Universidade do Minho
Escola de Engenharia

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June 2012

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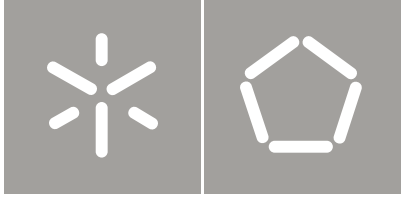

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ETdA: Ergonomic Tridimensional Analysis for Common Areas with Circulation of People

Dissertation for the PhD. degree in
Industrial and Systems Engineering

Supervisors
Professor Celina Maria Godinho da Silva Pinto Leão
Professor Pedro Miguel Ferreira Martins Arezes

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Celina, thanks for showing me how to develop an engineering thinking. Thank you for helping me in this hard journey. You know how hard it was.

I want to thank the University of Minho, as an institution, who provided all the necessary conditions to the development and conclusion of my thesis. For the same reasons, I also want to thank the Algoritmi research.

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Finally, to my family that is my true inspiration, special thanks. To my children: "*um sentido pedido de desculpa pela ausência. Ausência não é a mesma coisa que prioridade, porque vocês são, sempre, a minha prioridade. São o sentido das coisas e não a desculpa.*"

This thesis is dedicated to Antero, Zé António and Inês.

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Baba nan Kevalam

Para ti mano Zé (II)

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Abstract

Ergonomic Tri-dimensional Analysis (ETdA) is a new approach specifically developed for ergonomic assessments and redesign of Common Areas with Free Circulation of People (CAFCP). The available literature in the field of ergonomics provides an identification and description of several ergonomic contexts (considering man, machine and environment). According to the complexity of the analysed task and its level of automation and to the professionals' interrelation with the organization, a dynamic environment can be defined. In these environments, the total quality management philosophy is focused not only in workforce satisfaction, but also in clients' wellbeing, since in modern social-technical systems they are intrinsically linked to the organizations. It is important to notice that as a consequence of this interaction, clients and professionals can equally be exposed to the same ergonomic risk factors. From the management point of view, the ongoing concern with the clients requires a continuous improvement in several organizational keys-areas such as quality, occupational safety and health, environment protection, and cost of products and services. As a result of the market customization, the organizational adjustments taking place on the common areas must also benefit the ergonomic contexts of the professionals. Following these thoughts, and to optimize the performance of the overall system (economical goal), the strategies adopted by organizations and their goals must also consider the human wellbeing (social goal). In common areas, the human wellbeing is related to its users, both the clients and professionals. Therefore, processes of improvement are often multidimensional (considering all the organizational participants), cross and correlated. The ETdA development follows the ergonomics future tendency since it allows the participation of the entire organization in the identification of critical situations. It is a continuous model that assists the ergonomist (Analyst) in his/her ergonomic analysis allowing the diagnosis of the studied conditions and identification of the critical Ergonomic Factors (EF) and the consequent adjustments, which represents the ergonomic intervention. Different observation tools are used: a questionnaire, an evaluation sheet and direct and indirect observation (checklist) for the Clients, Professionals and Analyst dimensions, respectively. The development of the weighting tables allows the simplification and synthesis of the ETdA dimensions results, helping the Analyst in the decision making process regarding the ergonomic intervention. General guidelines for the use of ETdA model were established and a software was developed, ETdAnalyser. The ETdAnalyser main purpose is to help the analyst in the ETdA implementation, data analysis and report generation. The sustainability of ETdA model is clear in its realistic overview of the real work in CAFCP. Indeed, these areas are scenarios for different actors, and each one should be aware of the importance of ergonomic issues. ETdA model can also be seen as a model that will increase the population awareness for ergonomics. ETdA is a potential social instructive model, since the inclusion of clients' dimension in the ergonomic analysis it is important to focus the clients' attention towards the ergonomics issues. This will contribute to the spread of the knowledge on ergonomics. Clients' dimension results can highlight some risky situations that otherwise could not be detected. This particular issue is useful to support the analyst decision when the professional and the Clients are in agreement. Considering the managements point of view, it seems easier to make organisational changes when the principal intervenient, client, has the same opinion of the analyst and/or the professional.

