the work involving coworkers or first responders, notably police officers. The reference period for the self-confrontation interview was broadened to include the agent's prior experiences regarding each of these topics.

The self-confrontation interviews were conducted the day after the observation period, lasted approximately three hours, and were video-recorded.

5.2.3 Data analysis

5.2.3.1 Analysis of workstation layout

The purpose of analyzing the workstation layout was partly to evaluate the accessibility of equipment that could cause postural strains and partly to describe the agents' use of possible adjustments to the sit-stand workstation. The analysis concerned the following points: the description of the placement of the equipment compared to the ergonomic design of the workstations, the identification of the postural constraints, and the agents' comments during the self-confrontation interviews. The postural constraints refer to the observed range of motion away from the neutral zone combined with the absence of a point of support. Using the video films, two researchers observed the use made of each piece of equipment during the entire work

shift. They noted each postural constraint and its observable variations without doing a systematic survey per se. In fact, the variable position of the cameras in each of the centres made it difficult to observe the movement of certain joints of the upper extremities. The qualitative description of the postures was completed using the agents' comments on these postures.

5.2.3.2 Description of agents' work and workstation adjustments

The work performed in the situations observed was described (Table 3) using the video and telephone conversation recordings and Observer software. The Observer XT8® system is event-logging software from Noldus Information Technology. It allows all the different information collected to be compiled and processed, and a link to be established between the work activity observables and the various indicators (physiological and subjective).

Table 3: Description of agents' work and workstation adjustments

Observables	Descriptive analyses
Incoming lines: 911, city police, public works, internal calls, other lines	Frequency and duration of calls, by incoming line
Nature of the call: internal information, call originating from a public service, burglar alarm company, neighbourhood problem involving no violence, threat to or violence perpetrated against a person, damage to property, suicide, accident with no injury, accident with injury, accident impeding traffic, ambulance call, ambulance call and police intervention, road safety, fire, call for a municipal service, citizen complaint, public security information, unclassifiable (referred to as <i>VERPER</i> by the agents), involvement of a child in danger (specific variable that could provide additional information about the nature of the call).	Identification of the high-stress periods (any call involving a child in danger, any threatening or violent act, suicide, accident involving injury or resulting in a dispute or impeding traffic, road safety problems, fire)
Type of operation: working on the telephone, working on a case when off the telephone, break, using the radio console, action on the telephone console, consulting a document, printing a document, communicating with police officer in the centre, communicating with coworkers, communicating with observers, taking notes on paper, monitoring-standby, unknown activity.	Frequency and duration of work on the telephone, working on the case but off the telephone, other activities
Difficulties faced in calls: request not clear, caller panicking, caller does not answer agent's questions, difficult to interrupt caller, agent expresses disagreement with caller (who may become rude), caller difficult to hear, caller difficult to locate, difficult to find police vehicle that is free to intervene.	Classification of difficulties faced: cognitive problems (request not clear, caller difficult to hear or difficult to locate, difficult to obtain a vehicle), relational problems (caller panicking, caller does not answer agent's questions, difficult to interrupt the caller, agent expresses disagreement)
Workstation adjustment: sit, stand Working at workstation and/or away from workstation Working in sitting or standing position.	Duration and frequency of work performed in sitting or standing position

5.2.3.3 Perception rating scales

The distribution of the mental workload levels measured for the various items (workload, complexity, emotions) was described by the average and maximum levels recorded. The distribution of musculoskeletal pains was described for each agent according to the number of periods experienced without pain, with extremely little or little pain, and with moderate or intense pain.

For each agent, the correlations between two mental-workload and musculoskeletal-pain measurement items were calculated with Spearman's rho (ρ) using a significant threshold equal to or less than 0.10 (≤ 0.10). The median Spearman's rho for the significant correlations was then evaluated for each item. The result was therefore described by the median value and the number of agents exhibiting a significant correlation. If no significant correlation was present between two items, no value was given for any agent. The correlation between two variables was considered generalizable when the median Spearman's rho was greater than 0.50 for the majority of agents. When the median Spearman's rho approached zero, this meant that there was both a positive and a negative correlation, such that no clear correlation could be determined. Also, when the median of the correlations concerned few agents, the result was not generalizable, as the relationship depended on each case (the agent's characteristics and situational demands).

5.2.3.4 Analysis of EMG of trapezius muscles

5.2.3.4.1 Preparation of EMG data on trapezius muscles

The EMG signals were conditioned as described by Delisle et al. (2005). A high-pass digital filter with a cut-off frequency of 30 Hz was used to exclude the electrocardiographic signal and reduce the possible influence of electrode movement on the skin (Hansson et al., 2000). The RMS (root mean square) amplitude of the signal was calculated through successive 0.256-second windows. Various analyses were performed using these signals.

5.2.3.4.2 Analysis of EMG of trapezius muscles during pre- and post-work rest periods as point of reference

The pre- and post-work shift recordings of the EMG signals in seated and supine postures allowed the quality of the signals to be verified, while the recordings of these signals in abduction postures were used to assess the onset of fatigue in the trapezius muscles. This was assessed using the median frequency and the average RMS amplitude of the signals recorded during the sub-maximal reference contractions. A decrease in median frequency combined with an increase in average RMS amplitude, for the post-work shift contraction compared to that of the pre-work shift contraction, was interpreted as a sign of fatigue.

5.2.3.4.3 Analysis of EMG of trapezius muscles during work shift

The analyses of the EMG signals recorded during the work shift involved the measurement of muscle rest and activity levels. The muscle rest analysis consisted of counting the frequency of muscle rest intervals per minute and the relative time proportion of the muscle rest intervals. A rest interval was defined as a 0.256-second period with an activity level below a threshold that

was predetermined for each participant. This threshold was established in such a way as to obtain a 95% proportion of muscle rest intervals during the recording time for the supine reference posture, an approach similar to that proposed by Samani et al. (2008). The number of rest intervals per minute, as well as the total number, was determined in proportion to the recording time.

Activity levels were analyzed using the EMG RMS signal normalized on the basis of the sub-maximal reference contraction (RVE). The Amplitude Probability Distribution Function (APDF) (Jonsson, 1978) was used to calculate the EMG activity levels corresponding to the 10th (static level), 50th (median level) and 90th (maximal level) percentiles.

In order to relate the agents' responses on the perception rating scales to the muscle activity patterns, the above-mentioned EMG variables were calculated for the 30-minute periods preceding the subjective evaluations. These EMG values were compared in order to determine whether they corresponded to low or elevated levels for each item measured using the perception rating scales. Again for each item, a difference equal to or greater than 2, in terms of perception rating scale units, determined the elevated level and a difference of less than 2, the low level. The method used was in line with that proposed by Mork and Westgaard (2007).

The EMG variables were also calculated for 5-minute time periods before and after high-stress events identified during the agent observation period. The calculation concerned 54 periods.

To determine whether the activity patterns differed according to subjective perceptions and to high-stress periods, a Wilcoxon test was used to check whether the medians of the variables were different, at a 0.05 level of significance. This test was used under the same conditions by Mork and Westgaard (2007). The statistical analyses were performed using the following software: NCSS 2007 and GESS, Version 07.1.18 (Hintze J., 2007).

5.2.3.5 Analysis of heart rate

5.2.3.5.1 Preparation of HRV data

The spectral domain indices required the transformation of the ECG curves into regular curves, the sum of which was equal to the initial curve. This in turn required a fast Fourier transformation (FFT) routine performed on samples equal to or greater than 256 R-R intervals. These were split into two main parts: low frequencies (0 – 0.15 Hz; LF) and high frequencies (0.15 – 0.40 Hz; HF). All the analyses were based on five-minute periods.

The electrocardiogram was obtained using Rozinn software: Holter for Windows+. The R-R intervals were then imported into Kubios HRV Analysis Software 2 (Biosignal Analysis and Medical Imaging Group, University of Kuopio, Finland). This allowed the HRV indices to be extracted and time-domain, spectral, and Poincaré plot analyses to be performed.

5.2.3.5.2 Analysis of heart rate during pre- and post-work rest periods as point of reference

The pre- and post-work heart rates and HRV indices were compared independently for seven experienced and two novice agents. This distinction among the agents was attributable to the fact that heart rate can vary according to experience and notably due to anticipation of stressful conditions. The pre- and post-work values were compared using Student's *t*-test.

5.2.3.6 Analyses of heart rate during work shift

The heart rate and HRV indices (pNN50, HF, SDNN, LF and LF/HF) were calculated for 30-minute periods prior to the subjective evaluations. These data were then compared to the agents' responses on the perception rating scales measuring mental workload and fatigue. Correlation analysis was performed for each agent using Spearman's rho and the median of the significant correlations was calculated. The results were presented by indicating the median Spearman's rho for the number of agents concerned. They were interpreted in the same way as with the correlations between the subjective scales. In addition, as with the EMG, the HRV indices were calculated for five-minute periods prior to and following the high-stress events identified during the agent observation period.

All statistical analyses were performed using JMP® 9 MAC software.

5.2.3.7 Description of work situations based on responses obtained on perception rating scales

The work situations involving a high-level workload, complex calls, positive and negative emotions, and pain were documented by means of self-confrontation interviews and listening to the telephone conversations. The comments made during the self-confrontation interviews were transcribed and classified by two researchers.

The synthesis of the comments includes descriptions of the following: identification of the situations that are problematic or deemed to be positive, some of the strategies used by the agents to cope with problem situations, and the dilemmas faced such that some of these strategies involve risks of "error" or of relational problems with the callers or first responders. Moreover, by listening to the conversations using Observer software, it was possible to identify cognitive or relational problems and the strategies used by the agents to resolve them. The summaries were presented to and validated with the follow-up committee and a group of call centre agents.

5.3 Work psychodynamics study

The work psychodynamics study used a qualitative research design based on the data obtained from group discussions and a theoretical analysis framework used in work psychodynamics (Dejours, 2000). A total of four groups of emergency call centre agents located in four different regions of Québec participated in a series of two interviews, each lasting three hours. Each group consisted of at least five individuals who convened on a voluntary basis and under confidential

cover. They were recruited in a separate process from that for the ergonomic/physiology study. One of the requirements was that there be no hierarchical relationship between participants. A total of 11 men and 10 women took part in the interviews, essentially reflecting the same gender proportions as present in the work teams. Two of these individuals also took part in the ergonomic/physiology study.

The purpose of the first meeting was to acquire an in-depth understanding of the various aspects of the agents' work based on their perceptions of their work, the various demands they encounter, and their coping strategies. The meeting also helped clarify the predominant ways in which the agents discuss problems and assist and support each other, and allowed for more thorough documentation of the nature of the relationships between the agents and the other parties involved in dispatching calls and delivering the various emergency services. Lastly, it brought to the fore the means used by the agents to cope with the demands imposed by their work, from the standpoint of both occupational know-how and defence strategies.

The partial retranscriptions of the content of the group interviews (verbatim transcripts) were analyzed using a frame of reference designed for work psychodynamics. The transcripts first underwent vertical analysis, group by group, in order to identify the main topics covered. This was followed by transverse analysis, across groups, in order to identify the similarities and differences between the various 911 centres.

A second analytical step was carried out to compare the researchers' analyses and interpretations to those of a group of external researchers working in the field of work psychodynamics (Dejours, 2000; Institut de psychodynamique du travail du Québec, 2006). Themes and logics were gradually linked so as to build a coherent representation of all the results.

The specific purpose of the second meeting with the groups was to validate the researchers' analyses and interpretations. The intersubjective dynamics of the group discussion allowed the agents to share their own interpretations of the topics broached and to discuss them among themselves and with the researchers. This type of discussion serves to bring to light and clarify the different points of view and can lead to the construction of a shared interpretation of the topics raised.

6. RESULTS

6.1 Description of work of agents assigned to taking and dispatching emergency calls

The task of taking emergency calls includes the following communication steps: taking the call, analyzing the citizen's request to determine its nature and priority, asking questions to obtain the information needed for the intervention and to ensure the first responders' safety, providing the caller with answers, and ending the call. These steps vary, depending on the nature of the call and the work context. For non-urgent requests or those that can be handled without police intervention, the agent may direct the caller to other services. Sometimes the agent's questions help the caller to find his or her own solution to the problem. The agent may also consult data bases in order to situate the request in relation to prior facts or to verify the content of certain files. When the request is problematic, the agent may transfer the call to a police officer. In the largest call centre, this officer acts as the agents' supervisor, whereas in the other centres, the police officer whom they contact is the patrol sergeant, namely a police officer assigned to the reception desk at a police station.

Depending on the urgency of the situation, the request is passed on to paramedics, firefighters, or patrol officers, as well as to other emergency service providers such as public works, Hydro-Québec, and gas and telephone company employees. Calls for ambulance service are transferred to a specialized secondary centre. The MPSECC agents dispatch police officers and firefighters via the computer system by transmitting the calling card (call record form) or through radio or telephone communications in the case of a volunteer firefighter service. The calling card includes the event location, the caller's name and contact information, the call priority, a description of the event, and sections to be completed during request follow-up.

Each police-dispatching agent is responsible for one geographic sector in the municipality. The work consists of sending patrol officers to the event location according to the emergency priority, and of supporting them by responding to their information requests. The agents use a software program that keeps up-to-date information on police officer availability by municipal sector. They also have access to the Centre de renseignement policier du Québec (CRPQ) data base in order to assist patrol officers in their searches. When patrol officer availability poses a problem, the agents can call the patrol sergeant.

Each work team has a team leader, who performs the same tasks as the agents in addition to personnel management tasks and specific follow-up with the patrol sergeant.

The minimum job requirements for emergency call centre agents are a secondary school diploma and an ability to communicate orally in French and English. Each MPSECC then has its own specific hiring requirements such as, for example, having taken emergency call centre agent training at a CEGEP (Centre d'enseignement général et professionnel, a general and vocational college in the Québec education system) and having worked in a call centre. Candidates are selected on the basis of one or two interviews. The interview may include situational scenarios in which the candidates' capacity for judgment and reaction to stress are assessed. Selected candidates are given four weeks of training. During the first two weeks, they receive theoretical

training on emergency services, equipment, and work procedures. They are also exposed to different types of emergency situations. During the last two weeks, they are trained by an experienced agent, who gradually lets them answer calls. The experienced agent and the novice are hooked into the same listening system. After four weeks, the novices are assigned to a work team if the training has been successful. Their work is monitored and verified by the team leader or an experienced employee. They are first assigned to the task of taking calls for approximately six months. The new agents are then assigned to dispatching positions. According to the centre managers, many novices either do not finish their training or drop out during the first year. However, no statistics are available in this regard.

6.2 Ergonomic and physiological analysis of work situations

6.2.1 *Description of work performed in situations observed*

Out of a total of 1,409 calls received by the agents, 506 were 911 calls, representing approximately 36%. The other incoming calls were from the municipality's police department line (434 calls, or 31%) and from other public works or internal lines (469 calls, or 33%). In addition to telephone calls, the agents received radio calls that were not tallied. The total time spent communicating was 1,403 minutes, representing 26% of the total work time analyzed (5,477 minutes). Tasks other than communicating about cases accounted for 1,036 minutes, or 19% of the work time. Other activities, accounting for 55% of the work time, involved radio activities and related activities that varied from centre to centre (e.g. manning the reception counter, video surveillance, opening or closing the garage doors, updating information, or waiting). Eight agents considered that the activity level during the work shift observed was lower than usual, two felt that it was the same as usual, and one felt that it was busier than usual.

Roughly 20.5% of the calls that were monitored involved observable communication difficulties (cognitive or relational problems). Of all the calls monitored, 22% calls qualified as urgent and required a quick response from the agents.

6.2.2 *Description of study participants*

The 11 agents whose data were analyzed included six women and five men. The average agent age was 37; the oldest age was 51 and the youngest was 20. They had an average of 13 years' experience as an emergency call centre agent, and of 10.5 years at their current centre. The most experienced agent had 20 years of experience and the least experienced had four months. Six of the 11 agents had a secondary school education, while the five others had CEGEP-level education. Six of the agents were considered to have excellent health, four to have good health, and one to have fair health. Nine of them indicated that they had faced stressful situations during the 12 months prior to administration of the questionnaire, and one of them had been off work for this reason.

Ten of the 11 agents said they had felt at least occasional pain in one of the joint areas, and one agent said he had experienced pain constantly in his upper extremity joints and upper back during the 12 months prior to administration of the questionnaire. Nine had felt pain in the seven days prior to administration of the questionnaire (Table 2). The neck, shoulder, and upper and

lower back joints were those most affected. Five agents had had disrupted sleep and had consulted a specialist for pain felt during the last 12 months, one had had this experience in the seven days prior to the observation of the work shift activity. Two agents had been off work, one of them in the seven days prior to observation. The pain experienced was entirely work-related for four agents, partially work-related for two agents, with unknown causes for two agents, and unrelated to work for two other agents.

Table 4: Musculoskeletal pain experienced by agents participating in the ergonomic/physiology study

Agents n=11	In the past 12 months, did you experience major pain in one or more of the following areas of your body, to the point that it interfered with your activities?			In the past 7 days, did you experience major pain in one or more of the following areas of your body, to the point that it interfered with your activities?		
	Never	From time to time	Quite often All the time	Never	From time to time	Quite often All the time
Neck	4	4	3	5	4	2
Shoulders	6	2	3	8	2	1
Elbows	8	1	2	10	0	1
Wrists	8	2	1	10	1	0
Hands	9	2	0	10	1	0
Upper back	5	3	3	8	1	2
Lower back	3	6	2	6	4	1

6.2.3 Workstation layout

The MPSECCs are equipped with various machines positioned as described in Appendix 5. Four MPSECCS have acquired adjustable sit-stand workstations. Three of these MPSECCs have desks consisting of adjustable front and back worktables, and one MPSECC is equipped with desks that have only one adjustable worktable.

6.2.3.1 Screens

The workstations each have from four to six screens. Each workstation is dedicated to the performance of specific tasks, for which the software application is designed by specialized suppliers. The screens are positioned at one or two heights, depending on their number. The lower-level screens sit directly on the table top at call centres A, C and D, on an adjustable stand in the case of call centre B, and on a non-adjustable stand at call centre E. Reading the screens that are placed on a stand or at a higher level requires neck extension movements. The agents indicated that to minimize the need to adopt this constraining posture, the higher-level screen is the one they look at the least often. The lower-level screens are raised to prevent them from being hidden by the telephone console or the radio. The latter is placed in front of the screens in the middle of the desk in front of the agent. Some agents indicated that they adjust the height so that the centre of the screen is at eye level. When sitting, the agents position themselves in front of the main screen. They rotate to see the side screens. This rotation involves their neck or

shoulders, or the chair, depending on how far away the screen is. In standing position, the rotation involves turning their neck, back, or entire body in the direction of the most distant screens.

The distance of the screens from the edge of the table ranges from 67 cm to 95 cm. Reading postures vary over the course of the work shift depending on the screen and the workstation layout. Back flexion and twisting movements to read the screens were observed, but not systematically. To avoid leaning over, the agents had the option of enlarging the font size. However, they did not do so, because they preferred to have all the information visible on the screen. The agents in the study at call centres A and C found the font difficult to read, as did the agents in call centre D for one particular screen.

6.2.3.2 Keyboard

The keyboard is used mainly to enter information on the calling card and for emails and administrative tasks. At call centres A and B, the workstations are equipped with two keyboards dedicated to specific screens. At the other centres, one keyboard is used for all the screens. At call centre A, the two keyboards are positioned on each side of the table at an angle so that they are in front of the main screen. The main screen for each of the two keyboards is placed at the end of the row of screens, which forms a slight curve. At call centre B, the main keyboard is placed in the middle as the workstations have only one keyboard. The other keyboard is placed on the left side in front of the screen dedicated to the radio system.

The keyboards are positioned from 8 cm to 33 cm away from the edge of the table. At call centre D, the agent places the keyboard between the front and back worktables. The keyboard is positioned away from the edge of the table to make room for papers needed for handwriting notes. This space also serves as a support for the agent's forearms during data entry. At call centres A and B, the use of the keyboards that are 28 cm away requires back flexion.