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Resumo

O modelo de Análise Ergonómica Tridimensional (ETdA-Ergonomic Tri-dimensional Analysis) é uma nova abordagem ergonómica desenvolvida especificamente para análise ergonómica de áreas comerciais com livre circulação de pessoas. De acordo com a complexidade da tarefa analisada e o correspondente nível de automatização e de inter-relação do profissional com os vários níveis organizacionais, pode ser definido um ambiente de trabalho dinâmico. Esta situação verifica-se nas estruturas organizacionais mais recentes em que os clientes assumem um papel central estando intrinsecamente ligadas às políticas de desenvolvimento das mesmas. Da interação do profissional com o cliente em áreas comuns de livre circulação, considera-se que ambos podem ser igualmente expostos aos mesmos fatores de risco ergonómico. Pelo que, a gestão empresarial deverá concentrar os seus esforços não só na satisfação dos seus trabalhadores, como também no bem-estar dos clientes. Desta forma, e para otimizar o desempenho do sistema organizacional, as estratégias adotadas pelas organizações devem também considerar o bem-estar humano, constituindo este, o seu objetivo social. Todos os participantes da organização devem estar envolvidos nos processos de melhoria. No caso de áreas comuns com livre circulação de pessoas, os participantes identificados e que conjuntamente com o Analista farão a análise ergonómica, são os Profissionais e os Clientes, definindo assim as três dimensões da análise ergonómica. O desenvolvimento do modelo ETdA segue a tendência atual e futura da Ergonomia permitindo a participação de toda a organização na identificação de situações críticas. É um modelo de ação contínua que auxilia o ergonomista (Analista) na análise permitindo o diagnóstico das condições estudadas e a identificação dos fatores críticos. De acordo com a dimensão que faz a análise, diferentes instrumentos de observação são usados: um questionário para a dimensão dos Clientes, uma ficha de avaliação para a dimensão dos Profissionais e uma lista de verificação para a dimensão do Analista. Para efetuar a análise conjunta dos resultados das dimensões, são elaboradas tabelas de ponderação, permitindo a distribuição da classificação de cada categoria de resposta inerente a cada um dos domínios, numa escala que facilitará a construção do resultado final. A necessidade de elaborar tabelas de ponderação facilitará o trabalho final do ergonomista pois permite uma visão mais ampla e esquemática acerca das possíveis mudanças a implementar. Como resultado deste trabalho, são estabelecidas as orientações gerais para o uso do modelo ETdA bem como a aplicação informática, ETdAnalyser. O principal objetivo do ETdAnalyser é ajudar o Analista na implementação do modelo ETdA, na análise dos dados e na elaboração de relatórios. A utilização do modelo ETdA para análise ergonómica de áreas comuns com livre circulação de pessoas, permite ao Analista ter uma visão holística do problema identificado. Dado o envolvimento dos Clientes na análise, o modelo ETdA também pode ser visto como um instrumento que irá aumentar a consciencialização da população para as questões relacionadas com a ergonomia. Este facto contribuirá para a disseminação do conhecimento sobre ergonomia. Utilizar a opinião dos Clientes permite, por um lado, sensibilizá-los para as questões ergonómicas e, por outro lado, dar uma contribuição importante para a elaboração das propostas de mudança inerentes à intervenção ergonómica.

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PART I

Foreword

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Chapter 1. Introduction

The more profound is the influence of ergonomics in the modelling of the human being and its surroundings, the more important is ergonomic research in discovering new approaches to analysis (Wisner, 1995). Ergonomics may have an influence in the lives of the everyday public. It is a science that designs many things for many people. Challenges on the ergonomic field can be identified as our society evolves under the influence of technological advances and the globalization of economic and social conditions. Due to the difficulty of establishing a bridge between the conceptualization of a theoretical model and its application, this thesis is about the development of an ergonomic system approach in a real life context. A better understanding of the way in which organizations should tackle all aspects of ergonomics is particularly important at this time, as business faces new challenges, work practices and production process are constantly changing and Clients are more demanding.

1.1. Background and Motivation

In Loureiro (2008), a systematic and careful workplace description has been done in order to perform an ergonomic analysis in a pharmacy. The Ergonomic Workplace Analysis (EWA) was the methodology used for the ergonomic assessment. This methodology developed, by the Finish Institute of Occupational Health (Ahonen, Launis, and Kuorinka, 1989; Caple, 2008), is largely consensual in most developed countries and its structure make it suitable for most of the industrial manual and material handling activities, being currently used in many different activities. With regard to the EWA methodology, Macdonald and Bendak (2000) suggest that this is a method for "defining and evaluating job characteristics and work demands based on both expert and workers selecting scale values for a range of relevant factors". Factors assessed by EWA were selected by its authors based on their relevance to health and safety, and their quantifability (Aohen et al., 1989). Namely, these factors are attentiveness, thermal environment, lighting, decision making, general arrangements of the working space, accident risk, general physical activity, lifting, work postures and movements, control degree over physical activity, noise and work restrictiveness and repetitively. The theoretical background of the EWA lies in work physiology, occupational biomechanics, information psychology, industrial hygiene and socio-technical modelling of the organisation of work (Hakkarainena, Ketola, and Nevala, 2011).

During the ergonomic analysis performed in the pharmacy, two distinct areas were identified: one exclusive to Professionals (orders' area) and one common area, where both to Clients and Professionals can circulate (Clients' service area). Although two types of users having been identified in Clients' service area, Clients and Professionals, only Professionals and Analyst evaluation have been considered to perform the ergonomic analysis. So, one question that emerged at this point was: when Professionals/Clients interrelation is identified by the Analyst, why do not consider Clients on the ergonomic analysis evaluation?

Actually, the previous question was the starting point for developing the dissertation under the Master of Human Engineering degree (Loureiro, 2008). To understand the impact of Clients' involvement in the ergonomic analysis and intervention, a case study was done in the private health sector, the parapharmacies. This type of business represents an emerging and a growing marketing sector and may be defined as a single area of products and services supply related to the Health, Beauty and Wellbeing promotion. In these areas, Clients are assuming an important role by interacting with the employee in the product transaction. Findings revealed that important issues could be undervalued and consequently the ergonomic intervention would not be as effective as would be desired if an occupational analysis is used to assess ergonomic on common areas. The results indicated that the evaluation of Clients, on certain issues, could significantly contribute to the ergonomic intervention, highlighting some risk situations that otherwise might be underestimated.

This previous work was the starting point to the conceptualization and development of a new ergonomic analysis designed for common areas. This analysis should be tri-dimensional as the

assessment of the ergonomic issues is made by three dimensions, Clients, Professionals and Analyst.

1.2. Multidisciplinary Overview and Contributions

The current work was developed under two main research areas: Ergonomics and Statistics. Even though Computer Science was not considered as a main research area, its contribution was important to the development of a computational system to support the Analyst on the ergonomic analysis (Figure 1.1).

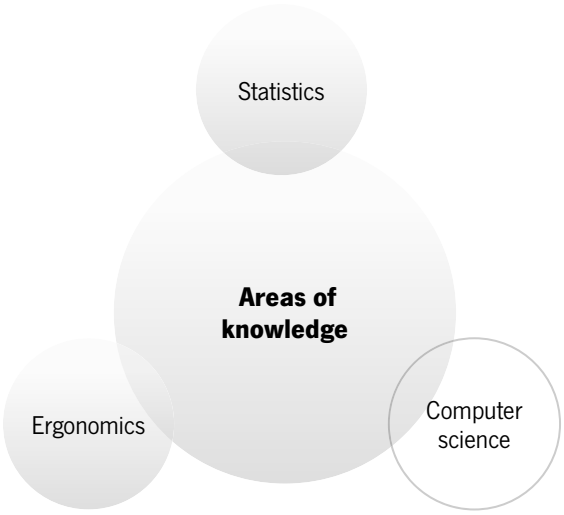

Figure 1.1. Considered research areas.