6.2.3.3 Mice

The mice are used to navigate between the various software applications and screens. One workstation has four mice, including one mouse for three screens (internal memoranda and calling cards, current cases, geographic map) and one mouse for each of the other three screens. The mouse dedicated to the three screens is placed behind the right-side keyboard; handling it requires shoulder flexion and elbow extension, with the forearm resting on the table. Three workstations are equipped with two mice, including one for the radio screen. The mice are placed to the right of the keyboard at a distance ranging from 10 cm to 80 cm, depending on the workstation and agent. Handling the furthest mouse requires greater shoulder abduction, as the chair stays in the same position at the middle of the desk. The agent rests his or her wrist or forearm on the table. In standing position, the agent moves sideways toward the mouse that is furthest to the right, reducing the need for shoulder abduction and elbow extension. The workstation with only one mouse is the station where use of the radio has not yet been integrated into the computer system. The mouse is placed on the right side near the keyboard.

6.2.3.4 Telephone and radio consoles

The telephone console is positioned in the middle behind the keyboard at call centre E, to the left on the back table at call centres B and D, and to the right at call centre C. The radio console is placed in the middle at call centres B and C, to the right at call centre E, and to the left at call centre E. In addition to the radio console, the radio receiver can be turned on or off by means of a touch screen at call centre C or a pedal at the other centres. At call centre A, the radio transmissions are controlled by using the mouse. These pieces of equipment, which are placed on the back table, are reached through back and/or shoulder flexion combined with elbow extension movements. When using the radio, these postural constraints can be avoided by using the pedal. At call centre C, the use of a touch screen placed like the other screens involves roughly 90 degrees of shoulder flexion as well as extension of the elbow of the upper limb involved.

6.2.3.5 Positioning of note paper

The agents can enter information directly on the calling card displayed on screen when they are taking a 911 call. However, they take handwritten notes when they are uncertain as to whether the event reported on the 911 line requires a calling card. Any information entered on the calling card cannot be erased and correcting it takes more time. In addition, the agents do not simply answer calls on the 911 line. They therefore require sheets of paper for purposes of noting down information and passing on messages. The agents at call centres A, B, and D place the paper in front of the keyboard so that it is in front of them. At call centres A and B, the tables are sufficiently deep to accommodate this paper. At call centre D, the necessary space is obtained by placing the keyboard between the front and back tables. The agents at call centre E have to place their note paper on the right side, and to write, they are obliged to tilt and twist their back due to the limited space available for moving their chair.

6.2.3.6 Overall layout of workstations

The overall layout of the workstations varies depending on the number of desks. At the MPSECCs with three or four desks, the desks are positioned so that the agents face each other. At the other MPSECCs, the desks are placed in rows. In this case, the police-dispatching workstations are placed side by side in groups of two to allow for work in pairs. The call-taking workstations are positioned in one row so that the call-taking and police-dispatching agents are either back-to-back or at right angles to each other. When one of the MPSECCs was rearranged, the call-taking and police-dispatching agents chose to be positioned back-to-back. This arrangement allows them to speak aloud yet maintain some privacy. In one MPSECC, the firefighter-dispatching workstations were positioned in another row facing the police-dispatching workstations, and in a third emergency call centre, they are placed in the same row as the police-dispatching workstations. In this last instance, the close positioning of these workstations resulted in complaints about noise emanating from the police-dispatching workstations due to the high volume of radio communications during firefighter dispatching.

Moreover, according to some agents, the increase in the number of desks when the premises were rearranged increased the noise level. Solutions were introduced in the form of acoustic surfacing on the ceiling, floor, or walls.

Several sources of light are present: natural light, general lighting of the premises with fluorescent tubes with light diffusers, and supplementary lighting at each desk. The direction of the natural light varies depending on the arrangement of the desks in the MPSECCs. It is controlled by the presence of curtains. The positioning of the ceiling lights and desks varies enormously. Some light sources are situated above the desks, and others to the side, front, or back of the desks. The agents have the option of adjusting the intensity of the general lighting; however, some agents find the light to be too strong while others find it too weak. The supplementary desk lamps do not always meet the agents' needs.

6.2.4 Work in sitting/standing positions

Of the nine agents who had adjustable sit-stand workstations, only two actually used this option (Table 5). A third agent, P-16, adjusted his workstation to standing position when he began his shift. Once he had entered the necessary codes, he adjusted it to sitting position for the rest of his shift. Generally speaking, the agents regarded the introduction of the sit-stand adjustment options as a positive change.

Agent P-12 adjusted the workstation to standing position for nearly the entire work shift. Even if the workstation was in sitting position, the agent stood up. He preferred to work in standing position as it allowed him to read the screens more comfortably. He found that in sitting position, the screens were placed too high, causing him to experience neck pain. He also said that he did not like having to move his chair sideways to access the various pieces of equipment. In standing position, the agent moved around, often shifting his weight from one foot to the other. He said that he did not like to stay seated for long periods of time.

Agent P-10 put his workstation in standing position for one-third of the time. He said that he liked to stand toward the end of the shift but not in the morning. He also said that when he was team leader, he always adopted a standing position in order to communicate more effectively with his coworkers.

Two other agents for whom the physiological data recording failed were included in these observations. These two agents worked one-third of their shift in standing position. One of them, P-03, said that he frequently changed the workstation back and forth between sitting and standing positions to control his low back pain caused by prolonged sitting. However, he could not make these changes during the night shift. In fact, the addition of a data-entry task during the night shift obliged the worker to work sitting down, making the work more difficult. Agent P-02 put his workstation in standing position half-way through his work shift at the same time as his coworker. They both worked in this position for around two hours before readjusting their workstations to sitting position. Both agents did this so that they were at the same height, which made it easier for them to communicate with each other. They were thus able to alternate between sitting and standing positions.

The agents who did not use the standing position adjustment said that they generally worked with their workstations in sitting position, except during certain situations. They tended to put their workstations in standing position for certain tasks or during certain periods: when they are obliged to move around, often due to people arriving at the reception desk; during shift changes; when dispatching firefighters, which is a more demanding task; during the night shift, in order to

stay awake at the very end of their shift; and depending on their fatigue, which is caused by always sitting down. They also found an immobile standing position to be uncomfortable and tiring.

Table 5: Proportion of time spent with workstation adjusted to sitting or standing position and proportion of work performed in sitting or standing position, by agent during work shift

Agent	Type of workstation	Workstation adjusted to sitting position (%)	Workstation adjusted to standing position (%)	Work in sitting position (%)	Work in standing position (%)
P-05	sit	100	0	98	2
P-06	sit	100	0	98.4	1.6
P-07	sit-stand	100	0	99.1	0.9
P-09	sit-stand	100	0	99	1
P-10	sit-stand	63	37	69	31
P-11	sit-stand	25	75	3	97
P-12	sit-stand	100	0	98.6	1.4
P-13	sit-stand	100	0	97.4	2.6
P-14	sit-stand	100	0	94.4	5.6
P-15	sit-stand	100	0	99.1	0.9
P-16	sit-stand	99.5	0.5	86.5	13.5

6.2.5 Subjective evaluation

6.2.5.1 Agents' responses on perception rating scales

The agents' perceptions of the average and maximum levels of workload, fatigue, complexity, and emotions rated during their work shifts are shown in Table 6. The detailed responses are found in Appendix C.

Table 6: Number of agents who perceived same average or maximum level of workload, fatigue, complexity, and emotion during work shift

Level on the perception rating scale		Low and less (0 to 2.5)	Moderate (>2.5 to 4)	High (>4 to 6)	Very high (>6 to 8)	Extremely high (>8)
Agents (n=11)						
Workload	Number of agents who perceived the same average level	4	5	2	0	0
	Number of agents who perceived the same maximum level	2	3	3	3	0
Fatigue	Number of agents who perceived the same average level	10	1	0	0	0
	Number of agents who perceived the same maximum level	5	5	1	0	0
Complexity	Number of agents who perceived the same average level	7	4	0	0	0
	Number of agents who perceived the same maximum level	2	5	3	1	0
Positive emotion	Number of agents who perceived the same average level	7	4	0	0	0
	Number of agents who perceived the same maximum level	2	6	3	0	0
Negative emotion	Number of agents who perceived the same average level	9	2	0	0	0
	Number of agents who perceived the same maximum level	3	7	1	0	0
Effort expended to control emotions	Number of agents who perceived the same average level	9	2	0	0	0
	Number of agents who perceived the same maximum level	5	3	2	1	0

The average evaluations of the perceptions of the various items were between low and moderate. Few agents gave maximum evaluations, i.e. high or very high level. For the most part, the agents perceived relatively low levels of workload and fatigue. The average workload level was evaluated as low or less by four agents, as moderate by five agents, and as high by two agents. The maximum workload was evaluated as moderate, high, or very high by three agents at each level. Ten agents out of eleven perceived their average fatigue level as low or less. The maximum fatigue level was perceived as moderate by five agents and as high by one agent.

The level of complexity encountered by the agents in taking and dispatching calls during the work shifts observed was generally low. The average level of complexity was rated as low or

less by seven agents and as moderate by the other four. The maximum complexity level was rated as very high by one agent, high by three agents, moderate by five agents, and low or less by two agents.

The level of negative or positive emotions experienced or of effort expended to control emotions when taking and dispatching calls during the work shifts observed was perceived as low by the agents. Three agents rated the maximum level of positive emotions as high. One agent rated negative emotion at the maximum level and two agents rated effort expended to control emotions at the maximum level. Also, one agent rated the effort expended to control emotions as very high.

The agents' perceived pain levels during work are presented in Table 7. Of the 11 agents, two felt no pain, one felt pain in all musculoskeletal areas, six mentioned pain in the lower back and neck-shoulders-upper back, and two in the neck-shoulders-upper back. Five agents rated the level of intensity of their lower back pain as extremely low or low. For two agents, P07 and P15, the episode of low-level pain lasted for a single period, based on the 11 and 16 periods evaluated respectively. For one agent, the pain increased from moderate to high during the last periods toward the end of the work shift. For three agents (P10, P12, and P13), pain was present for more than half of the periods evaluated during the work shift.

Regarding the neck-shoulder-upper back pain, eight agents had episodes of extremely low-level or low-level pain. Three of the eight agents also had episodes of moderate-level pain. The pain was felt by five agents during at least half of the periods observed. One agent felt pain of low to slightly-more-than-moderate intensity throughout the work shift in the elbows-wrists-fingers.

Table 7: Number of periods during which agents felt pain during work shift

Agent	Lower back pain			Neck-shoulders-upper back pain			Wrist pain		
	None	Extremely low or low (0.3 to 2.5)	Moderate (>2.5 to 4)	None	Extremely low or low (0.3 to 2.5)	Moderate (>2.5 to 4)	None	Extremely low or low (0.3 to 2.5)	Moderate (>2.5 to 4)
P05 (n*=11)	7	4	0	0	7	4	11	0	0
P06 (n=9)	9	0	0	7	2	0	11	0	0
P07 (n=11)	10	1	0	9	1	1	11	0	0
P09 (n=9)	9	0	0	9	0	0	9	0	0
P10 (n=9)	4	5	0	6	3	0	9	0	0
P11 (n=13)	13	0	0	9	4	0	13	0	0
P12 (n=13)	3	5	5	0	13	0	13	0	0
P13 (n=12)	4	8	0	0	0	12	0	3	9
P14 (n=12)	12	0	0	6	6	0	12	0	0
P15 (n=16)	15	1	0	0	16	0	16	0	0
P16 (=11)	11	0	0	11	0	0	11	0	0

* n equals the number of periods evaluated

6.2.5.2 Correlations between responses on perception rating scales

Table 8 presents the significant correlations found between the various responses on the perception rating scales. The results can be described as follows:

- The responses on the perception rating scales, in chronological order, correlated positively with fatigue for the 11 agents (median of $\rho=0.81$) and with musculoskeletal pain for the vast

majority of the agents who reported experiencing such pain for half or more of their work shift (low back pain: median of $\rho=0.82$ for two out of three agents; upper back-neck-shoulder pain: median of $\rho=0.66$, for five out of five agents; elbow-wrist-finger pain: median $\rho=0.70$ for one agent out of one). Similarly, fatigue correlated positively with musculoskeletal pain (low back pain: median of $\rho=0.60$ for three out of three agents; upper back-neck-shoulder pain: median of $\rho=0.77$ for five agents out of five; elbow-wrist-finger pain: median of $\rho=0.61$ for one agent out of one).

- Workload correlated positively with call complexity for a majority of the agents (median of $\rho=0.90$ for seven agents out of 11) and with effort expended to control emotions (median of $\rho=0.65$ for six agents out of 11). Similarly, for those agents reporting musculoskeletal pain during half or more of their work shift, workload correlated positively with upper back-neck-shoulder pain for three agents out of five (median of $\rho=0.63$).
- Call complexity correlated positively with effort expended to control emotions for six agents out of 11 (median of $\rho=0.61$) and with upper back-neck-shoulder pain for three agents out of five (median of $\rho=0.70$).
- Negative emotions correlated positively with effort expended to control emotions for eight agents out of 11 (median of $\rho=0.77$) and with lower back pain for three agents out of the three who felt this type of pain for half or more of their work shift (median of $\rho=0.52$).

Table 8: Median of significant correlation coefficients (Spearman's ρ) (≤ 0.10) between responses on rating scales, for 11 agents analyzed. Number of agents for whom correlation is significant given in parentheses.

Items on subjective evaluation scale	Workload (n=11)	Fatigue (n=11)	Call complexity (n=11)	Positive emotion (n=11)	Negative emotion (n=11)	Effort expended to control emotion (n=11)	Pain: lower back (n= 3, agents with pain for half of work shift or more)	Pain: upper back, neck, shoulders (n=5, agents with pain for half of work shift or more)	Pain: elbows, wrists, fingers (n=1, agent with pain for half of work shift or more)
Chronological order of scale administration	0.05 (4)	0.85 (11)*	0.81 (3)	-0.13 (4)	0.10 (2)	-0.46 (1)	0.82 (2)	0.66 (5)	0.70 (1)
Workload	–	0.59 (3)	0.90 (7)	0.76 (2)	0.84 (3)	0.65 (6)	0.15 (2)	0.63 (3)	- (0)
Fatigue	–	–	0.70 (2)	-0.55 (5)	0.03 (2)	-0.61 (1)	0.60 (3)	0.77 (5)	0.61 (1)
Call complexity	–	–	–	0.58 (3)	0.73 (4)	0.61 (6)	0.76 (1)	0.70 (3)	- (0)
Positive emotion	–	–	–	–	0.82 (2)	0.53 (3)	0.02 (2)	0.60 (1)	-0.59 (1)
Negative emotion	–	–	–	–	–	0.77 (8)	0.52 (3)	0.11 (2)	- (0)
Effort expended to control emotions	–	–	–	–	–	–	0.73 (1)	- (0)	- (0)

* The figures in **boldface type** indicate the significant correlations with a median Spearman's rho greater than 0.50, based on a majority of the agents involved.

6.2.6 Trapezius muscle activity

6.2.6.1 Trapezius muscle activity and work shift

The median level of muscle activity (50th percentile) observed during the work shift was on average 12% RVE (Reference Voluntary Exertion – submaximal reference) (10th percentile: 3% RVE; 90th percentile: 38% RVE) for the dominant trapezius muscle, and 10% RVE (10th percentile: 3% RVE; 90th percentile: 34% RVE) for the non-dominant trapezius. The proportion of muscle rest time was 30% for the dominant trapezius and 34% for the non-dominant trapezius. No systematic progression over time was observed in these variables when they were calculated every 15 minutes.

A comparison of the pre- and post-work shift submaximal reference contractions (RVEs) did not allow for the conclusion that muscle fatigue developed during the observed work shifts. In fact, a decrease in the median frequency combined with an increase in the average amplitude of the signal was observed for four participants (one for both trapezius muscles, two for the dominant trapezius only, and one for the non-dominant trapezius only).

6.2.6.2 Trapezius muscle activity and perceived workload

Muscle activity level was higher for the periods corresponding to a perceived high workload compared to periods of perceived low workload (Figure 2). The proportion of muscle rest time was also lower for the periods corresponding to a perceived high workload (Figure 3).

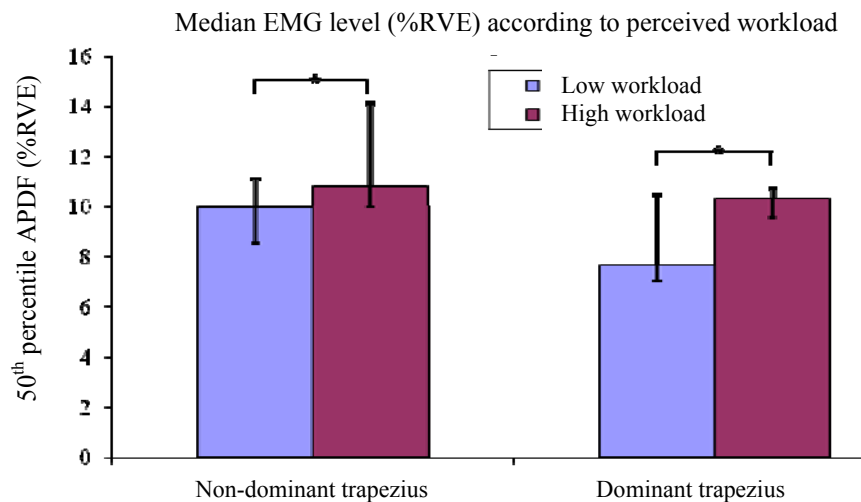


Figure 2: Median level of muscle activity (50th percentile) for non-dominant and dominant trapezius muscles according to perceived high- and low-workload periods. The median values and their confidence interval (95%) are shown for all subjects. * Significant difference ($p < 0.05$) using the Wilcoxon test.

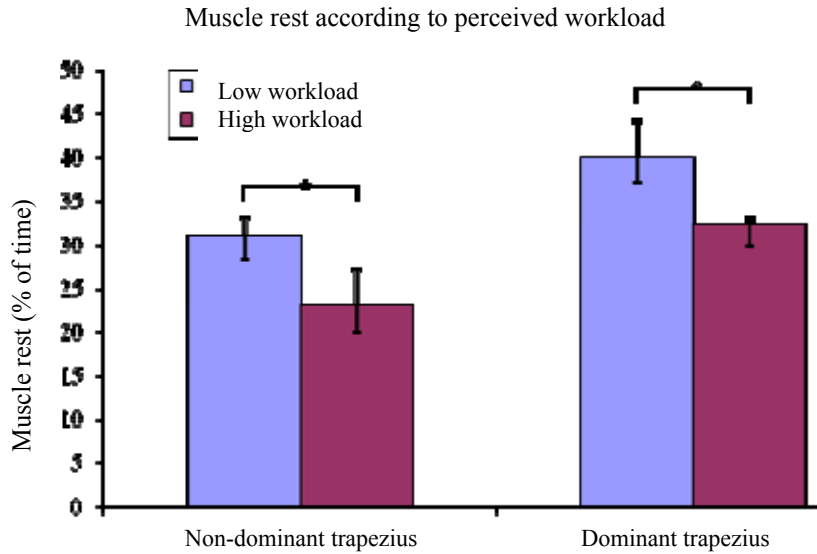


Figure 3: Proportion of muscle rest time (%) for non-dominant and dominant trapezius muscles according to perceived high- and low-workload periods. The median values and their confidence interval (95%) are shown for all subjects. * Significant difference ($p \leq 0.05$) using the Wilcoxon test.

6.2.6.3 Trapezius muscle activity and perceived work complexity

Muscle level activity was higher for the periods corresponding to perceived high work complexity compared to periods of perceived low work complexity (Figure 4). In addition, the proportion of muscle rest time was lower for periods corresponding to perceived high work complexity (Figure 5).