Wilson (2000) defined ergonomics as the "theoretical and fundamental understanding of human behaviour and performance in purpose full interacting socio-technical systems, and the application of that understanding to design of interactions in the context of real settings". At this point in time, he also supported that a re-examination of new ergonomics contexts must be taken into account and if possible adjustments of the existing methodologies to the identified contexts, should be made. Following this thinking, the appropriateness of the present work is justified. In fact, the proper study of the Clients' involvement in the ergonomic analysis is in line with the future challenges for ergonomics that propose a greater involvement of the public on ergonomic issues.

Graham (2006) stated that, statistics is a "key area of the school of mathematics curriculum where mathematics and the real world meet". The aim in using statistics was to learn more about working on and designing statistical tasks and, understanding the statistical thinking.

Statistics as become increasing important to all levels of research, where more and more data is collected and available to inform decision-making. As suggested by MacGillivray and Mendonça (2011), there must be coherence between those who collect and analyze data and those that take its decisions based on prior information. Therefore, the identification of the main purpose of data collection is an important issue on a research work based on statistical analysis. This view

has been supported in the work of Frankelin et al. (2005) and Pfannkuch and Wild (2005). These last two authors stated that "foundations of statistical enquiry rest on the assumption that many real situations cannot be judged without the gathering and analysis of properly collected data". It is then necessary to develop a statistical thinking by dealing with real-world problems and issues. Chance (2002) states that "statistical thinking processes clearly involve, but move beyond, summarizing data, solving a particular problem, reasoning through a procedure and explaining the conclusion. According to Olani, Harskamp, Hoekstra and Van der Werfa (2010), this definition implies that statistical reasoning requires understanding and integrating statistical concepts to interpret data and make decisions based on a given outcome. The Guidelines for Assessment and Instruction in Statistics Education – GAISE Report - A Pre-K-12 (Frankelin et al., 2005), suggests that the statistical thinking should be developed under on four main steps: (1) Question formulation, (2) data collection, (3) data analysis, (4) data interpretation of the results.

In the present work, statistical thinking is used for perceiving an ergonomic context under a work reality. The incorporation of statistics it is important to test the proposed theoretical assumptions. It also reveals a personal interest in developing a statistical thinking, by improving a specific knowledge about statistical tasks design leading to a model framework used to perform an ergonomic analysis in a real work context.

Although computer science was not the main purpose of this work, the integration of a team for the software development was important to the ETdA final presentation. The knowledge exchange between the Ergonomics and computer science fields was a very positive experience and also reveals the multidisciplinary of this research work.

1.3.Thesis Organization

The present thesis is divided in three main parts: Foreword, Developed Work and Conclusions.

In Part I, Foreword, the background and motivation as the multidisciplinary and contribution of this work is presented. In Chapter 2, the definition of ergonomics as a science is presented as well as its importance on work organizations. Several ergonomic approaches are described illustrating the available ergonomic methodologies.

Part II, Developed Work, is presented in terms of Research approach (Chapter 3), Methodology (Chapter 4) and Results and Discussion (Chapter 5). In Chapter 3, both research problem and research goals are identified as well as the conceptualization of the proposed model. In Chapter 4 the steps of the procedure adapted for the work development, and the conceptualization of a new ergonomic model approach are described. In Chapter 5 the results obtained from the implementation of the new ergonomic model in a real-life context are presented and discussed.

Finally, the general conclusions drawn from this work and the suggestions for the future are provided in Chapter 6 (Part III).

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Chapter 2. Literature Review

Ergonomics knowledge and applications have evolved over the time as work organization has progressed. The emergence of several ergonomic contexts with a certain level of complexity may in some way, affect human activities and individual performances. As changes arise in the work organizations, it is necessary to understand the role of ergonomics in the design of systems organizations, jobs, machines, software, interfaces and products. However, due to the multidisciplinary and variability of applications in the field of ergonomics, the definition and communication of the concept may be difficult to achieve.

In this chapter, the advancements of ergonomics as a science and the on-going need for adjustment with the real work will be analyzed.

2.1. Ergonomics: an Added Value Definition

Literature presents several definitions of Ergonomics. The study of the added value to the definition of ergonomics throughout time may be helpful to understand the importance of this discipline in the design of all kinds of systems-organizations. Ergonomics must accurately reflect what work is, and how it is being considered all over the years. Changes in society, developments in technologies and important historical events that occurred around the world, should be studied in order to understand the value of ergonomics in organizations. Organizations are stages to different actors. Understanding the role that each one of these actors performs is a challenge to ergonomics.