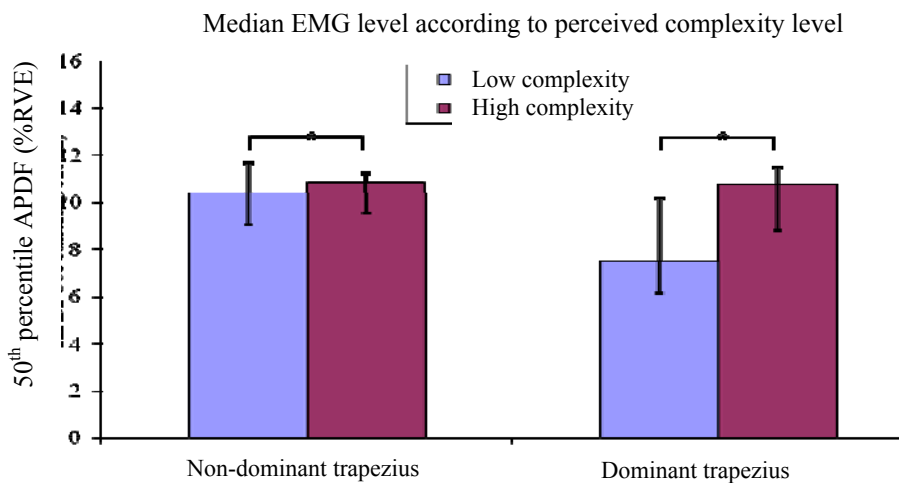


Figure 4: Median level of muscle activity (50th percentile) for non-dominant and dominant trapezius muscles according to perceived high and low work-complexity periods. The median values and their confidence interval (95%) are shown for all subjects. * Significant difference ($p \leq 0.05$) using the Wilcoxon test.

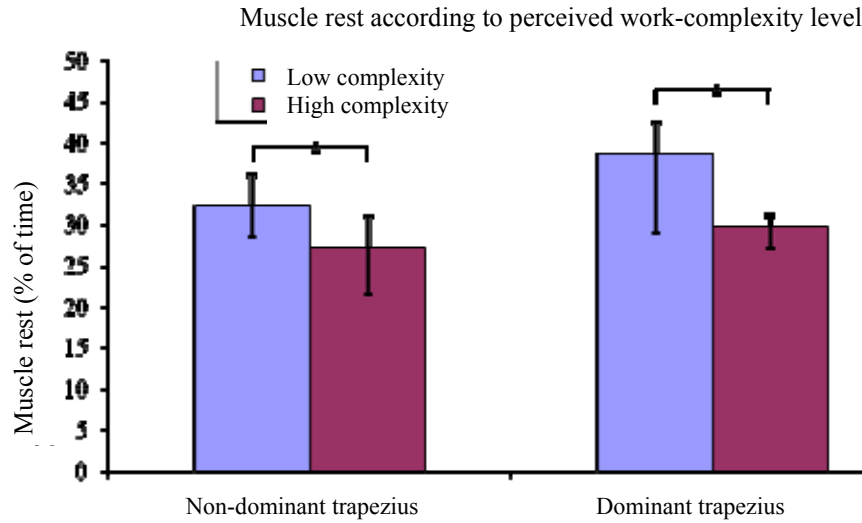


Figure 5: Proportion of muscle rest time (%) for non-dominant and dominant trapezius muscles according to high and low work-complexity periods. The median values and their confidence interval (95%) are shown for all subjects. * Significant difference ($p \leq 0.05$) using the Wilcoxon test.

6.2.6.4 Trapezius muscle activity and perceived level of negative emotion

The level of non-dominant trapezius muscle activity was significantly higher during periods of perceived high levels of negative emotion (Figure 6). No other EMG variable showed a significant difference according to perceived level of negative emotion (Figure 7).

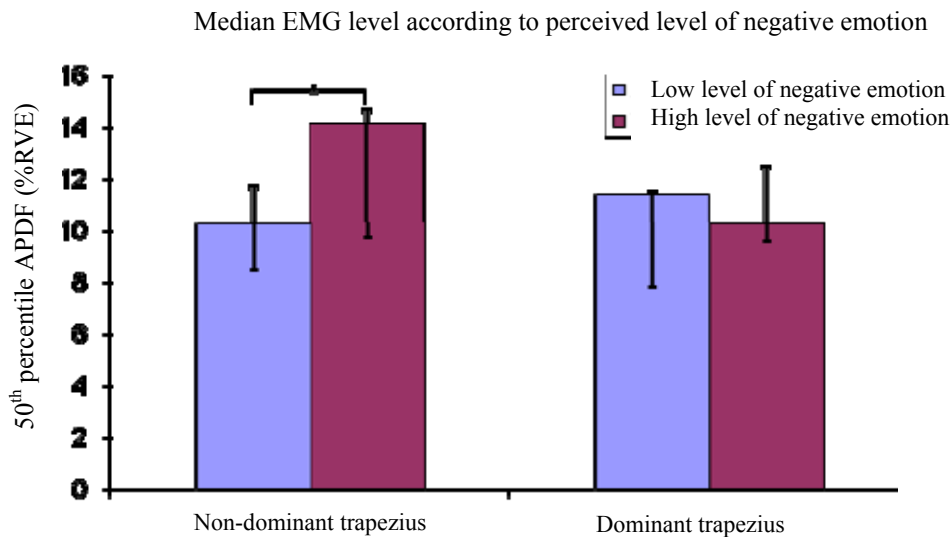


Figure 6: Median level of muscle activity (50th percentile) for non-dominant and dominant trapezius muscles according to periods of perceived high and low levels of negative emotion. The median values and their confidence interval (95%) are shown for all subjects. * Significant difference ($p \leq 0.05$) using the Wilcoxon test.

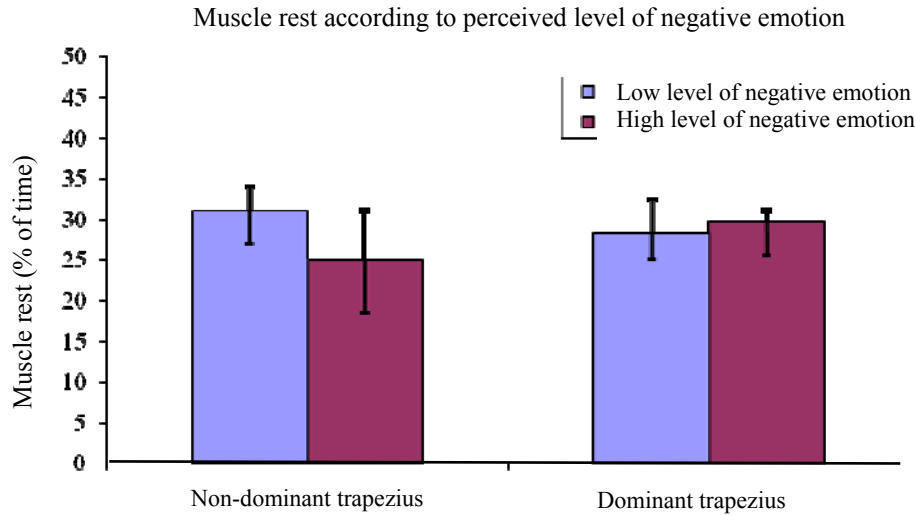


Figure 7: Proportion of muscle rest time (%) for non-dominant and dominant trapezius muscles according to periods of perceived high and low levels of negative emotion. The median values and their confidence interval (95%) are shown for all subjects. * Significant difference ($p \leq 0.05$) using the Wilcoxon test.

6.2.6.5 Trapezius muscle activity and high-stress periods

No significant difference was observed between the EMG variables corresponding to high- and low-stress periods (figures 8 and 9), despite a tendency toward an increased activity level and decreased rest time for high-stress periods.

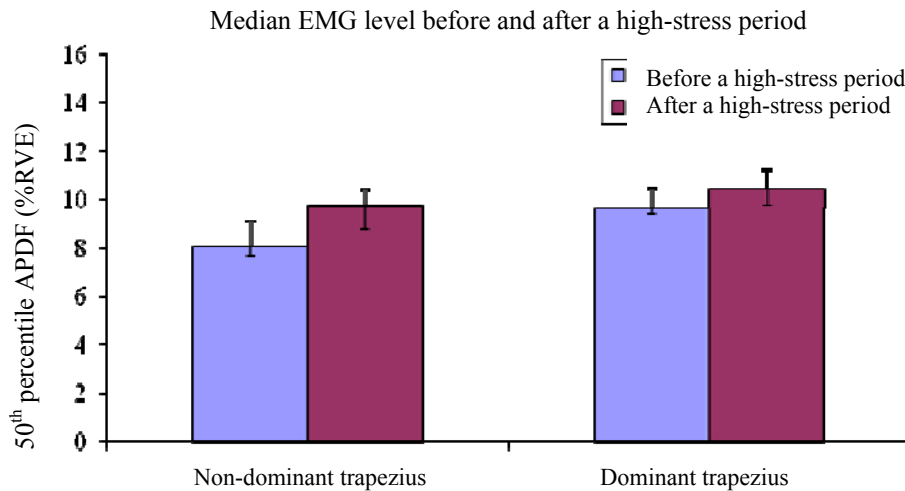


Figure 8: Median level of muscle activity (50th percentile) for non-dominant and dominant trapezius muscles according to high- and low-stress periods. The median values and their confidence interval (95%) are shown for all subjects. * Significant difference ($p \leq 0.05$) using the Wilcoxon test.

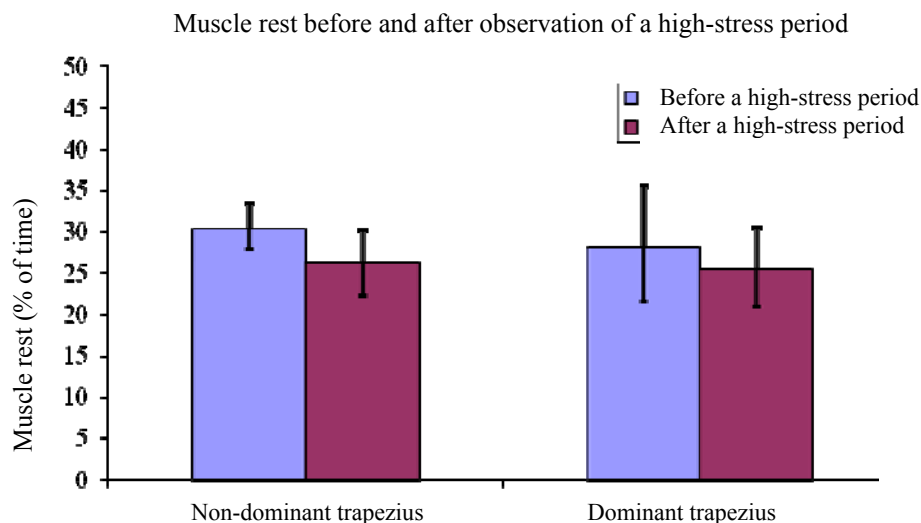


Figure 9: Proportion of muscle rest time (%) for non-dominant and dominant trapezius muscles according to high- and low-stress periods. The median values and their confidence interval (95%) are shown for all subjects. * Significant difference ($p \leq 0.05$) using the Wilcoxon test.

6.2.7 Heart rate

6.2.7.1 Comparison of heart rates at rest before and after work shift

The differences revealed by the preliminary HRV analyses for the novice agents (n=2) and experienced agents (n=6) led to the separate presentation of the results (Table 9).

The heart rate in sitting position was higher than that in supine position, except for a slight increase of 1 bpm (beat per minute) for the experienced agents before their work shift. The HR of both novice and experienced agents was lower after work. The sample applied to the SDNN (standard deviation of normal interbeat intervals (NN) expressed in milliseconds, or ms), although the experienced agents had lower values that were closer to 50 ms. The SDNN of both novice and experienced agents increased between pre-observation rest in sitting position and pre-observation rest in supine position as it did between post-observation rest in supine position and post-observation rest in sitting position. The pNN50 (percentage of successive NNs that differ more than 50 ms) was lower before work.

Table 9: Heart rate and heart rate variability (HRV) indices before and after work shift for novice and experienced workers

	HRV indices	Pre-observation rest (sitting)	Pre-observation rest (supine)	Post-observation rest (supine)	Post-observation rest (sitting)
Novice agents (n=2)	HR (bpm)	72.7	69.8	59	62.1
	SDNN (ms)	96.7	111.0	105.2	160.8
	pNN50 (%)	21.2	28.4	41.9	50.8
Experienced agents (n=6)	HR (bpm)	83.3	84.3	71.9	76.1
	SDNN (ms)	46.1	55.9	43.6	80.7
	pNN50 (%)	3.1	4.3	6.3	5.6

6.2.7.2 Heart rate during work shift and over 24 h

Changes in the HR and HRV were calculated over successive five-minute segments.

During the work shift, the average HR of the experienced agents was between 74 bpm and 85 bpm; it was slightly higher than that of the two novices, whose average HR varied from 70 bpm to 71 bpm (Table 10). The standard deviation for all the agents appeared to be homogeneous, ranging from 3.7 bpm to 6.2 bpm.

As for HRV, the average of the SDNNs for the experienced agents was between 68.4 ms and 41.3 ms; this was lower than the SDNN measured in the novice agents, for whom the average ranged from 121.2 ms to 79.1 ms (Table 11). Analysis of the SDNN distribution revealed that the modal values of the experienced agents were lower than 50 ms, while those of the novice agents were higher than 70 ms.

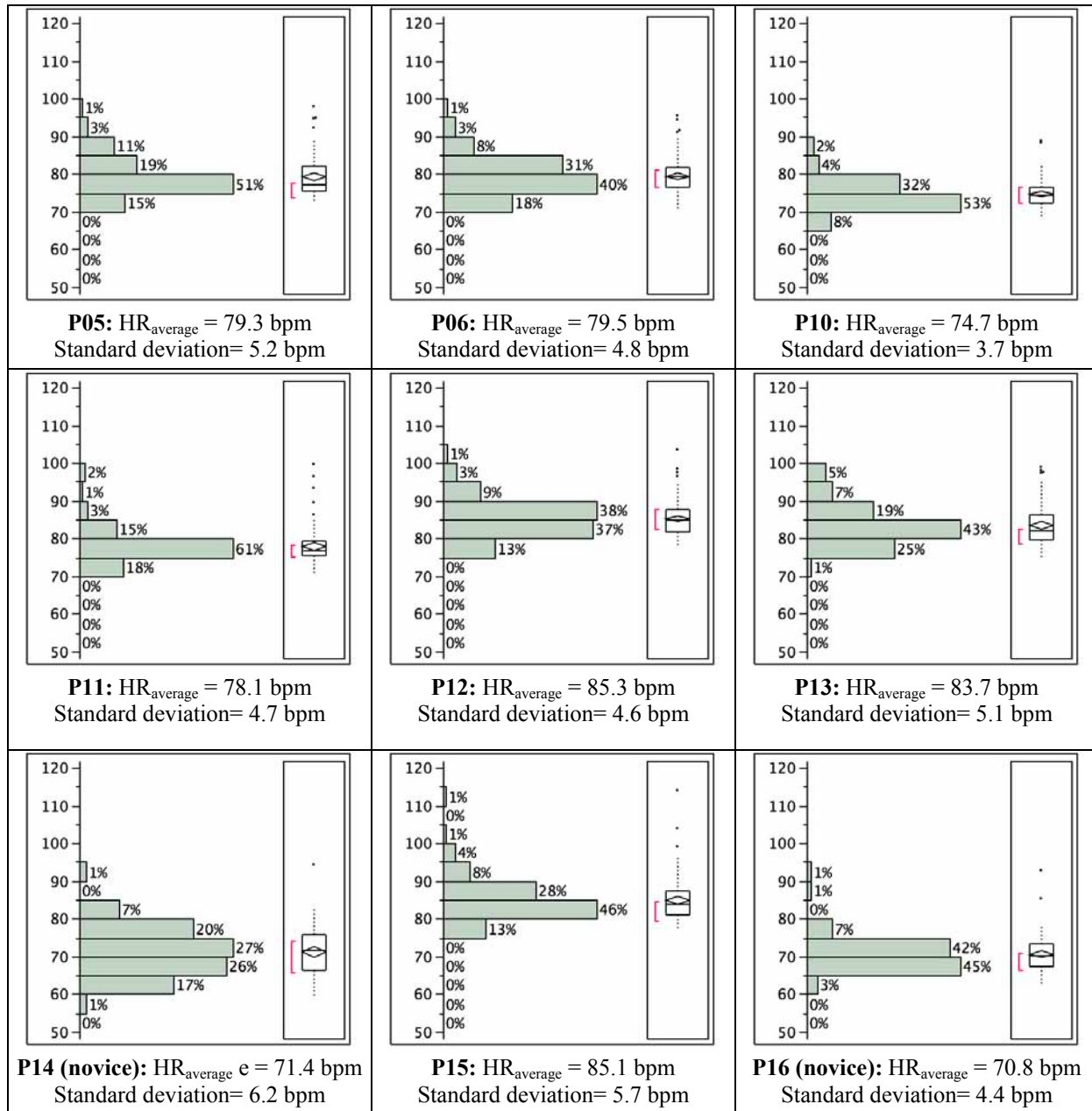


Figure 10: Heart rate distribution among agents during work shift

The heart rates shown are the averages of the heart rates calculated over successive five-minute segments. On the left, a distribution of time spent is shown, with 5-bpm increments, from 50 to 120 bpm. On the right, this distribution is presented in a form commonly referred to as a “box plot,” indicating the interquartile interval (50% of the HRs are found in this box). The HR_{average} (over the work shift) and the standard deviation are specified at the bottom.

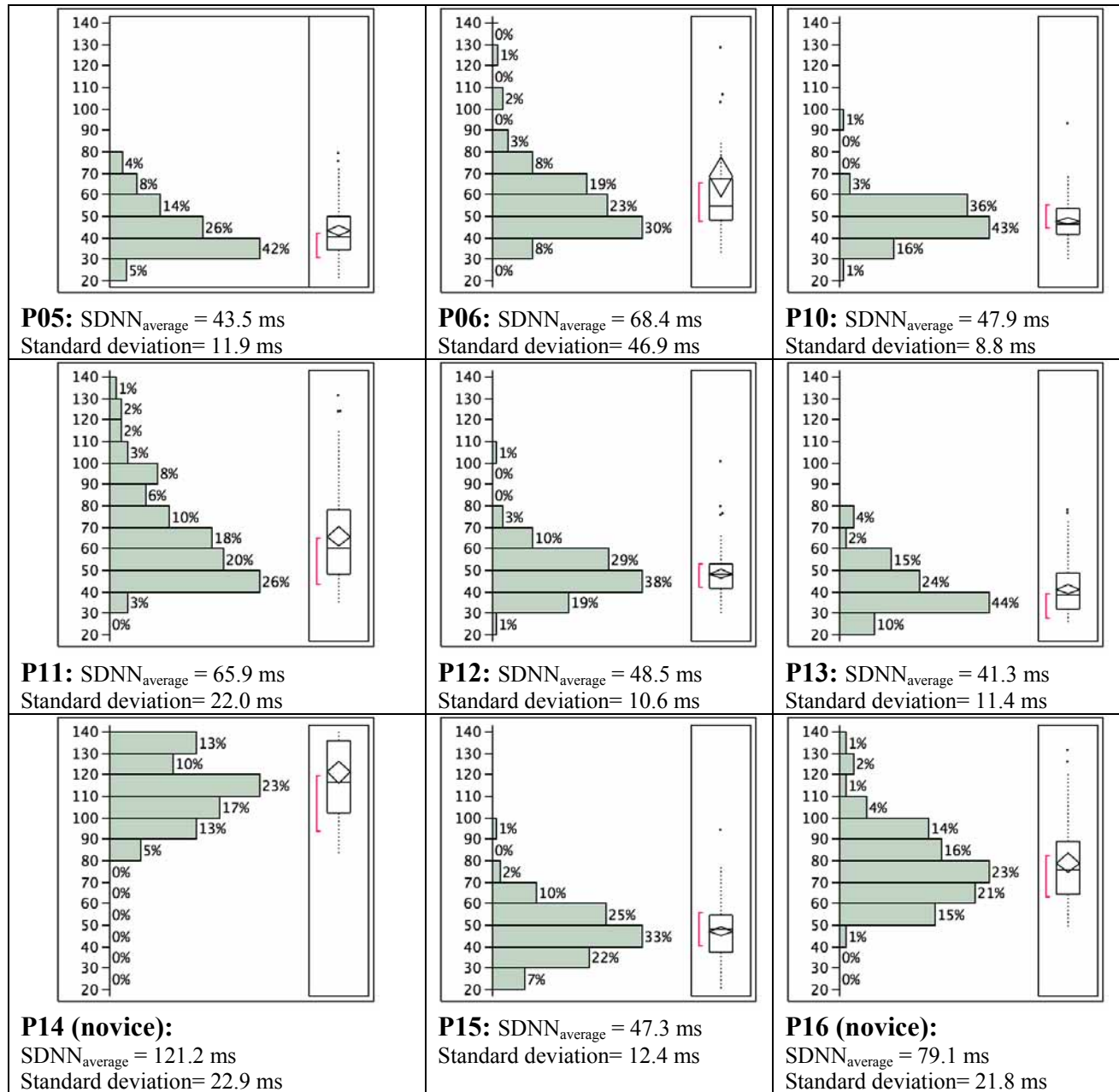


Figure 11: Distribution of SDNNs among agents during work shift

The SDNNs of the interbeat intervals were calculated over successive five-minute segments. On the left, a distribution of time elapsed is shown, with 10-ms increments, from 20 to 140 ms. On the right, this distribution is shown in the “box plot” form, indicating the interquartile interval (50% of the SDNNs found in this box). The SDNN_{average} (over the work shift) and the standard deviations are given at the bottom.

The SDANN measurement (standard deviation of the averages of interbeat intervals calculated over successive five-minute segments) was from 1.6 to 3.5 times lower during the work shift than during the full 24 hours measured (Table 10). For eight of the agents, these values fell within the value limits defined as normal by cardiologists, i.e. 127 ± 35 ms (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). For agent P11, the SDANN measurement was below the values defined as normal.

Table 10: SDANN relative to length of work shifts observed and to 24 hours, for each agent

Agents SDANN	P05	P06	P10	P11	P12	P13	P14	P15	P16
Work shift SDANN (ms)	45.4	43.9	37.9	38.9	35.9	41.3	72.9	43.0	47.8
24h SDANN (ms)	93.8	147.8	130.9	62.8	125.0	126.3	132.7	116.8	109.7
Ratio of work shift SDANN / 24h SDANN	48%	30%	29%	62%	29%	33%	55%	37%	44%

6.2.7.3 Fatigue and heart rate

The correlations between perceived fatigue levels and heart rate concerned few agents (Table 11). The HR of three agents correlated negatively with fatigue and with the LF/HF ratio for two agents. It correlated positively with the pNN50 for two agents and with the SDNN and HF for only one agent. It should be noted that the average fatigue level perceived was low for ten agents. Moreover, there were few differences in perceptions, and when present, the differences in perceived levels were small (Table 6).

Table 11: Median of significant Spearman’s ρ correlation coefficients (≤ 0.10) between fatigue and heart rate variability indices, for nine agents analyzed. Number of significant cases given in parentheses.

Heart rate and HRV indices	Fatigue Median of the significant Spearman’s ρ (≤ 0.10) (n=9)
HR (bpm)	-0.57 (3: P06, P13, P15)
SDNN (ms)	0.52 (1: P11)
pNN50 (%)	0.62 (2: P05, P11)
HF (ms ²)	0.77 (1: P11)
LF (ms ²)	0.47 (1: P15)
LF/HF ratio	-0.68 (2: P11)

6.2.7.4 Workload and heart rate

Perceived workload did not correlate with the HR for any of the agents, and the correlations with the HRV indices concerned only a small number of agents (Table 12). The correlations with the SDNN were negative for two agents and with the HF for one agent. A positive correlation with the pNN50 was found for one agent. Sympathovagal balance (LF/HF) did not correlate with perceived workload. It must be recalled that the perceived levels of workload were generally low (Table 6).

Table 12: Median of significant Spearman's ρ correlation coefficients (≤ 0.10) between workload and heart rate variability indices, for nine agents analyzed. Number of significant cases given in parentheses.

Heart rate and HRV indices	Workload Median of the significant Spearman's ρ (≤ 0.10) (n=9)
HR (bpm)	(0)
SDNN (ms)	-0.62 (2: P05, P12)
pNN50 (%)	0.73 (1: P10)
HF (ms ²)	-0.66 (1: P12)
LF (ms ²)	0.62 (3: P06, P10, P14)
LF/HF ratio	(0)

6.2.7.5 Call complexity and heart rate

Similarly, the perceived level of call complexity correlated very poorly with heart rate and the HRV indices, as the correlations concerned only one agent (Table 13). Sympathovagal balance (LF/HF) did not correlate with level of call complexity. The level of complexity was on average rated as low by seven agents and moderate by four agents. The maximum level of call complexity was very high for one agent, high for three agents, and moderate for five (Table 6).

Table 13: Median of significant Spearman's ρ correlation coefficients (≤ 0.10) between call complexity and heart rate variability indices, for nine agents analyzed. Number of significant cases given in parentheses.

Heart rate and HRV indices	Median of the significant Spearman's ρ (≤ 0.10) for the nine agents, for call complexity
HR (bpm)	-0.68 (1: P10)
SDNN (ms)	-0.52 (1: P05)
pNN50 (%)	0.54 (1: P05)
HF (ms ²)	-0.44 (1: P15)
LF (ms ²)	-0.52 (1: P14)
LF/HF ratio	(0)

6.2.7.6 Emotions and heart rate

Positive emotion did not correlate with HR indices for any of the agents (Table 14). Negative emotion correlated negatively with HR for three agents. For these same agents, negative emotion also correlated positively with the pNN50. Negative emotion correlated positively with the LF and the LF/HF ratio for one agent. Effort expended to control emotions did not correlate with HR. It correlated negatively with the HF for only one agent.

Table 14: Median of significant Spearman’s ρ correlation coefficients (≤ 0.10) between emotion and heart rate indices, for nine agents analyzed. Number of significant cases given in parentheses.

Heart rate and HRV indices	Median of significant Spearman’s ρ (≤ 0.10) for the nine agents, for positive emotion	Median of significant Spearman’s ρ (≤ 0.10) for the nine agents, for negative emotion	Median of significant Spearman’s ρ (≤ 0.10) for the nine agents, for effort expended to control emotion
HR (bpm)	-	-0.52 (3: P10, P12, P13)	(0)
SDNN (ms)	-	(0)	(0)
pNN50 (%)	-	0.52 (3: P10, P12, P13)	(0)
HF (ms ²)	-	(0)	-0.59 (1: P16)
LF (ms ²)	-	0.57 (1: P12)	0.03 (2: P13, P15)
LF/HF ratio	-	0.53 (1: P16)	(0)

6.2.7.7 High stress and HRV

A comparison of the five-minute segments that included an urgent call, presumed to place high stress on the agents, to the preceding five-minute segments revealed no significant difference ($P > 0.10$) in the HRV indices (SDNN, pNN50, LF, HF, LF/HF ratio).

6.2.8 Description of situations involving high level of workload, call complexity, and emotional strain

6.2.8.1 Situations causing high workload level according to agents

Workload was defined and understood by the agents as the quantity of actions required within a given amount of time. They considered it high when they had to take a large number of incoming calls from citizens or first responders, and when answering these calls required quick searches in databases and simultaneously dispatching the call and answering the first responders.

The agents reported using a number of strategies to handle the increased number of calls, including teamwork, reducing the amount of time taken to speak with the caller, postponing certain information searches for police officers that they do not have time to do before sending the calling card, prioritizing calls by order of urgency, and putting first responders’ non-urgent calls on hold. Some of these strategies entail risks that can create a higher level of emotional or

cognitive strain. Certain agents indicated that the fact of being obliged to give fewer explanations or less assistance to citizens whose 911 calls are not urgent creates a sense of frustration, particularly if these citizens seem vulnerable. In addition, the agents face dilemmas, such as whether to answer a call quickly or not in order to take another call that could be very urgent, yet running the risk of failing to detect an emergency situation because they have not analyzed the request in depth. Also, the fact of putting first responders' non-urgent calls on hold may be more or less well regarded by the latter and can even lead to disagreements. Moreover, when the call frequency allows, the work team plays an important role in preserving the quality of communication while at the same time allowing for quick responses. Such is the case, for example, with urgent calls requiring information searches. The agent who has taken the call can stay on the line and continue speaking with the citizen while a coworker does the information search. In other words, the fact of providing mutual aid allows them to take the first responders' calls faster. A coworker can thus respond to a first responder who needs information about a case dispatched by another coworker who is busy on another line. To be able to respond to calls that have been dispatched by coworkers, the agent must keep abreast of all events in progress.

When a major increase in the number of calls is expected due to the occurrence of a specific event, an additional agent may be requested by the team leader to support the work team. However, no specific guidelines exist in this regard, leaving the team leader to make the judgment call.

Team leaders can also ask an additional agent to come in when there is a major increase in the number of incoming calls. However, this directive seems more or less effective and difficult to apply. Team leaders encounter three types of obstacles. First, the high call-volume period may be shorter than the time it actually takes the agent to reach the MPSECC. Second, team leaders do not always have the time to call an agent in because they are so busy working themselves. And third, they may have difficulty reaching the agents at home. In fact, there is no formal system for keeping agents at work or on-call.

According to the agents, the presence of a novice agent also increases the workload. New employees are not autonomous and very often have to refer to their more experienced coworkers. Moreover, the latter are much more attentive to and alert about calls taken and responses given by the novice agents than they are regarding those of their more experienced coworkers.

6.2.8.2 Situations described by agents as complex and creating an emotional strain

The situations described by the agents varied in terms of complexity and emotional strain. The descriptions given of some situations focussed more on high level of complexity, others concerned a high level of negative or positive emotional strain, and still others focussed on both dimensions.

- The situations in which the workload level was perceived as high were also considered complex by the agents. The accounts given of the different situations in the self-confrontation interviews pointed to three types of complexity:

- The first type involves having to divide attention and actions in order to respond to and act quickly regarding the requests received. This type of situation concerns mainly the dispatching of fire services: *“Each fire is complex because you have to listen to everything you are being told and write down everything you are told, and then you have to call all the emergency service providers being asked for; it just never stops.”* Some agents said they were able to handle this level of complexity, while for others, it was more difficult. One of the reasons for this difficulty is lack of practice. In fact, one agent said he could go through long periods of time without having to dispatch fire services.
 - The second type of complexity involved the dilemma the agents face in managing a high call volume. This dilemma involves the choice of methods, each of which, depending on the circumstances, includes the risk of missing a call or of increasing the wait time for a very urgent call, as the following situation illustrates: *“Sometimes the agents receive a high call volume for the same event, which can result in missing or slowing the response time to an emergency call concerning another event. To prevent this risk, the agents pay closer attention to incoming numbers with regional codes different from that of the event location. However, this method does not exclude the risk of increasing wait times or missing an urgent call for another event occurring in the same sector.”*
 - The third type of complexity concerns the interruption of tasks caused by incoming 911 calls or radio calls. Such interruptions oblige the agents to quickly memorize the details of the task then under way in order to take the incoming call. In addition, they have to immediately clear their minds in order to listen attentively to and process the new request. Interruptions do not necessarily entail negative emotions if the call is warranted. However, they may feel a sense of frustration if they have too many interruptions for unwarranted 911 calls.
- Callers do not always express their requests clearly and quickly, such that the agents cannot necessarily determine quickly which emergency service providers should be sent and what priority to ascribe to the call. Agents face problems related to a number of factors: caller confusion, how to interrupt a caller who gives lengthy details about the event background, the caller’s use of colloquial expressions or vocabulary whose meaning varies from that in the reference language, the use of a foreign language, the risk of trivializing certain requests, or obtaining no answer on the 911 line. For several agents, the complexity of understanding the request and of the resulting workload lies in the analysis process: *“Calls where you don’t manage to understand what the caller is saying are exhausting. It’s totally draining. It’s long and hard, you have to guess, you have to pull words out of their mouths, and then keep going back. What do you mean? Please start again because I can’t understand you. It’s the analysis that’s complex, not the steps. We have a lot of calls like that.”*
- One agent commented as follows: *“We need a clear and concise message. We can say as much we like that we’re in control of the call, but it’s not always the case. We tell them to be clear and get right to the point, but they don’t always obey.”* Sometimes it is difficult for the agent to identify the reason for the citizen’s confusion, for example, whether it is a passing state of mind, a mental health problem, a state of inebriation, or a person with a disability.
- The complexity of dispatching certain calls to the police does not lie solely in the uncertainties arising from a lack of information about the request, but also from the

difficulty of distinguishing whether certain events concern the civil code or the criminal code, prank 911 calls that may seem suspect, lack of availability of patrol cars, and the risks of trivializing certain requests. Faced with these various aspects of complexity, some calls may elicit negative emotions in the agents owing to feelings arising after the fact of not having handled the call to the best of their abilities or of having made a mistake. For certain events, there is a fine line between applying the civil code or the criminal code: *“The dividing line between disagreements, life problems that we can do little about, and situations requiring police intervention is very thin.”*

This difficulty arises when the agents have to make quick decisions and when their prior training in the area is limited to the application of general instructions. Essentially, they learn on the job through contact with coworkers and police officers. In fact, when agents are in doubt, they are instructed to refer to a police officer. However, the latter may not always be available when needed. To avoid this situation, one of the MPSECCs set up a phone chain involving several police officers, but even that is not always effective, and it can happen that the call comes back to the agents.

- The lack of availability of patrol cars involves carrying out additional steps such as calling police officers or having to revise priorities, depending on the uncertainties surrounding the request. Agents may also refer to the patrol sergeant. The agents also indicated that they have to juggle the requests that are on hold and reassess their priority depending on the urgency. According to the agents, the complexity stems from having to choose from among a number of sufficiently major requests where to send a patrol car quickly.
- The agents receive many requests, some of them recurring or from the same citizens and whose emergency priority level is difficult to determine (e.g. whistleblowing on a mole, reporting a suspicious individual, or noise complaints). They said that they have to learn not to trivialize these calls, particularly when they are short of patrol cars. If the request meets the requirements for calling in the public security services, they are not authorized to decide on the request’s eligibility in place of police officers. They can only classify it as urgent or non-urgent based on questions they ask the caller and information obtained through database searches. The agents provided examples of events that were not taken seriously enough and that subsequently had dramatic consequences, and by contrast, events that seemed insignificant but that were taken into account, thus preventing worst-case scenarios.
- Some of the agents said they had little tolerance for certain complaints made by some callers: *“Parents who call the police because they can’t control their under-age child. That makes me angry because I can’t believe that they would bother the police for something like that. The person hasn’t touched a knife or flaunted a weapon. Personally, if on Saturday morning my son did not want to clean up his room, I couldn’t see myself calling the police.”*
- Once the request’s eligibility has been determined, the agents must obtain the information needed to dispatch police to the event site. They encounter a number of obstacles in seeking to obtain information, notably, the difficulty of identifying the address for a call made from a mobile phone, lack of cooperation from the caller, the caller’s difficulty in describing the event or in reporting suspicious individuals, among others. The complexity is all the greater since the intervention’s success depends on obtaining information quickly. In addition, the

agents feel responsible for the first responders, particularly police officers: *“We are the eyes and ears of the officers who go to the site. The police officer forms an image or constructs a story out of what we tell him in order to prepare himself before going to the site.”*

To obtain information from the caller, the agents said they try to create an atmosphere of trust with the person. When the caller wants to cooperate, but struggles to answer the agent’s questions, the agent tries to reformulate the questions to make them easier to answer. Based on their experience, the agents therefore use a set of open-ended or closed questions that help the caller to think clearly and give the most precise answers possible.

- Rudeness on the part of a caller is a major source of negative emotion for the agents: *“You nearly always have to control your emotions. When someone lights into you, it knocks you flat. You take it lightly, but sometimes it affects you more.”* According to the agents, callers can be rude for different reasons: their personality type, they react badly to the agent’s more directive behaviour as the latter tries to take control of the conversation, they react badly when their request cannot be met by emergency services, or they become impatient about real problems that are difficult for emergency services to resolve. *“The man who called wanted us to find his son and was telling me off. This isn’t the toughest situation to deal with; it’s just that you have to keep calm. And at a certain point, it’s hard to stay calm. You just want to tell him where to...”*

It seems that the agents never get accustomed to this type of situation and, in fact, that these situations affect the agents even more with age. *“But also, before, if someone insulted me or something, I found it easier to let it go (sign of indifference), whereas now, it affects me much more.”*

In order to defuse potential conflicts with citizens that could also result in lengthening unfounded 911 calls, some agents find it easier to give citizens the information available. Moreover, when the agents anticipate the risk of angering the citizen, they may give explanations justifying their response. In the event of major conflicts with impolite citizens, the agents transfer the call to a coworker. The agents said that this strategy generally calms the citizen, who thinks he is speaking to a more senior person or police officer, particularly if a female agent transfers the call to a male agent. In the worst cases of rudeness, the call may in fact be transferred to the patrol sergeant.

- To be able to do a job that exposes them to dramatic events, the agents must take a certain psychological distance from these events, while retaining a degree of sensitivity that allows them to respond efficiently. *“You have to learn to make distinctions, to remember that this is not your real life. You mustn’t give in to your emotions... because if you do you might just explode.”*

However, the possibility of acquiring, or effort required to acquire, this psychological distance depends on how closely related the dramatic event is to the agent’s private life. The following case was cited by one agent who had just become a father: *“I still remember to this day, and I think I will always remember (it was already around 10 years ago). The story of the baby, because it hit close to home... I had a baby at home and that could have happened to him.”*

Generally speaking, the involvement of a child in a tragic event has a greater impact on the agents. Moreover, the dramatic nature of the event does not have to be explicit. A suspect's tone of voice can trigger a strong feeling of discomfort in the agent. Likewise, the agent may have to answer more or less serious calls concerning people who are friends or family members. The first tragic event experienced directly by the agent also engenders strong negative emotions that are hard to forget.

This psychological distance, which the agents call a "shell," takes years to build up. The new employees build up this "shell" with the help of the more experienced agents. They believe it takes two or three years. It is formed by relativizing certain dramatic events. One experienced agent explained that he had to teach the new agents to build up a "shell": *"You see the young ones. I train them; I've been training them for 15 years. At the beginning, they take it personally: 'My God! What are we going to do? A son who attacks his mother to take money for drugs.' At some point, you have to tell them to let it go. The first time, they talk about it with people they're close to. You have to tell them to let it go because otherwise you won't get through it, because what we receive all the time are negative calls. It's rare that people call to thank us, to say thanks for having saved their baby. You can't be waiting for that. All 911 calls are negative. They need help; they don't call just for the fun of it. You have to learn to separate your job from your social life. Elderly people who have lost it, that affects me. But after work, I close the door. That's because you asked me the question, but I don't like to get hung up about things like that, because otherwise I'd be unhappy my whole life."*

The psychological distance that the agent had to take to cope with these dramatic events had repercussions on his relations with close friends or family outside of work. One agent reported as follows: *"My mother finds me heartless."* Another one said that his spouse or people close to him reproached him for not reacting emotionally like them to certain "little incidents" in life, but the agent explained that it takes more than that to make him sad.