Christensen (1976) expresses that the very essence of ergonomics, is related to the early hominids survivability. That is, the use of specially pebbles, made scoops from bone and fashioned tools to execute several survival tasks, like, fishing and hunting, evidencing the reactions to the interactions between man and his environment. In his review of ergonomics, the author also suggests that knowledge of anthropometry may be reported to ancient Greek sculpture design or the care with which Hippocrates performed his medical tasks, using specialized instruments or by having major ergonomic considerations, as postures to be adopted in a surgery according to individual comfort conditions.

During the Great War (1914–1918), an extremely influent textbook written by Bernard Muscio in the Ergonomics Editorial (as cited in Stanton and Stammers, 2008), shows the importance of applying physiology to work by promoting some changes in a certain piece of machinery that could allows workmen more easily to have control on the machinery. The proposed arrangement of the system may represent the first attempt to fit machinery to Men. In the 1930s, the National Institute of Industrial Psychology and the Industrial Health Fatigue Board initiated several detail studies related to the workplace design. Displays and control arrangements were studied regarding a usability perspective.

Until now, there was no evidence of published papers that make reference to ergonomics as a science. Even though, words and actions related to ergonomics as it is well known nowadays, are not visible on writing work. Instead, words such as “recommendation” and “workplace analysis” are used. Balchini (1931) used words that indirectly are implicit to ergonomic issues. Take as example the words used by him in the following sentences: “...we recommend that a central instrument board for each unit should be placed in a convenient, light and central position....”, “...man would be greatly facilitated by an arrangement of his instrument” (Balchini, 1931).

Ergonomics was traditionally (in the decade of 1940) related to the physical aspects of work, studying the interactions between humans and their surrounding work environment (Wogalter, Racicot, Kalsher and Simpson, 1994). Similar explanation was made by Murrel (1971), when he refers to Ergonomics as the “study of the relationship between man and his working environment”. At this point on time, environment was defined broadly to include machines, tools,

the ambient environment and tasks (Welford, 1976). Worker was limited to a workstation and ergonomics was more related to the physical aspects of the field. In those days, ergonomics was linked mainly to reducing errors and improving the human-machine performance. Research in industry, at that time, was also related to solving problems as fatigue at work (Staton and Stammers, 2008). In the later, knowledge of the body was extended to be included in the workplace and equipment design. Studies conducted on the knowledge of the body contributed to emphasize the importance of biomechanics on the ergonomics field.

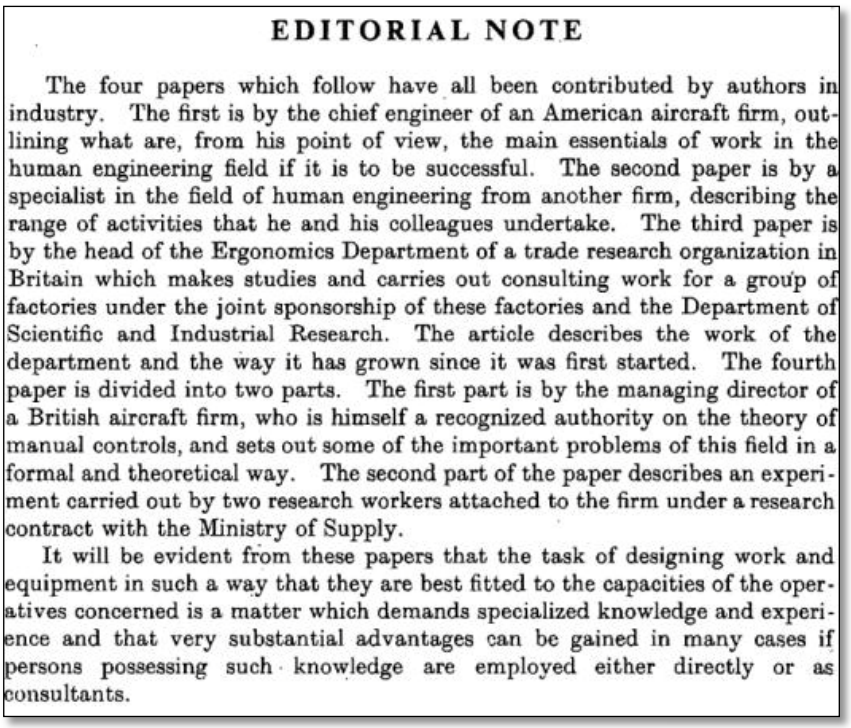
What could be categorized as ergonomic problems was certainly a part of the intellectual milieu during the pre-Second World War period. During World War II it was necessary an intensive industrial production, by both men and women, due to the massive needs of war products. Gradually, it became clear that systems and products would have to be designed, considering human and environmental issues, if they are to be used safely and be fitted to their purpose (MacLeod, 2003). A casual examination of the history of ergonomics might suggest that studies comprise researches only considering the physical aspects of the work. Research by Belbin, Belbin and Hillb (1957), Broadbent (1957), Collins and Hopkinson (1957), and Scholz (1957), support discussions about this subject (Table 2.1).