- Taking a call from a citizen who is threatening suicide while talking with the agent represents a complex situation that is heavily charged with emotion. It differs from situations where the suicidal person can be referred to a specialized help centre. In the former cases, the agent must first obtain the address where the citizen is located and then information about the event to assist in preparations for the intervention and ensure the first responders' safety. Lastly, the agent has instructions to stay on the phone with the caller until the first responders' arrival at the location in question. One agent mentioned the enormous efforts that have to be expended in these situations to control one's emotions, to ensure that one does not make an error in the address of the event location, to remember the important questions to ask to ensure the police officers' safety, and to resolve communication and mutual intelligibility problems that can occur with the caller. In addition, all the agents stressed the great attention they pay to the words they use so as not to say one word too many and lose the connection with the caller: *"the fear, the stress of asking the wrong question that... but you can't know, it's very stressful."*

On the other hand, these possibilities of conversing with the suicidal caller give the agent a certain power to act (depending on how decided the caller is to actually follow through) and to save the person. In such instances, the agents feel a great sense of satisfaction at having helped save a life and spare the person's family and friends from suffering. However,

sometimes their efforts are in vain, and the agents may then be faced with a situation they experience as a failure. They ask themselves what they neglected to do or what they should have done for a different outcome, even if they see clearly that when dealing with a person who has made up his or her mind, there is not much they can do. New employees may struggle with this feeling of failure: *“I was distressed for the first few years. Because when you’ve got someone on the line who wants to commit suicide... It just takes a couple of seconds for them to tell us that they have no friends... and then what do you say? We didn’t have any training.”*

An agent in another centre emphasized the importance of training to be able to cope with this type of situation: *“It’s only recently that we had training on suicidal calls. In the 13 years that I’ve been here, we’d never had it before.... So we had training, and overall, everyone found it incredible. We could finally understand a lot of things. We didn’t know that we could actually ask the person how they were going to do it, I mean, really talk about the suicide. At so many levels, you have to develop ways of questioning, of dialoguing with the caller.”*

- Of their interactions with all the first responders, the agents essentially reported situations revealing the complexity and emotional strains associated with working with police officers. These situations concern problems understanding each other’s work, assisting officers in major interventions, and the responsibility borne by the agents for the police officers’ safety. The agents stressed the importance of having relationships of trust in their communications with police officers in order to limit the risks of misunderstanding associated with the reasons for the officers’ movements, the agents’ requests to the officers, delays in the agents’ response time, or differences in the information collected from the caller by the agents and that collected by the police. The reasons for the officers’ movements that are written on the calling card are generally based on facts. However, it can happen that the reasons cited are based on more intuitive factors. A relationship of trust between agent and police officer is therefore important. In addition, the agents indicated that the police can get impatient when the agents make them wait and that the police ask them to do excessive searches in the databases when they have their own computer in their cars. The same agents said that there are few systematic opportunities for them to learn about each other’s work. In some centres, police visits to the centre are organized or agents are invited to accompany police officers, but this happens only occasionally. Not all the MPSECCs are located in a police station.
- Assisting police officers in major interventions or the fact of serving as communication intermediaries between a caller (a witness or someone involved in the event) and police officers in dramatic situations represents a complex situation that is highly emotionally charged for the agents, particularly as they are not prepared for such events. One agent described how he experienced this type of situation: *“At the actual time when you are taking the call, you become a super champion; you don’t even recognize yourself. But once the call is over, you say to yourself, ‘what just happened?’ ... there is an aftershock...then I continued my work, but in fact, I really needed to stop working because not long after that, I got sick. It was largely due to my work, to the stress.”*

- The work of assisting gives a source of satisfaction when it is recognized by police officers. However, it also happens that it is ignored. For the agents, the safety of the first responders whom they dispatch to an event location is an important factor. They feel a sense of responsibility for the quality of information they collect from the callers, as it can play a role in the first responders' safety. They are also strongly affected when the intervention has dramatic consequences for the first responders: *“One call that I’ll never forget was a call from a citizen saying that a police officer had had an accident and that he had died. When the citizen phoned, he just said it was a police car. There was no chase going on; they were simply looking for a guy who had stolen a taxi. But the officer who died was one of my co-workers.”*
- Writing up the calling card can be a complex process. In the case of a non-urgent call, some agents said they take notes and then write up the calling card. This allows them to write the card more clearly to avoid any risk of confusion when police officers read it later on. Correcting erroneous information on the calling cards also takes time. When the information is complicated to write up, the agents prefer to pass it on by radio.
- The agents' work as intermediaries between citizens and emergency services exposes them to complaints from dissatisfied citizens and first responders. Yet, according to the comments obtained, their successes receive less attention: *“It’s always the wrong moves, when you’ve done something not right, that you hear about it... you hear about it pretty quickly compared to if you did something really really good, then it’s rare that you hear anything.”*
- The feeling of doing a good job, of helping first responders or citizens, is a source of pride, as for example, when the questions they ask callers or their information searches serve to move the case forward (e.g. locate a person who has been reported missing, arrest a suspect, save people, or simply help the caller). Also, *“regarding citizens, when I feel that I’ve made a difference, when I feel like I’ve really helped, for example, sometimes you take a 911 call and the person tells you that everything is fine, that they made a mistake in calling, but you’re not convinced and you send a police officer anyway, and it ends up that the call was warranted.”*
- Receiving oral or written thanks from citizens is appreciated, but *“it rarely happens, because when they call, they are going through a hard time in their lives. I’m not saying that callers never thank you, but it’s rare.”*
- Coworkers' positive attitudes promote good moods during work.
- So too does recognition received from coworkers, their supervisor, or police officers for a job well done.

6.2.9 Preliminary conclusion regarding the ergonomic and physiological analysis

The ergonomic and physiological analysis provided a better understanding of the dynamics of the musculoskeletal risks and the conditions pertaining to the cognitive and emotional workloads. The introduction of sit/stand workstations was regarded as positive because it

allowed the workstation to be more suitably adapted to the agents' activity. However, physical demands remain in terms of the layout due to the design of the worktables and the difficulty in adjusting them.

The musculoskeletal pain experienced during half or more than half of the work shift increased with time and fatigue. Pain in the upper back, neck, and shoulders correlated positively with workload and call complexity for three of five agents, while pain in the low back correlated positively with negative emotion for three out of three agents. In line with subjective measures, there was a correspondence between workload and call complexity and the EMG of the trapezius muscles. Regarding heart rate, the data showed a considerable loss in HRV in experienced agents for the entire work shift. The correlations between heart rate and responses on the perception rating scales concerned only a small number of the nine agents analyzed and cannot therefore be generalized.

The cognitive and emotional demands encountered in the handling of emergency calls were identified through the self-confrontation interviews. These interviews revealed the agents' need for support regarding both the content of the requests, which involve various areas of emergency services, and the relational and emotional component of communicating with the callers.

The following section investigates the ways in which the agents manage the psychic work demands in order to safeguard their psychological health and continue to render emergency services.

6.3 Analysis of work psychodynamics

6.3.1 Description of work based on group interviews of agents

6.3.1.1 Evaluating implicit and explicit nature of request for help

Taking calls and dispatching them to the appropriate service provider constitutes the key aspect of the visible work performed by 911 emergency call centre agents. In actual fact, answering calls from citizens requires the prompt and complex handling of requests for help, but also having to constantly remain receptive listeners, knowing how to evaluate the implicit and explicit nature of the requests, and assessing which type of assistance is most pertinent.

The urgency of the call cannot necessarily be gauged by the caller's level of panic: some of the calmest calls can camouflage a person who is in danger. To evaluate the situation, the agent first has to determine whether the request is urgent or not. If it is, the next question is the level of urgency because all requests are important but it is the level of urgency that varies and determines the type of intervention to be set in motion, as well as the fastness of the response.

Over and above taking the caller's request, the agents must know how to interpret the ambient sounds, read between the lines, hear the silences, and decode screams within a few seconds to decide on the most appropriate intervention. In other words, the speed of execution of the entire chain of intervention depends on these few seconds. *"You can hear the clock ticking away in*

your head.” Any seconds gained in assessing the appropriate help to dispatch translate into saved property and lives.

6.3.1.2 Taking control of the call

The agents make their judgments based on a set of questions and reformulations that allow them to quickly obtain the initial and essential information needed to launch the emergency intervention. This investigative tool serves to both earn the caller’s trust and cooperation and obtain information that refutes or confirms the agent’s assumptions.

To make this judgment as quickly as possible, they have to take control of the call, using tact and self-assurance to gain the citizen’s cooperation. The agents may have to push the callers to formulate their requests. This requires a clarification process involving an exchange of information in which questions and doubt become the key strategies for clearly identifying and validating the request. Doubt used as a work tool becomes an investigative practice. In fact, the agents work on the side of investigators. Their work is no longer that of simply call dispatchers, but rather that of alert sentinels acting at the heart of the city’s public security system.

6.3.1.3 Reframing the request for help

Handling calls from citizens can also require reframing the emergency request by helping callers reconsider the event in light of the scope and limitations of the services for which they will qualify following their 911 call. Using pedagogical strategies, the agents embark on a back-and-forth exchange, with questions and answers, making it possible not only to listen but also to be heard. They have to simultaneously reason with, convince, and reassure the caller and sometimes deconstruct scenarios and inform the caller of rights and responsibilities: *“It’s about pointing them in a certain direction, because some of them just don’t want to be told anything. They ask you to do something that concerns civil law, and you explain to them that you can’t do anything more, and often they hang up, blaming you for not wanting to do anything, whereas for us, there is nothing else we can do.”*

Much more than simply dispatching, the job is one of analysis that requires intelligence, presence, and attentiveness. In addition, the agents acquire and use knowledge from a wide range of specialized fields such as psychology and helping relationships, housing law, and the *Highway Safety Code*. *“We are psychologists, lawyers, marriage counsellors, teachers, mediators, etc.”*

The agents preserve the institutional image of the 911 emergency service through their efforts. In fact, their work is that of a mediator between citizens and the city’s emergency and administrative services. They have to reconcile citizens’ requests with the service’s mission and available resources. It requires an enormous amount of work to help citizens understand that the level of urgency of their request does not necessarily require as fast an emergency services intervention as they would like.

The agents are often the last resort when citizens no longer know who to turn to and have exhausted all their resources. The agents are also in a sense the first to respond, the first to initiate action. A large part of their work makes it possible to resolve citizens’ problems directly

without having to call on other first responders. Sensible, thoughtful responses to a vast array of requests, ranging from the most ordinary to the most unlikely, will often allow the problem to be resolved in one call. Most of the calls are thus treated upstream from emergency services, with the agents playing a prevention role that serves to de-escalate a large number of situations before they can turn into a major incident. Many agents would like to receive more support in this regard in the form of training that would give them greater self-assurance in their daily work.

6.3.1.4 Channeling their emotions

Taking and handling emergency calls means knowing how to channel one's emotions, keep a hold of oneself, and neutralize the situation. Within a short period of time, the agents can shift from a relatively passive state to an intensely active state with their adrenalin pumping hard. This emotional regulation process involves taking into account partly the simultaneous occurrence of the call and the event and partly the danger level (whether or not a life is in jeopardy). When the call involves a live event such as a thief in the act, where a life is in danger, the agents are involved in a higher risk action where anything can happen. In this case, their physical posture changes and chest rises, and they move closer to their workstation. The agents are talking while their adrenalin is pumping.

The agents enter and physically settle into a bubble offering protection from the outside world. Their concentration levels are at their highest and the emotional stress culminates to the point that it has to be brought back into balance. This work on the emotions is less present when the call involves a situation where the danger lies ahead or has passed. The identification of these respective moments has an impact on the analysis of the situation and determines the level of urgency and appropriate alertness required to respond to the request. Moreover, the agents frequently have to answer several calls at the same time, and therefore have to switch back and forth from one state to another within a few seconds. Lastly, while the agents are dealing with their own calls, they are also lending an ear to the other agents' calls because they have to be able to assess whether or not they should assist their coworkers.

6.3.1.5 Shift work and conflicting schedules

The work of 911 call centre agents is carried out on an ongoing basis: 24 hours a day; 365 days a year; days, evenings, and nights. The fact that the work is performed on a shift basis and divided into day, evening, and night shifts, imposes a double strain. First, over the years, night shift work becomes particularly taxing and recovery increasingly difficult. And second, these schedules are difficult to reconcile with the pace of family life because they often conflict with other family members' schedules.

6.3.1.6 Work involving the darker side of life

The fact of daily witnessing emergency situations experienced by citizens necessarily exposes the agents to the darker side of life. They can no longer pretend that such situations do not exist. With the veil lifted on the shadow side of life, the challenge is how to sleep and live with this knowledge. Once certain things have been heard, they can no longer pretend they are unaware. It is no longer possible to not think about these things or to not take them into account. How then do they retrieve a sense of security?

This immersion in the darker side of life imposes an insidious form of suffering with long-term effects. The agents become more cautious and mistrustful. *“You’re no longer able to trust anyone, not even alarm systems.”* They are condemned to a sort of heightened and distorted lucidity: the dark side takes up a larger proportion of their thoughts. Thieves, negligent parents, violent spouses, neglected seniors, and young people in distress are part of their daily life, constituting a close-up of the symptoms of a sick society that takes up all the space.

Moreover, taking into account the suffering of others while remaining seated in a position where the body can act only by listening, requires restraining the body’s inclination to leap up; at most, the agents straighten up, move toward the front edge of their chairs, or adjust their desks to standing position. Outside, police officers and firefighters take physical action at the heart of the operations, the scene of the tragedy. Physical involvement helps release body tension. But this is not the case for agents, who work at a distance and suffer from the physical limitations of their actions. This does not alleviate the tensions that accumulate in their body. They are faced with the challenge of remaining attentive to each call without lapsing into despair.

6.3.2 Sources of pleasure

6.3.2.1 The pleasure of helping

The impetus for being able to listen and ready to hear anything and everything is sustained by the agents’ very strong desire to help. For them, helping citizens means responding to them by trying to hear the message behind the words; it means anything from saving a life to simply reassuring an elderly woman who has lost her flower pots. In other words, they help citizens in many different ways. The pleasure they derive from helping is expressed in their relations with their coworkers, but also with first responders. They are constantly concerned with protecting the first responders’ lives by checking the context and level of dangers present at the event site at the time of the call.

6.3.2.2 Intense work

There is no such thing as routine in the agents’ work, which is one of its strengths. *“You never know what to expect with each call.”* In addition, experiencing sudden and frequent increases in emotional demands makes this type of work difficult to compare to anything else: the thrill of being on the edge of your seat. It is a type of work that *“hooks you”*; the agents spoke about the pleasure of *“running on adrenalin.”*

6.3.2.3 Unravelling the mystery and making sense of the call

The agents’ work calls their intelligence into play: they have to decode the call and resolve the mystery, and to do so, they must think and remain alert. This occupation presents a vast array of situations that demand their practical intelligence and gives them a sense of pleasure that is hard to replace.

“It takes judgment; you can’t just get rid of the call; you have to stay with it right through to the end.”

“Asking a lot of questions means that you have to create an atmosphere of trust, and that takes time.”

Unravelling the mystery and passing on information to ensure intervention is one of the sources of pleasure the agents derive from their work. This means that they have learned to properly read the indicators, that they know how to identify what they call “the red flags” to reconstruct a coherent story that thus becomes accessible to the other first responders and even to the caller. Their work consists of making sense out of what initially did not make sense. The result of the call also equates to the outcome of the event. Even when the agents find themselves at an impasse, they may still contribute to a happy outcome (e.g. prevent a suicide).

As for the more complex calls, “*the big incidents,*” this pleasure may only be complete after they have gone back to the calling card to see the outcome of the intervention. When the police officers’ conclusions give credence to their first intuitions, they experience the pleasure of recognition of a job well done: the police officers’ conclusions confirm the validity of the agents’ investigative process.

Although not always recognized by the police officers in all the centres, the fact remains that the agents’ ears are the officers’ eyes. The agents hear things that make sense out of the call and to which the police only have access through the agents.

6.3.3 Occupational know-how and defence strategies

Analysis of the interviews shed light on the occupational know-how and defence strategies required to handle calls in emergency situations, specifically: 1) taking a distance from the emotional strains by building a hermeneutic for understanding emergency situations; 2) using the narrative ethic as a means of symbolically processing the experience, and 3) using therapeutic humour to say the unsayable and as the ultimate bridge to maintaining health.

6.3.3.1 Taking a distance from the emotional strains by building a hermeneutic for understanding emergency situations

Occupational know-how appears to be developed in three phases during which the pressure gradually dissipates. Whether grappling with difficult calls, the stress generated by an unforeseen situation, or fear of error, regardless of the forms they take, fear is gradually mastered. With time and experience, agents learn the occupational ropes and develop a hermeneutic for understanding emergency situations. This process is so demanding that some of the agents acknowledged that if they had to start over again from the beginning, they would not do so. The price is too high.

The first phase: learning the contours of the job terrain

Learning the ropes of this occupation involves a first phase of approximately 18 months during which the agents become familiar with the contours of the job terrain. It constitutes the period when situations are encountered for the ‘first time,’ the period needed to run the full gamut of big and small events. These successive encounters leave the first imprint, forming the foundations of experience, namely, the vast majority of situations encountered in the job. In this phase, experience is built by identifying typical situations that give shape to the “occupational

map” and by shading in the contours of the terrain. Calls are experienced once, then relived mentally and recounted to others. The agents tell their own narratives as much as they listen to those of others. They all recall their first experiences and their effects, as well as the errors they made. They also remember the other agents’ “first time” stories, for they have listened to them being recounted. Not a single narrative was reported to us that others did not immediately recognize upon hearing the first words and whose relevance they did not underscore: *“Mmh! That’s the best example!”* The narrative both refines and validates the occupational know-how. Little by little, the full gamut of situations is experienced and gives way to second, third, and tenth recurrences: the job falls into place, the hermeneutic gesture is built, and a first easing of tensions is experienced.

“Experience means that when you get to your 240th robbery [with violence], it doesn’t upset you anymore, but when it’s just your second time because you’ve only been working at the job for three or four months, you haven’t had time to run the gamut of events and you say to yourself, ‘I hope I won’t have a robbery tonight’.”

The learning takes place in two complementary ways. The first concerns the actual “doing,” carrying out the actions, i.e. taking the calls, interlinking the questions, and performing the telecommunications operations involved in dispatching. The second way of learning involves the narrative.

“In the first year: you go to bed and you dissect what happened. ‘I did such and such and then something else’; you ask yourself questions. It’s only afterwards, when you start to take control, that you can actually clear your mind of the day’s events.”

At this stage, the agents have not yet encountered all aspects of each situation. However, they gradually develop a repertoire of scenarios or blueprints that guide them in their work. This first year constitutes the hurdle to overcome. It is the time for taking stock of all “firsts,” and above all, the first suicide: *“the first suicide, I think everyone is afraid of the first one.”* Once this step has been completed, the agents start gaining confidence, and rightfully so: they have gone through a series of trials, like an initiation in which they progress from one status to another. They can begin to relax. When they do so, the other agents also relax. An atmosphere of mutual confidence can be established.

They do not complete this first lap of the track alone. Peers “train” novices through a buddy system. As they work, the novices rely on their more experienced workstation neighbours. They learn to listen on two fronts simultaneously, as they overhear their coworkers’ calls. This provides them with knowledge of the basic valid investigation techniques used by the team: tone, wording, reaction time, and common questions and answers. When they find themselves caught off guard or uncertain, the “apprentices” ask their coworkers about procedures; they seek confirmation of the content or form of the answers to be given to citizens; they consult their peers about work organization procedures. Conversely, the more experienced agents listen to the novices while handling their own calls. They are thus in a position to be able to assess the quality of the novices’ calls and to provide them with the information or advice that will help them progress.

“Feeling comfortable, like you’re on top of things... The stress goes away after a year and a half at least. It takes from one and a half to two years before the person is autonomous. Everyone has to go through it, go through the stages, and then they feel that things fall into place.”

The second phase: building a repertoire

Then comes the second phase, in which the situations are documented and the details on each event “map” are filled in. It takes several more years to see a repeat of each situation from different angles, which serves to reinforce the agents’ experience, case after case. The agents slowly build up a “database” that continues to grow over the years. This constitutes the phase in which they consolidate their repertoire, a tool for making sense of the hermeneutic gesture.

The more detailed the map of the terrain, the faster the agents are able to identify the situation at hand. This provides the agents *a priori* with a repertoire of hypotheses that they no longer have to think up case by case, thereby saving them energy. Perrenoud (1999) refers to pre-prepared response formats built through anticipation. The accompanying feeling of mastery and the relaxing of emotional stress enable the agents to be much more subtly attentive to callers. The smoothness of their investigation in fact depends on the resources they have available for listening: knowing how to cut off, clear their heads, and prepare a clean slate in order to start again and afresh on the next call or next shift.

Paradoxically, the beginning of this phase is a time that can prove hazardous. The agents are aware of the great risks involved in thinking that they have learned everything, that they know everything about every situation and how to control it. Once the database has been built, it would be easy to sit back, let it take over, and go onto automatic pilot. Gradually, the agents learn how to perform their work while sparing their emotions. The work takes precedence over the emotions that overwhelm them during their first calls. Tension and anxiety are replaced by the ability to concentrate on the work.

This phase is also marked by the honing of their listening skills and the development of a “super ear.” Being an attentive listener requires being relaxed enough to hear the nuances. It is through this super ear that the agents become autonomous while simultaneously acting as team members who are perceptive and sensitive to times when the rest of the team needs assistance.

“There’s always someone keeping an eye out, listening to the discussion, someone who really has his ears to the ground, who is really alert! It’s like an implicit agreement, we all pretty much back each other. We try to know everything that’s happening around us.”

The agents are listening even when they are doing something else, even something completely different such as crossword puzzles, talking, or knitting. It is considered essential to listen to what their coworkers are saying because *following the thread* means staying attentive and keeping the group cohesive and vigilant. Attentive listening is a practical skill used both within the group and on the telephone. Similar practices have been observed by Dejours (1993a) when operators in a petrochemical plant play scrabble while constantly keeping an eye on the installations from the control room. “They ‘listen’ to the process while they play. They listen to the noise, vibrations, periodic alarms, and humming of the machines” (Dejours, 1993a, p. 51).

The body is impregnated with this background noise; it takes over to ensure a quiet watch, acting as a constant lookout system allowing for prompt reactions to the slightest abnormal noise. *Deliberately listening* is not the same thing as simply listening or even hearing; rather, it is an active form of listening, of listening intelligently with the body. Dejours (1993a) identified this as the body's primary intelligence that precedes awareness and acts directly on work praxis. In other words, the agents' ears serve as a form of radar, a mid-range radar for their own calls and a long-range radar for the general atmosphere, for the critical turnarounds in an emergency situation. The agents keep watch over the city and over each other.

The third phase: consolidating the repertoire

Lastly, only after several (often more than seven) years of experience do the agents acquire a more comprehensive overview of all the different configurations: representations of past experiences, formulations of hypotheses, representations of the consequences, and so forth.

“It's as if you've just gained a deeper understanding of all the situations, of all the contexts, and the chessboard is in place.”

In this phase, the repertoire is consolidated and the system of reference starts kicking in, protecting the agents from the major emotional fluctuations caused by disruptions in routines. This process allows them to conserve energy and last longer. It also gives them a feeling of control, which in turn enables them to use less emotional energy and again, to last longer.

“With time, nearly all the calls become routine, even calls that, for a person who has never done this, could be very stressful. But for us, when we've heard the same thing dozens and dozens of times, it no longer stresses us as much.”

Once the desensitization process has taken place, the agents will say that there are few things that affect them, like water running off a duck's back. However, while this system protects against emotional fluctuations, it does not eliminate them. It simply takes more to reach the same level of emotional intensity, without losing one's sensitivity. Working in a known and familiar terrain allows them to take calls while remaining in full control of their faculties. Without a desensitization process, the agents would be perpetually taxed by already familiar situations.

The fact of relying on a reference system allows the agents to sleep at night, disconnect, and gain confidence. They manage to turn off and not take the burden of the day's calls home with them. Assimilating this reference system thus becomes a life raft that enables them to stay on the job more than ten years. Conversely, the system of interpreting situations on the basis of schemas or patterns is not without risks. The risk is that of becoming rigid, of functioning on automatic pilot. In fact, a rigid system exposes the agents to the danger of believing themselves infallible. Overly sure of themselves, they may fail to see the differences in situations as indicators that need to be reinterpreted. The risk is therefore that of believing that everything is now a known and that doubt is no longer necessary. On the other hand, remaining aware that this risk exists helps to keep the system open; continuing to doubt keeps the agents perceptive and lucid. This process is reminiscent of those of power linemen, who leave a small electric current live, despite

safety instructions, to keep themselves alert and prevent themselves from falling asleep through a false sense of security (Brun, 1994).

The schemas in the reference system are not simply an automatic decoding device. They cannot be compared to a table of codes where each sign is matched with a fixed immutable meaning. Rather, the agents must let themselves be surprised by faltering tones of voice and incongruous behaviours, remain responsive to the new forms that the indicators of this incongruity can take, and assess each situation in terms of its unique characteristics while also identifying all the invariables. In fact, the repertoire is not one of responses and typical situations, but rather of hypotheses that allow the person to continue thinking outside the box of ready-made responses in order to be open to incongruous situations. The repertoire obliges the person to think. It is a hermeneutic for emergency situations that includes the processes of understanding needed to interpret events.

However, risky situations always exist in which, despite experience, the call hits the agent with full force. There are danger periods, notably during summer, when the most experienced agents are on vacation and several novice agents need assistance. The more senior among those who are at work risk being quickly oversolicited, such that their reference systems are on overload and can no longer be updated: within the space of an instant, they no longer know what they are doing. They lose the thread of the events and of the action: *“Did I do this or that? You no longer remember.”* The energy savings achieved by referring to the schemas is no longer sufficient to respond to the pressures. Added to these demands is that of having to oversee the mental health of the novices, a task that the more senior agents sometimes perform at arms-length within an organization that is experiencing work intensification.

The more experienced agents would like jobs where they can catch their breath and recover more effectively, but also where they receive the consideration they are entitled to for their loyalty and reap the benefits of years of contributing. In concrete terms, this would mean no longer doing night shifts or taking calls, but instead, focussing on dispatching, or in other words, specializing. However, this request represents a double-edged sword, which the agents know.

In fact, compartmentalizing and divvying up the work among the agents poses a hazard, as this would create categories of agents. The workers would then have to concentrate on a single task, which would prevent them from using all their know-how and intelligence. Yet it is precisely the opportunity to use their intelligence and ingenuity at work that is one of the most decisive factors in their occupational health. The task of listening makes the agents' occupation risky for their health, and to deprive them of the possibility of thinking and creating would render their job perilous.

Moreover, distancing the more senior agents from the novices would deprive the work environment of the very dynamics that contribute most to building the agents' occupational identity, such as the informal exchange of knowledge, daily building of the emotional repertoire of the occupation, and sharing of prudent knowledge.

6.3.3.2 A narrative ethic as the symbolic processing of the experience

Narratives allow for the development of the reflexes needed for fast decision making in emergency situations: anticipating, questioning, and initiating the intervention. They also provide a means of reliving, reconstructing the story, and reconstructing the emergency situations or how they were handled, with all their ins and outs, twists and turns, and fallout. This verbalization of the experience is part of a symbolic processing that plays a role in the metabolization of affects and the transmission of occupational knowledge and standards. Whether the narrative comprises an inner dialogue or one with a coworker, the call is “dissected to the core,” reviewed, and revisited until the residual stress is completely absorbed through the realization, after analysis, that one has done one’s job well. It is an opportunity for going over an occupational action outside of the real work context and for taking ownership (Clot, 2002).

The principle of trust is a prerequisite for the narrative to work. Total trust must exist between the person recounting the narrative and the person listening. It is also one of the reasons why narratives are not accessible to laypeople, and why, very quickly, as the agents gain experience in their occupation, they recognize that they only talk about work with their fellow agents, with those who can understand. On the basis of trust, by recounting their narratives the agents agree to expose themselves to their peers’ judgments. In return, their coworkers offer comments, rectifications, or support; in other words, they analyze the practice that has been revealed to them. They therefore make a form of judgment. The narrative provides the material that enables them to assess whether the work performed reflects “compliance with the common rules” (Dejours, 1993b, p. 295). It also provides a means of narrating the work experience that sidesteps the rules, the work experience in which they have doubts about the well-foundedness of their actions; the narrative further serves to socialize the suffering experienced in connection with work (Molinier, 1995; 2006).

By doing so, it is the entire team that debates and validates new question formulations, computer tricks for getting around an uncooperative program, and so forth. At the same time, it is the entire process of integrating into the team and into the occupational emergency-service provider identity that is taking place. The agents’ practices highlight several aspects of the narrative. Recounting their calls to each other first signifies using the cultural function of the narrative as an instrument, a set of principles for working together. If, as Bruner (2002) saw it, a narrative consists of [free translation] “organizing and transmitting our experience in a narrative form” (p. 18), it could then be seen from the perspective of intersubjectivity as “the mind’s capacity to read,” a specifically human capacity. In fact, narratives serve as a “translation” that makes it possible “to convert individual experience into a collective currency,” thus expanding the interpersonal relationship to a much broader community. The withdrawal of some members and the formation of small groups or clans are therefore experienced as major threats to the whole. Big teams are at greater risk of becoming disunited. Jokes, pleasantries, and social activities apart, hushed whisperings undermine the effectiveness of the narrative as a cultural and historical vector that allows subjects to bond with their work community.

From the standpoint of meaning, narratives make it possible to [free translation] “say what people are, what their worlds look like” (Bruner, 2002, p. 79) by providing in the story the conventions that govern our lives, thus defining the limits between the expected and the unexpected. Lastly, narratives, as a story-building process, are therefore a means of freeing

ourselves of the *contingency of the world*, “a means of coping with the surprises and hazards of the human condition” and of rectifying humans’ ontological vulnerability to the reality of their condition. Narratives have the capacity to “tame the unexpected, to render it a little more ordinary” (*ibid*), and in this sense, they have a protective function. For the agents, this function of the narrative is all the more vital because it allows them to rehabilitate their view of the world.

6.3.3.3 Therapeutic humour to say the unthinkable and as the ultimate bridge to health

Humour plays a continuous role in the agents’ work. It is an extremely effective and intelligent humour that allows them to say everything without being blamed: to swear, let off steam, insinuate, and say what is normally left unsaid, even the unthinkable. The agents use humour as a defence strategy that works in two ways.

The first level on which this strategy works is to limit suffering. Humour is a mechanical process that acts by direct impulse resulting from the pressure imposed by the emotional strain of taking emergency calls. This defence function of humour was found to be particularly apparent in the literature, mainly in occupations involving death in emergency and operating rooms and at the morgue (Logeay and Gadbois, 1985; Carpentier-Roy, 1991; Molinier, 1995; Trompette and Caroly, 2004). Molinier (1995) has shown how, specifically in nursing work, the use of humour in the narrative provides a means of expressing emotions of hatred in an acceptable and communicable form. In this case, the workers use it as a means of venting their feelings in a defensive way. The venting of hatred in this manner is then replaced by self-derision about their own vulnerability (Molinier, 2006), which in turn allows them to accept their weakness and be receptive to that of others.

In the case of the 911 call centre agents, they can find it difficult to initially express this humour without feeling uncomfortable. For example, some agents told us about their discomfort following a narrative in which they told an explicitly racist and cruel joke. They quickly tried to justify themselves by explaining that the nastiness of what they had said did not reflect their true feelings.

“It was nasty! You can’t be more racist than that! Not that I really think like that; it’s just a way of letting off steam. I am raising my daughter not to have prejudices about any nationality...”

The second level involves an empathic intent that forms part of a relationship with the other person. The intent is to comfort and protect the distressed ego, both their own and that of the other person. It is part of the work performed by the more senior agents, those whose mature repertoire of experience entitles them to make light of a serious subject while still focussing on the act of assisting. According to Freud (1930), the central aspect of humour does not lie in the joke itself, but rather in the purpose it serves: [free translation] “when the superego is forced, through humour, to console the ego and protect it from suffering, this in no way contradicts its origin, the fact that it derives from parental authority” (p. 211). It is at this level that the more senior agents accompany their less experienced coworkers during painful moments: by stifling the expression of anxiety and converting it into pleasure. In fact, this constitutes an act of affirmation: [free translation] “The ego refuses to let itself be engaged, to let external realities

impose suffering upon it; it refuses to acknowledge that the traumas of the world can affect it: rather, it shows that these traumas can even become opportunities to experience pleasure” (*ibid*, p. 208).

In concluding his narrative of the suicide of a woman who slit her throat, one agent commented “*elle n’a pas raté son coup*”⁴. This allowed the agent to rise above his encounter with death and give his coworkers the same narcissistic, jubilant pleasure. Not only does humour have a liberating effect, but it offers both the subject and others a glimpse of the unthinkable aspect of the darker side of life, while at the same time limiting suffering. In other words, the agent’s humour allows him to half-say something of his own truth and of others’ truths. Freud (1930) likens humour to regressive processes used to withdraw from pain (neurosis, madness, intoxication, withdrawal, and ecstasy) because like them, it implies the “triumph of the ego” and the affirmation of the pleasure principle despite the constraints and demands of reality. However, unlike the other regressive processes, humour does not fall outside the realm of psychic health. Not only does humour allow a person to say the unthinkable in a relationship with another person, but it also limits suffering and remains a health-promoting mechanism.

Despite these defences, we noted that for most of the agents, one type of call resisted their defence strategies. Each agent’s story revealed a sensitivity concerning one type of call that he did not always manage to laugh about.

“We all have our weaknesses. For some people, it’s children; for others, it’s old people...”

Though faced with their own individual impasses where laughing feels impossible, the agents are nonetheless able to let their coworkers laugh about the situations, while they wait for passing time to release them from the grip of these devastating calls.

“For me, it’s when someone loses an immediate family member; it takes time before I’m able to laugh about it.”

With time, the agent will indeed be able to laugh about it, but he will always remain vulnerable to a particular type of situation, as if this vulnerability protected him from the risk of indifference.

6.3.4 Preliminary conclusion of the work psychodynamics study

The occupation of 911 emergency call centre agent falls into the category of an investigative job, but is also a job focussed on helping others. Our analysis of the group interviews revealed the existence of occupational know-how and defence strategies. It is only through time-consuming and exacting work carried out over years and through daily and risk-filled exposure to awareness of the suffering and misery of the world that the agents are able to build a hermeneutic for emergency situations, a narrative ethic, and a therapeutic sense of humour. Guardians working

⁴ Translator’s note: The French here involves a play on the word *coup*, which means stroke or blow; literally, “she did not miss her stroke” (figuratively, she did not fail). In other words, the woman did not miss her stroke and actually succeeded in taking her own life.

vigilantly behind the scenes on the other end of the telephone line, 911 emergency call centre agents contribute silently to ensuring the city's safety and citizens' tranquillity. However, much work has yet to be done to give this occupation visibility in the eyes of other emergency service providers: police officers, firefighters, and paramedics.

7. DEVELOPMENT OF COURSES OF ACTION

Courses of action were developed with the project follow-up committee at four meetings. Two of these meetings were devoted to presenting the study results, with the first looking specifically at the work psychodynamics study, and the second, at the ergonomic/physiology study. Both studies made it possible to identify the work dynamics and the psychosocial risks of musculoskeletal disorders (MSDs) and psychological health problems (PHPs). And the results of both studies pointed to the need to provide the agents with support. They identified calls that are problematic to handle and showed the importance of building this support on the basis of the agents' experience and know-how. Two meetings were then spent identifying courses of action, which were discussed taking into account the context and the predisposition and capacities of the follow-up committee members. This report mentions the progress of the work in this regard. Other meetings are planned to help in the implementation of the courses of action.

7.1 Courses of action

The courses of action developed with the follow-up committee involve offering support at three levels: individual and group support for the agents, support from the organization, and professional support.

7.1.1 *Individual and collective support for the agents*

Providing individual and collective support for the agents has three components: training for the agents in the MPSECCs, psychological support in dealing with particular situations, and support during high call-volume situations.

Agent training

The need for training was mentioned by several agents during the self-confrontation and work psychodynamics interviews. The results of the study in fact show that the job of taking emergency calls is not limited to giving simple answers to citizens' requests for help. In reality, the agents are involved in a communication task that implies the development of skills in posing questions about the reason for the request and creating a specific relational atmosphere specific to emergency situations, but this communication work is not really factored into the agents' training.

Moreover, it would appear that the agents have little opportunity to maintain their dispatching skills for major emergency events. Yet dispatching for such events is a highly demanding task, mainly due to the high volume of incoming and outgoing calls. This lack of practice makes it more difficult for the agents to maintain the skills required to perform the work. During their interviews, some agents stressed the potential value of training in this regard.

In addition, the training given when the new sit/stand desks were introduced essentially concerned the technical aspects of using the adjustment controls. During the study, however, it became apparent that some of the safety principles applicable when adjusting the computerized workstations were poorly understood by the agents. Agent training in this regard would therefore

appear advisable, although it would not resolve the problems associated with the worktable design.

In summary, training in the following areas appears to be advisable:

- training on the psychological dimensions of communicating in emergency situations (training to be developed)
- training on decision making with reference to the civil and criminal codes (training to be developed)
- training of the agents to stay on the telephone during attempted-suicide calls (existing training)
- training on dispatching for major and rare events (e.g. fires) (training to be developed)
- information on techniques for adjusting the dimensions of the computerized workstations (information to be adapted).

Several of the proposed types of training need to be developed. The particular conditions associated with the agents' work imply that these types of training should be developed with the agents' input. In fact, whether it is in the area of communication psychology or the application of the civil or criminal code, it is less a question of passing on general knowledge than of making available the skills pertaining to the particular conditions applicable to their occupation.

Psychological support in dealing with particular situations

The agents face emotionally demanding situations. These demands concern not only the dramatic aspect of the situations, but also the system of moral and social values involved. The work psychodynamics study and self-confrontation interviews revealed the importance of the work collective and defence strategies in coping with these demands. In addition, according to several agents, the employee assistance programs (EAPs) do not appear to be adapted to their occupational needs. In this regard, it is important for the agents to have opportunities to discuss and reflect on the topics that are troubling them and the methods used to deal with them.

- Include discussion periods in the continuing education courses where the agents can talk about the issues that trouble them in handling emergency calls. These discussions should be led by a professional with a psychology background, but who is also very familiar with the nature of the work.

Support during high call-volume situations

When there is a significant increase in call volume, the team leader can requisition an additional agent. However, there are limitations involved in applying this procedure. The first concerns how to predict the duration of the high call-volume period, and the second, the difficulties involved in reaching agents at home.

- To help resolve the first limitation, it would be advisable to clarify the procedure for requisitioning an additional agent.

- The second limitation could be resolved by drawing up a recall list identifying the agents who can be easily reached.

7.1.2 Support from the organization

Support from the organization includes support in facilitating the work and team management, as well as support in improving agent/police interaction.

Support in facilitating the work and team management

Support in facilitating the work and team management means circulating information on work methods for handling complex or emotionally demanding calls, holding debriefing sessions after major events, and determining the role and function of the person in charge of quality.

- Circulating information on work methods for handling complex or emotionally demanding calls

The work team plays an important role in the fast handling of complex calls, in the handling of high-call volume and simultaneous calls, and in the provision of psychological support. Research in this field has shown that work efficiency is based on the building of a common set of rules for all team members (Caroly and Weill-Fassina, 2007). For the agents, building rules means developing work methods for responding to certain difficult calls or resolving certain problematic situations. Rules are developed by each work team, but the other teams are not informed of them. Yet because they face common problems, an exchange of work methods could help to reduce mental workload while improving service efficiency and quality. It would therefore be advisable to encourage the circulation of information on work methods among the different teams. This initiative could be entrusted to the agents, the team leader, or the person in charge of quality control. The procedures for passing on information on work methods could be determined on the basis of experiments already conducted more or less successfully in some of the MPSECCs.

- Holding debriefing sessions following major emergency events

To improve the psychological support available, the follow-up committee is looking into the possibilities of holding *ad hoc* debriefing sessions immediately following major emergency events. Their investigation concerns the type of debriefing (operational or psychological), the resource persons, and implementation procedures.

- Determining the role and function of the person in charge of quality

Québec's *Civil Protection Act* was amended in 2008 to oblige municipalities to ensure that their territory is served by a 911 emergency centre and to confer on the Québec government the power to adopt a regulation imposing quality standards on the 911 emergency centres. This regulation has been in force since February 2011 (*Civil Protection Act*, RRQ, c. S-2.3, r. 2). Enforcement procedures are now being developed. The type of quality control that is determined may have a major impact on the support given to agents. In order for this quality control role to be positive, it must not simply involve assessing response times or complaints, but also assisting the agents

with difficult calls. From this perspective, the person in charge of quality can play an important role in ensuring the circulation of information on the methods developed by the agents to handle particular problems. This person can also lead discussions on the pros and cons of certain methods.

Support for improving agent/police interaction

The agents in the MPSECCs work closely with first responders and particularly, police officers. The results of the study show that sources of misunderstandings exist in the communication with police officers related either to the information transmitted to the officers or to the officers' requests. In fact, given the complexity of the agents' and officers' work, effective communication cannot be achieved solely through the mechanical application of procedures. It is also important for an atmosphere of trust to be established. To create this, each party needs a better understanding of the other party's work. Actions could be taken at several levels to achieve this:

- Organizing systematic work visits by police officers to the MPSECCs, and conversely, allowing agents to accompany police officers on their job. These exchanges, which have already taken place in some MPSECCs, were positively evaluated by the agents.
- Creating a committee of users made up of representatives of first responders in order to solve recurring problems, a formula that is already being followed in one of the MPSECCs.
- Improving the training currently given at the police school regarding call-taking and dispatching work. This training, which is focussed on practice, could be enhanced with the results of this study.

7.1.3 Professional support

Professional support includes improving academic training, producing a video explaining the agents' work, and approaching office furniture suppliers with a request that they improve their desk designs.

1. Integrating information on the psychological and police-related aspect of the agents' work into the academic training

Currently, first responders receive their academic training in two CEGEPs. The courses are part of the continuing education program. One course is available online; another course is 720 hours long. The courses focus on the acquisition of technical, procedural, and communication skills, and on written and oral French. Lastly, in one of the CEGEPs, a course was introduced on the subject of suicidal callers. There are plans to contact those in charge of the training program to ask them to introduce the knowledge gained from this study into their courses.

2. Producing a video explaining the work of the MPSECC agents

The agents' work is performed behind the scenes of emergency services and the results are therefore low profile, particularly when everything goes well. The agents consider that the skills required to do this job are misunderstood and underestimated, which might explain why it is difficult to obtain training in certain areas. The production of a video would therefore provide

municipal officials as well as first responders and citizens with a clearer picture of the agents' work.

3. Approaching office furniture suppliers (consoles, computer hardware and software)

The introduction of office furniture allowing for the individualized adjustment of the workstations and offering a sit/stand option constitutes a major step forward in terms of reducing the postural constraints that can lead to MSDs. However, this study shows that certain problems persist with regard to the design of the front and back worktables. These problems stem from the lack of depth of the back table and the fact that the tables are not designed to integrate a touch screen. Suppliers therefore need to take steps to improve the work-table design.

7.2 Steps toward implementing the courses of action

The follow-up committee's discussions on the various courses of action led to a consensus about the need to place priority on implementing the specific course of action that consists of providing a clearer picture of the work realities of MPSECC agents, notably through the production of a video. Simultaneous steps will also be taken regarding aspects related to training in the MPSECCs, the integration of the person in charge of quality, academic training, and improvements in agent/police interaction.

8. DISCUSSION

The aim of this study was to describe and identify the difficulties that MPSECC agents have in regulating their musculoskeletal and mental workloads, with a view to developing courses of action for reducing the related risks. The study posed a number of challenges pertaining to the implementation of a multidisciplinary approach combining physiological and perception measurement methods with descriptive methods that allowed the workers to express themselves subjectively. The ultimate goal was to use the knowledge gained to develop possible courses of action. Not all these challenges were met with equal success. A detailed discussion follows.

8.1 Physical risks present in MPSECC agents' work

The physical risks present in the work performed by MPSECC agents are associated with both exposure to constraining postures caused by working in prolonged sitting position and equipment accessibility problems. To avoid the need to work in prolonged sitting position, four MPSECCs acquired worktables offering sit/stand options. The fifth MPSECC followed suit after the study. Some authors assert that this type of adjustment helps reduce exposure to certain constraining postures, mainly those involving shoulder rotation (Karlqvist, 1998). Our study in fact revealed that standing position facilitates the adoption of less constraining postures to access the equipment located on the sides of the worktable. During the interviews, the agents indicated their satisfaction with the introduction of these worktables, yet little use was made of the stand adjustment option as only three of the 11 agents observed took advantage of it. These results are similar to those of a Swedish study (Wilks et al., 2006). However, unlike the authors of that study, who questioned the merits of investing in this type of equipment due to its limited use, we consider this adjustment option to be useful for the agents. In fact, several of them, who had not used the adjustment option during observation, mentioned various situations in which they would have preferred to work standing up: during very busy periods, when they felt tired from sitting, when they had to move around frequently beyond their workstation, or when working as team leader.

Apart from the fact that the adjustable worktable allows for either sitting or standing position, the agents can adjust the table height to their size and work methods. However, the quality of these adjustments appears to be limited due to the desk design and the agents' lack of information on the ergonomic principles of computer workstation layout. The desk design does not allow the worktable height to be adjusted properly in relation to the screen height. This problem stems either from the difficulty of adjusting the worktable relative to the screens or from the narrowness of the computer keyboard tray. Moreover, the fact that the touch screen is positioned in the same way as the regular screens creates major stresses on the shoulder joints.

8.2 Psychosocial risks present in MPSECC agents' work

The psychosocial risk study was conducted using ergonomic/physiological and work psychodynamic approaches. These approaches served both to identify these risks and to describe their presence and ways of regulating the work demands and mental workload. The combined use of these approaches was feasible due to the fact that they have several points in common. First, they focus on the work as a whole and the activity per se; second, they refer to the concepts

of regulation concerning the demands and workloads likely to cause risks. They appear to be complementary inasmuch as ergonomic analysis allows for description of the conditions fostering or limiting the regulation of work demands for the purpose of attaining the task's and the worker's objectives, while work psychodynamic analysis seeks to describe the psychic processes that allow continuing performance of the activity, despite the demands, load, and high risks associated with the work.

The ergonomic analysis of the mental workload was based on conventionally used tools, i.e. observation, administration of perception rating scales, and self-confrontation interviews, in addition to measures evaluating its effects in terms of the presence of musculoskeletal pains, trapezius muscle activities, and heart rate. Their contribution will be examined next.

8.2.1 Observation

Through observation during the study of the agents' mental workload, it was possible to describe the frequency and duration of certain work sequences and to identify the communication problems and the questioning strategies used to resolve them. The study results indicate that communication problems occurred in 20% of the calls. However, in this work context, the attribution of a value to assess the scope of the problem is entirely relative because in reality, when an emergency call is involved, the fact of encountering even a single problem can have serious consequences. Examples are described in several studies (Fele, 2006; Tracy, 1997; Whalen et al., 1988). Also, the agents may feel the effects long after the call. They may rethink the problem encountered, particularly if they had been unable to resolve it or if they doubted some of their decisions. They may reconstruct different scenarios for the problem in their quest for solutions that might have been more effective, thus reassuring themselves that if this problem were to recur, they would know how to respond to it. Contrarily, they may also remain at an impasse, as certain communication problems cannot be resolved quickly. To avoid or reduce the psychological impact of such problems, defence strategies (such as euphemism) supported by the work collective are used. These aspects clearly cannot be brought to light through observation alone. It simply allows for objectifying what the observers may define as communication problems. These observed problems then had to be supplemented and examined with the agents to specify the cognitive and emotional impact. This impact was estimated by administering perception rating scales and through discussion in the self-confrontation interviews.

8.2.2 Perception rating scales

Perception rating scales are administered in ergonomics to assess mental workload (Reid and Nygren, 1988), emotions felt (Grosjean and Ribert-Van De Weerd, 2005), physical efforts, or the presence of pain (Borg, 1998). Their use is justified by the very definition of the psychosocial factors that result from perceptions of work and the conditions under which it is carried out. By using these scales, we were able to verify the correlations between mental workload indicators and the presence of pain on the one hand, and between trapezius muscle and heart activity on the other. In addition, the answers obtained on the perception rating scales during the self-confrontation interviews helped document the work situations related to the perception of various indicators of a high-level mental workload.

The mental workload study was subject to the unpredictable frequency and content of the incoming calls. In order to examine the variations in this regard, observations were therefore made at different times of day: in the daytime and evening and at night, or during particular events. However, these methods did not suffice to observe major variations in mental workload. In fact, major events did not occur during the observation periods. On the contrary, several agents indicated that the work shift observed was quieter than usual. Even so, the results showed significant correlations with the answers obtained on the perception rating scales.

Perceived fatigue increased with amount of time spent at work. Call complexity correlated positively with workload for seven agents. Also, both call complexity and workload correlated positively with effort expended to control emotions for six agents. The self-confrontation interviews provided an understanding of the conditions likely to result in these correlations. In fact, the agents explained that it takes longer to handle complex calls. They also have less time between calls, which can sometimes even overlap. They can thus find themselves in situations where they have to perform two tasks, which in turn creates an overload and increases the work's complexity. In these situations, the effort expended by the agents to control their emotions may stem from the caller's slowness in expressing the emergency request, lack of clarity, failure to answer the questions asked, or bad mood. This effort to control their emotions correlates with stronger negative emotions. This result concurs with those obtained by Hochschild (1983), Maslach and Jackson (1981), and Perlman and Hartman (1982). In our study, the effort expended to control emotions did not generally result in positive emotions, as can happen when this effort receives recognition, according to Zapf (2002).

The intensity of musculoskeletal pain also increased with the work duration and fatigue. The increase in pain in the upper back, neck, and shoulders correlated positively with the assessment of perceived workload and call complexity. This is probably more the result of the increased activity of the upper extremities than it is of the mental workload. The increase in low back pain correlated positively with the intensity of the negative emotions. As with fatigue, it is possible that these emotions reduce the pain tolerance threshold in keeping with the hypothesis that higher stress could lead to people's greater sensitivity to pain (Westgaard, 1999).

8.2.3 Trapezius muscle activity

The average activity levels observed in the agents (50th percentile: 15% RVE) were similar to those observed in a population of office workers (Delisle et al. 2008). Considering that the sub-maximal reference contraction used corresponds to nearly 15% of a maximum voluntary contraction (MVC) (Hansson et al., 2000), the level of activity in the agents would be of the order of 1% of the maximum capacity of these muscles, which corresponds to the median level reported by Mork and Westgaard (2007) for seated computer work. The proportion of muscle rest time observed in the agents (30% for both trapezius muscles) is comparable to that observed by Mork and Westgaard (2007) for the dominant trapezius (29%), despite differences in the definition of the variable. However, for the non-dominant trapezius, the latter reported a clearly higher proportion of muscle rest time (45%). It therefore appears that despite a low level of trapezius muscle activity, the muscle rest time of the non-dominant trapezius in the agents was shorter. These results reveal similar use of the dominant and non-dominant sides in the agents

contrary to less use of the non-dominant side for other computer tasks (Delisle et al., 2006; Mork and Westgaard, 2007).

The level of trapezius muscle activity corresponded to the perception of high or low workload or complexity. Conversely, the proportion of muscle rest time was lower during periods of perceived high workload and complexity than during periods when perceived levels were lower, but no difference was observed in activity level or in muscle rest time in connection with perceived emotions. The correspondence between muscle activity and workload and call complexity cannot, however, be associated with the increase in mental workload. In fact, in our study, it was not possible to measure the postural activity of the upper extremities and neck precisely in order to control for impact. Even taking the definitions of workload and call complexity into account, it is probable that the greater increase in muscle activity resulted more from the increase in the agents' gestural actions than in the mental workload.

8.2.4 Heart rate

Measuring heart rate provides interesting data for understanding the cardiovascular system's reaction to work where people are exposed to high mental demands. In our study, it showed primarily the existence of an anticipatory stress in the experienced agents, in whom a major loss of HRV was noted before they started work. This loss diminished quickly after they finished work and then returned to normal. The increased loss of HRV noted at the beginning of work appears to be related to an anticipatory stress (Dikecligil and Mujica-Parodi, 2010), which would seem to correspond to the experienced agents' physiological preparation in order to be completely ready to respond to the high demands involved in handling emergency calls.

The results are less robust when it comes to establishing links between heart rate variations or loss of HRV within a work shift. The evolution and distribution of the average HR did not show significant variations in relation to the perceived levels of call complexity, the emotional valence or intensity of the emotions felt. According to the literature on this subject, HR is not recognized as a good indicator of mental workload, particularly cognitive load (De Gaudemaris et al., 1998); it is recognized more as a reaction to emotional (Brosschot et al., 2003) and physical workload (Astrand et al., 2003). HRV is more generally recognized as a better physiological indicator of mental workload (Hjortskov et al., 2004; Garde et al., 2002; Kamada et al., 1992; Miyake et al., 2009; Vuksanović et al., 2007). Each of the HRV correlations with the answers obtained on the perception rating scales involved only a small number of the nine agents analyzed. This number was slightly higher for negative emotions and pNN50. These correlations cannot therefore be generalized. Several factors can explain these results:

- HRV indices are likely to vary according to a number of conditions, which, as a whole, are difficult to control in real-life situations. In fact, HRV oscillates mainly with physical activity and thermal discomforts (Lan et al., 2010), air quality (Devlin et al., 2003; Park et al., 2005; Pöyhönen et al., 2004), and Circadian rhythm (Massin et al., 2000).
- In addition, certain conditions may have reduced the correlation possibilities:
 1. The major loss of HRV during the entire duration of the workshift limited the variation in the HRV indices relative to the variations in perceptions and already indicated a high and sustained level of attention and alertness.

2. The intensity of the perceptions measured varied only slightly. The measurements were generally low and moderate, and the maximums obtained were only slightly elevated and few in number.
3. Perceptions were measured over 30-minute periods. Possibly this duration was too long to reveal correlations. In fact, when the agents gave an evaluation for the 30-minute period, they may have weighted it, which could have led to an underestimation or overestimation of certain reactions. This in turn could explain the contradictory correlations obtained between some agents. The correlations were more dependent on each case.

The high-stress periods identified by the researchers did not correlate with the HRV oscillations, probably for the same reasons as cited above.

8.2.5 *Self-confrontation and work psychodynamics interviews: for enhanced understanding of the agents' work*

The self-confrontation interviews conducted after the days of observation and the work psychodynamics interviews served to document the work situations imposing a high mental workload. This information formed the basis for developing the courses of action. In fact, the information obtained went well beyond the mere factual description of the situations, a key component in itself; it also allowed these situations to be related to elements involving the cognitive, psychic, collective, organizational, and occupational aspects of the work. Analysis revealed the explicit and implicit requirements of the task of making a sound judgment. Indeed, the judgment that the agents must make is complex in nature and not based solely on a logical, simple method of reasoning leading to the "right answer." The decision to dispatch a call must be made quickly on the basis of information that is difficult to obtain and sometimes incomplete and of indicators derived from facts or sometimes intuitions (e.g. the sound of the caller's voice or background noise), decision-making rules that are not always clear and that can vary with the context.

In addition, mixed in with the cognitive skills are skills concerning the relational and emotional aspects of communication. In the latter case, the agents must achieve, if needed, a delicate balance between exercising sufficient authority to take control of the conversation in order to quickly ascertain the reason for the request and the standard courtesies that create a relational atmosphere conducive to good communication. Depending on the type of caller, this balance can be difficult to achieve. Dysfunctions can result that lead to rudeness and even the failure of the communicative interaction, as shown in some studies in the field (Tracy, 2002; Tracy and Anderson, 1999; Whalen et al., 1988).

The work psychodynamics shed light on the psychic aspects of the work situations, where the agents are faced with uncertainty in their judgments, responsibility for decision making, the dramatic nature of the decisions, and relational issues with first responders. It revealed how the agents' occupational experience is built over time, and that their psychic development is based on the presence of pleasure, operational know-how, and defence strategies. These aspects help the agents cope with the particular demands of this occupation. They experience pleasure in their work from helping individuals in distress and first responders in the field and from the challenges posed by their work. However, to cope with these difficult challenges and the

dramatic consequences, the agents develop defence strategies as a means of self-protection and endurance. To counteract the anxiety caused by the uncertainty surrounding decisions, the agents may minimize their role through a process of understatement. Also, to combat the psychic invasiveness of dramatic situations, the agents develop a sense of humour on two levels: one, to distance themselves from the strains, and two, to support their coworkers. However, this humour is not applied to all the tragedies that occur. Depending on the agent's sensitivity, some of these tragedies cannot be "replayed" with humour. In such cases, the agents are left with a profound mark that does not dissipate easily over time. Even years later, these particular tragedies are still present in their minds, as observed in the narratives of the agents who participated in this study.

8.2.6 Development of courses of action

Few studies exist on this occupation or they have been carried out in very specific fields, notably sociolinguistics and communication (Goffman, 1955; Grosjean, 2008; Tracy, 1997; Zimmerman, 1984, 1992). Their results have had no impact in terms of support for communication activities (Fele, 2006). In Québec, improvements have largely concerned technological aspects, with the introduction of sit/stand desks and the purchase of software (such as mapping and communication software) to facilitate the agents' work. However, improving the physical conditions does not resolve the problems pertaining to the human and socioaffective aspects of the work. Training efforts have been undertaken in recent years by the MPSECCs, with emphasis on the agents' responsibilities and the use of technologies (Gariépy, 2010). The results of this study demonstrate the need to continue these efforts by concentrating on the skills related to communication and decision-making tasks in the context specific to emergency situations. For this to happen, these skills need to be identified, recognized, and supported. Work has been done in this regard by the follow-up committee with the assistance of the centre managers. It now appears important to develop means of disseminating information that will explain the agents' work in greater detail and ultimately promote implementation of courses of action designed to support agents who face the cognitive, relational, and emotional demands of emergency communication.

8.3 Limitations and scope of the study

The main aim of this study was to enhance understanding of 911 call centre agents' work in relation to the onset of MSDs and PHPs in order to develop courses of action that would reduce the physical and psychosocial risks. The methodology used therefore encompassed several disciplines that are not customarily juxtaposed. To achieve this type of aim, we believed it important to adopt an approach that would allow us to describe and understand how the work situations were developed and to clarify their links with musculoskeletal and psychological health. The case study methodology was deemed the most appropriate. Given that five MPSECCs of different sizes and serving a number of different regions were investigated, the study conceivably covers the problems faced by the majority of the MPSECCs. With regard to the study population, the sample of agents who participated is fairly representative of the personnel categories described in the first study, with the exception of the temporary employees.

The study of the psychosocial demands was conducted using a multidisciplinary approach intended to identify in greater detail the nature of the risks involved and to document their

presence during the actual work activity. The risk evaluation was therefore based on exploratory physiological measurements, and mainly on the administration of perception rating scales, whereas the documentation of these risks within the work activity was based on observation of the problems identified, listening to the conversations, and self-confrontation interviews. The work psychodynamics analysis brought to light the existence of occupational know-how and defence strategies for coping with these demands. The construction and use of an open-ended reference system, as well as the use of narrative and humour, are the outcome of arduous time-consuming work in which the agents are exposed to the daily risks of dealing with people's suffering and misery.

The purpose of collecting EMG data was to objectify the intensity of the trapezius muscle activity relative to the presence of pain in the upper back, neck, and shoulders in connection with the mental workload. However, the fact that the upper extremities' exposure to postural constraints could not be controlled prevented verification of the impact of the mental workload. This laboratory-demonstrated relationship is very difficult to reproduce in the workplace.

Our investigation of HRV allowed us to assess the impact of the work on the agents' cardiac system. Major differences were observed between the experienced and novice agents in this regard. These results are consistent with the occupational learning process described by the agents during the group interviews. The novices, who had not yet had enough time to experience the full gamut of emergency situations, were found not to undergo the same physiological preparation for tackling the work as the more experienced agents. However, as the knowledge in the field currently stands, this impact cannot be related to a cardiac pathology or to MSDs. Regarding MSDs, it would be interesting to investigate the effects of a loss of HRV on blood flow reduction in the muscles used. To the best of our knowledge, the only study that exists in this field involved dogs (Just et al., 2000), and its results suggest that such a correlation would exist.

The merit of perception rating scales is that they can be used to document in real time the sensations felt by workers during their activities. In the context of an ergonomic approach, this provides data on the psychosocial risk factors, which are otherwise only available at the population level through the administering of questionnaires. It may therefore be possible to establish statistical links between certain psychosocial risks and musculoskeletal pains or physiological condition during the activity. For this purpose, correlation coefficients were calculated between the perception indices for mental workload on one hand and those for musculoskeletal pain, EMG, and ECG on the other. The results of the correlations between the mental workload and musculoskeletal pain indices correspond to the trends observed in the epidemiological study (Toulouse et al., 2006). Given that emotional strain is not measured directly in current psychosocial questionnaires, the results provided even further clarifications. In addition, the interpretation of the results of the ergonomic study was facilitated by the self-confrontation interviews, which yielded a description of the work situations causing a mental overload. These descriptions improved understanding of the risk determinants, allowing interventions to be made to rectify the problem. The situation appears more complex regarding the correlations with the physiological measurements due to the large number of conditions that can interfere in natural situations versus the laboratory setting. Certain results are consistent with the EMG but not with the HRV, with the exception of three agents, with regard to the perceived negative emotion and the pNN50 measurement.

The results of the self-confrontation interviews group together the descriptions of the complex situations evaluated as either complex or eliciting positive or negative emotions according to the 11 agents in the study. This grouping masks the individual differences that result in the agents not being affected in exactly the same way, depending on their personal experience during their occupational career. These situational descriptions are, however, sufficiently significant to have some points in common and reveal problems common to most of the situations. They correspond very closely to the results of the group interviews on work psychodynamics conducted with other agents.

The results were more mixed when it comes to the contribution of the physiological measurements that were taken from an exploratory research perspective. Unlike in laboratory studies, it was not possible to establish a correspondence between trapezius muscle activity and cognitive or emotional strain. The workload levels measured were relatively low. The measurement of HRV revealed the agents' extremely high stress, which was totally unexpected based on simple observation of behaviour or responses on the subjective rating scales. Even during the calmest periods, the agents are highly stressed.

The work psychodynamics analysis, in addition to providing insight into the occupational know-how and defence strategies, highlighted the importance and role of narrative in the building of occupational knowledge and in the processing of taking distance from the emotional demands. The importance of the narrative will come up again during development of the courses of action concerning dialogue on and transmission of occupational knowledge.

The results of the work psychodynamics analysis improved our understanding of the contribution of the psychic aspects that enable the agents to stay on the job and cope with the work demands identified in the ergonomic study. More specifically, the work psychodynamics analysis revealed the vital role of the work collective in the process of learning the occupational ropes and in the psychic mechanisms developed to protect against the highly emotional content of the work. The results of the work psychodynamics study also complement and reinforce the more factual data obtained from the self-confrontation interviews, mainly by highlighting the psychic processes and giving meaning to actions that could be misinterpreted in superficial analysis. Such is the case, for example, with the humour displayed by the agents. This could be misunderstood and seen as a sign of a cavalier attitude toward work, when in fact, it is totally the opposite. Thus, the understanding of the work gained through the ergonomic analysis and the work psychodynamics provides us with elements essential to the development of courses of action, given the organizational and developmental context planned for the MPSECCs.

9. CONCLUSION

Following a first study that described the prevalence of physical and psychosocial risk factors in the MPSECCs, another research project was launched to clarify how these risks arise in order to develop courses of action aimed at preventing MSDs and PHPs. This project, developed using a case study methodology, included conducting ergonomic/physiology and work psychodynamics studies in five MPSECCs. These studies led to a better understanding of the presence of the physical and psychosocial risk factors for MSDs and PHPs.

Adjustable sit/stand desks were introduced to prevent the physical risks, thus offering the agents greater flexibility to cope with the various demands imposed by the work and with feelings of musculoskeletal pain or fatigue. However, the limitations of the worktable design are such that the design does not appear entirely satisfactory in terms of reducing MSD risks. The worktable design should be rethought in light of both the agents' activities and evolving technologies.

The ergonomic/physiology and work psychodynamics studies enhanced understanding of the presence of psychosocial demands and modes of regulating them. The psychosocial demands, measured through subjective evaluation of the mental workload, were found to be associated with the intensity of musculoskeletal pain, in relation to time spent at work, fatigue, workload, and negative emotion, for the lower back. For pain in the upper back, neck, or shoulders, this result concurs with an increase in muscle activity and a decrease in rest time and in the EMG of the trapezius muscles.

Significant correlations between the perception measurements and HRV indices were only present in very few agents. The variations in the perceptions measured were slight, and the result appeared highly dependent on interference by many confounding factors present in natural situations. Nonetheless, the heart rate measurement showed a major loss of HRV during the entire workshift for the experienced agents. This loss of HRV constitutes a physiological response for coping with stress.

The self-confrontation interviews and observation of the cognitive and relational problems in the communicative interactions allowed us to describe the work situations posing a high-level mental workload. The work psychodynamics analysis completed the picture by providing explicit details on the psychic dimension of the work content. This analysis gave psychic significance to the work situations described in the ergonomic study. It brought to light how, over time, the agents' occupational experience is built, and the fact that their psychic development is based on the presence of sources of pleasure and defence strategies. These help the agents consulted to cope with the particular demands of their occupation.

The results of the ergonomic/physiology and work psychodynamics studies shed light on aspects of the work that served as the basis for the development of courses of action by the follow-up committee, taking into account the research project and MPSECC contexts. These courses of action form part of the development prospects for an occupation that has only been organized relatively recently in Québec. First, efforts were made on the technological level. They involved the purchase of computer equipment to support the agents' work and of furniture that took into account the demands associated with a job that is performed on a continuous basis, where the agents take turns working at the same workstation. The results of this study concerning the

psychosocial factors show that the efforts in a second phase must be focussed on providing cognitive and emotional support at three levels: the agents on the job, the organization of the work, and more generally, the occupation itself. To be pertinent, this support must be developed starting with the skills acquired by the agents if it is to dispel the uncertainties that generate emotional risks. It also involves cultivating better relationships with first responders, particularly police officers on patrol. For this to happen, the implementation of the courses of action implies having knowledge of the agents' communication work, which must necessarily involve the various emergency service providers and decision makers in the municipal public service. The follow-up committee is continuing initiatives in this regard.

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APPENDIX A: WORKSTATION LAYOUT

Name of the call centre: _____ Date: _____

Work shift: _____

GENERAL LAYOUT OF THE WORKSTATIONS

Plan of the workstation layout in the call centre and/or photograph

LAYOUT OF THE INDIVIDUAL WORKSTATIONS

PARAMETERS

Sketch of the arrangement of the screens (# of screens) and/or photo:

PARAMETERS	SCREENS	SCREEN 1	SCREEN 2	SCREEN 3	SCREEN 4	SCREEN 5
Use	Description of the screen display function (software):					
Model	Name of the manufacturer of all the system components:					
Dimensions	Diagonal measurement of the screen (cm):					
	Depth of the screen (flat screen) (cm):					
Position	Positioning of the screen relative to the workers: (in front, diagonally to the right or diagonally to the left)					
	Height of the screen relative to the floor (centre of the screen) (cm):					
	Distance of the eyes relative to the upper edge of the screen (cm):					
	Distance between the edge of the table and the screen (cm):					
Glare	Presence of glare on the screen (windows or other light sources)?					
Adjustment	How tilted is the screen from the vertical (degree)?					
	Can the screen position be adjusted?					
Typeface	Does the size of the typeface make it easy to read (colour, size)?					

PARAMETERS	MOUSE	MOUSE 1	MOUSE 2	MOUSE 3	MOUSE 4	MOUSE 5
Use	For which tasks and which software programs do you use the mouse? (Check whether there is only one mouse for all the screens)					
Model	What is the mouse model?					
	Use of a wired or wireless mouse					
	Use of a laser or scroll wheel mouse					
	Is the mouse ambidextrous, right-handed, left-handed?					
	Distance between the mouse and the edge of the table (cm):					
	Distance between the mouse and the space between the letters "J" and "H" on the keyboard (cm):					
	Height of the mouse relative to the table (cm):					
	Positioning of the mouse on the worktable (placed to the right or left of the keyboard):					

PARAMETERS	KEYBOARD	Keyboard 1	Keyboard 2	Keyboard 3	Keyboard 4	Keyboard 5
Use	For which tasks and which software applications do you use the keyboard?					

Model	Description of keyboard:					
	Enhanced keyboard					
	No numeric keypad					
	Colour: Letters/Background					
	What is the keyboard model?					
Position	Positioning of the keyboard: (Placed on the table, on a shelf, attached, mobile, centred)					
	Dimensions of keyboard:					
	Front and back height (cm):					
	Length (cm):					
	Width (cm):					
Adaptation	Distance from the letter "J" to the end of the worktable (cm)?					
	Presence of a wrist support?					

PARAMETERS		EQUIPMENT				
# Equip.	Name (coded)	Function (e.g. radio, printer)	Description (For which tasks and which software applications do you use this equipment?)	Dimension Height from the floor (cm)	Adjustment (Possibility of adjusting the size parameters)	Location (Positioning of this piece of equipment in relation to the worker during use)
1						
2						
3						
4						

APPENDIX B: PERCEPTION EVALUATION FORM USING BORG'S CR-10 SCALE

Code opérateur :	_ _ _ _ _ _ _
Date :	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ h _ _ _
	Année Mois Jour Heure
<p>Consigne : Au cours de la période des 30 dernières minutes, indiquez l'intensité la plus élevée ressentie au niveau des dimensions suivantes (veuillez encercler la valeur correspondante) :</p>	

Complexité du travail																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Élevée		Très élevée		Extrêmement élevée (peu supportable)		Maximum absolu supportable

Charge de travail																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Élevée		Très élevée		Extrêmement élevée (peu supportable)		Maximum absolu supportable

Emotion positive																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Forte		Très forte		Extrêmement forte (peu supportable)		Maximum absolu supportable

Emotion négative																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Forte		Très forte		Extrêmement forte (peu supportable)		Maximum absolu supportable

Effort pour contrôler ses émotions																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Élevée		Très élevée		Extrêmement élevée (peu supportable)		Maximum absolu supportable

Douleurs articulaires : bas du dos																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Élevée		Très élevée		Extrêmement élevée (peu supportable)		Maximum absolu supportable

Douleurs articulaires : cou, épaules																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Élevée		Très élevée		Extrêmement élevée (peu supportable)		Maximum absolu supportable

Douleurs articulaires : coudes, poignets, doigts																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Élevée		Très élevée		Extrêmement élevée (peu supportable)		Maximum absolu supportable

Fatigue ressentie																
0	0,3	0,5	1	1,5	2	2,5	3	4	5	6	7	8	9	10	11	
nulle		Extrêmement faible		Très faible		Faible		Modérée		Élevée		Très élevée		Extrêmement élevée (peu supportable)		Maximum absolu supportable

APPENDIX C: AGENTS' RESPONSES ON THE PERCEPTION RATING SCALES

Responses of Agent 05 (P05) on the perception rating scales

P05 Time Items on Borg's Scale	07:34	08:03	08:37	09:09	09:46	10:33	11:34	12:15	12:53	13:11	14:57
Fatigue	0	0	0	0	0	0	0.5	0.5	0.5	1	2
Low back pain	2	0	0	0	0	0	0	0.5	0	0.5	0.5
Pain upper back, neck, shoulders	1	1	1	2	2.5	2.5	3	2.5	3	3	4
Pain elbows, wrists, fingers	0	0	0	0	0	0	0	0	0	0	0
Workload	2	2	2	2.5	3	3	2.5	2.5	4	3	4
Complexity of the work	0.5	2	2	2	2	3	3	3	5	2.5	3
Positive emotion	3	3	3	2.5	3	2.5	2	2.5	2.5	1.5	3
Negative emotion	2	2	2.5	3	3	3	2	3	4	5	4
Effort expended to control emotions	1	3	2.5	2.5	3	3	2	2.5	3	8	3

Responses of Agent 06 (P06) on the perception rating scales

P06 Time Items on Borg's Scale	16:23	17:02	17:39	18:12	19:01	20:27	21:06	22:02	22:34
Fatigue	1	0	1	0	0	0	1.5	2.5	1
Low back pain	0	0	0	0	0	0	0	0	0
Pain upper back, neck, shoulders	0	0	0	0	0	0	0	2	0.5
Pain upper back, neck, shoulders	0	0	0	0	0	0	0	0	0
Workload	7	3	3	2	3	2	2.5	3	1.5
Complexity of the work	5	3	3	2	3	2	2	3	1.5
Positive emotion	3	3	3	3	2.5	4	2.5	3	2
Negative emotion	3	3	3	3	2.5	4	3	3	2
Effort expended to control emotions	3	3	3	1.5	3	6	1.5	1.5	2

Responses of Agent 07 (P07) on the perception rating scales

P07 Time	15:56	16:33	17:02	17:43	18:14	19:07	20:26	21:01	21:39	22:29	23:09
Items on Borg's Scale											
Fatigue	0	0	0	2	0	2	2.5	3	3	3	3
Low back pain	0.5	0	0	0	0	0	0	0	0	0	0
Pain upper back, neck, shoulders	0.5	0	0	0	0	0	0	0	0	0	3
Pain elbows, wrists, fingers	0	0	0	0	0	0	0	0	0	0	0
Workload	2	2	3	3	3	3	3	3	4	4	3
Complexity of the work	4	2	3	2	3	2	3	2,5	4	2	2
Positive emotion	2.5	2	4	0	3	2	2	2	2	2	2
Negative emotion	3	2	2	0	2	2	3	2	2,5	2	2
Effort expended to control emotions	3	1	2	0	2	0	3	2	2	2	2

Responses of Agent 09 (P09) on the perception rating scales

P09 Time	00:24	01:00	02:11	02:59	04:39	05:37	05:57	06:36	07:11
Items on Borg's Scale									
Fatigue	0.5	1	1	3	4	4	3	4	4
Low back pain	0	0	0	0	0	0	0	0	0
Pain upper back, neck, shoulders	0	0	0	0	0	0	0	0	0
Pain elbows, wrists, fingers	0	0	0	0	0	0	0	0	0
Workload	1	4	3	1	2	1	1	1	1
Complexity of the work	2	3	3	1	3	1	1	1	3
Positive emotion	4	3	3	4	3	3	3	3	3
Negative emotion	1	3	3	0.5	2	0.5	1	1	1
Effort expended to control emotions	0.3	2	2	0.5	2	0.5	1,5	1	1

Responses of Agent 10 (P10) on the perception rating scales

P10 Time	15:57	16:45	17:35	18:10	18:37	19:16	20:05	21:40	22:52
Items on Borg's Scale									
Fatigue	0	0	0	0.5	0.5	0.5	1	0.5	2
Low back pain	0	0	0	0	0.5	0.5	2	0.3	0.3
Pain upper back, neck, shoulders	0	0	0	0	0	0.3	0.5	0	0.5
Pain elbows, wrists, fingers	0	0	0	0	0	0	0	0	0
Workload	0.3	5	3	5	7	7	6	5	5
Complexity of the work	0.3	1	2	1	2	3	3	3	3
Positive emotion	0.5	2	2	2	3	3	3	3	3
Negative emotion	0	1	0	1	2	2	1	2	1
Effort expended to control emotions	0.5	0	0	0	1	0.5	0.5	0.5	0.5

Responses of Agent 13 (P13) on the perception rating scales

P13 Time	23:43	00:28	01:00	01:30	02:05	02:42	03:24	03:58	05:31	06:00	06:51	07:12
Items on Borg's Scale												
Fatigue	2	2	2	2	2	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Low back pain	0	0	0	0	2	1	1.5	1	2	1	1	1
Pain upper back, neck, shoulders	5	3	3	3	3	3	4	2.5	2.5	3	3	4
Pain elbows, wrists, fingers	3	2	2	2.5	3	3	4	3	3	3	4	4
Workload	3	3	4	4	5	6	5	6	4	5	2.5	3
Complexity of the work	3	4	4	3	4	4	4	4	4	4	2.5	3
Positive emotion	5	2	2	2	1	1	1	1	1	1	1	1
Negative emotion	2	2	2	2.5	4	3	3	2.5	2	2	2	3
Effort expended to control emotions	2	2	2.5	2.5	3	3	2.5	2.5	2	2.5	2	2

Responses of Agent 14 (P14) on the perception rating scales

P14 Time	11:30	12:02	12:33	13:01	13:36	14:01	15:01	15:38	16:04	16:32	17:07	17:35	17:57
Items on Borg's Scale													
Fatigue	0.5	1	0.5	0.5	2	1	2.5	2	2	2.5	1.5	2.5	3
Low back pain	0	0	0	0	0	0	0	0	0	0	0	0	
Pain upper back, neck, shoulders	0.5	1	0.5	0	0.5	0	0.3	0	0,3	0	0	0	
Pain elbows, wrists, fingers	0	0	0	0	0	0	0	0	0	0	0	0	
Workload	3	3	2	0.5	6	2.5	8	7	3	2	1	2	0.5
Complexity of the work	2.5	3	1	0.5	4	2	7	4	2.5	1.5	1	1	0.5
Positive emotion	5	2	1	3	7	2	2	3	2.5	2	3	2.5	2.5
Negative emotion	0	0.5	1	0.5	0	0	3	2	0	0.5	0	0	0.5
Effort expended to control emotions	0	1	0.3	0	3	0.5	5	2	2	0.3	1	0.5	0.5

Responses of Agent 15 (P15) on the perception rating scales

P15 Time Items on Borg's Scale	19:42	20:02	20:44	21:07	21:42	22:18	23:01	23:52	00:59	01:25	02:04	02:49	03:32	05:35	06:27	06:54
Fatigue	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5	1	0.5	1	1.5	3	5	6	6
Low back pain	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
Pain upper back, neck, shoulders	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	1	0.5	0.5	0.5	0.5	1
Pain elbows, wrists, fingers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Workload	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.5	0.3	0	2	2	0.3	0.0	0.0
Complexity of the work	1	0.3	0.3	1	0.3	0.3	0.3	0.5	0.5	0.3	0.3	1	0.5	0.3	0.0	0.0
Positive emotion	0.3	0.5	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5
Negative emotion	0.3	0.3	0	0.3	0	0.3	0	0.3	0.3	0	0	0	0	0.0	0.0	0.0
Effort expended to control emotions	2	0.3	0	0.3	0	0.3	0.3	0.3	0.3	0	0	0	0.5	0.0	0.0	0.0

Responses of Agent 16 (P16) on the perception rating scales

P16 Time Items on Borg's Scale	15:54	16:25	16:49	17:26	19:01	19:40	20:29	21:20	22:00	22:40	22:56
Fatigue	1	1	1	1	1	1	1	2.5	3	3	3
Low back pain	0	0	0	0	0	0	0	0	0	0	0
Pain upper back, neck, shoulders	0	0	0	0	0	0	0	0	0	0	0
Pain elbows, wrists, fingers	0	0	0	0	0	0	0	0	0	0	0
Workload	3	4	6	4	5	3	3	3	2	2	1
Complexity of the work	6	4	4	4	6	5	3	3	2	2	6
Positive emotion	5	5	4	5	5	3	3	4	2	1	2
Negative emotion	0	0	0	3	3	1	0	0	0	0	0
Effort expended to control emotions	0	0	0	3	3	0	0	0	0	0	0