Table 2.1. Studies on physical aspects of the work.

Author (s)	**Date**	**Title of the paper**	**Summary**
Belbin E., Belbin M., Hillb, F	1957	A comparison between the results of three different methods of operator training	Description of a type of operative training in its application to the mending of worsted cloth.
Broadbent D. E.	1957	Effects of noises of high and low frequency on behavior,	Case study performed on three groups of subjects working for two sessions in noise, at a five-choice serial reaction task. This study aims to measure reaction times to the same noises.
Collins J. B., Hopkinson R. G.	1957	Intermittent light stimulation and flicker sensation	Study of the flicker sensation variability in different occasions with the same observer, or for different observers.
Scholz, H.	1957	Changing physical demands of foundry workers in the production of medium weight castings Automation in civil transport aircraft Original	Study of the effects of lighting conditions on human work

This perspective of ergonomics may also be stated in a special issue entitled “Summaries of papers published elsewhere” in Ergonomics, 1(4), 1958 (Figure 2.1). In the editorial note, authors of papers with ergonomic interest which have been published in others journals rather them Ergonomics Journal or have reports in privately circulation, are invited to submit their papers to this journal.

It is possible to notice that, all submitted papers are related to research on handling work, engineering design field and physical aspects of the work.



EDITORIAL NOTE

The four papers which follow have all been contributed by authors in industry. The first is by the chief engineer of an American aircraft firm, outlining what are, from his point of view, the main essentials of work in the human engineering field if it is to be successful. The second paper is by a specialist in the field of human engineering from another firm, describing the range of activities that he and his colleagues undertake. The third paper is by the head of the Ergonomics Department of a trade research organization in Britain which makes studies and carries out consulting work for a group of factories under the joint sponsorship of these factories and the Department of Scientific and Industrial Research. The article describes the work of the department and the way it has grown since it was first started. The fourth paper is divided into two parts. The first part is by the managing director of a British aircraft firm, who is himself a recognized authority on the theory of manual controls, and sets out some of the important problems of this field in a formal and theoretical way. The second part of the paper describes an experiment carried out by two research workers attached to the firm under a research contract with the Ministry of Supply.

It will be evident from these papers that the task of designing work and equipment in such a way that they are best fitted to the capacities of the operatives concerned is a matter which demands specialized knowledge and experience and that very substantial advantages can be gained in many cases if persons possessing such knowledge are employed either directly or as consultants.

Figure 2.1. Extract of the special issue: "Summaries of papers published elsewhere" Ergonomics, 1(4), 1958.

At this point of time, ergonomics became to be seen as a discipline. It is a fact that wartime contributed to its rapid development. Sir Frederic Charles Bartlett [1886–1969] was a British psychologist and the first professor of experimental psychology at the University of Cambridge. He was a renewed researcher on ergonomic fields. In the immediate postwar period, he published several papers related to this issue, demonstrating the need of a subject that could study the problems that emerged from the war. Although he has contributed to the development of ergonomics it is interesting to note that, he did not use the word ergonomics in his writings. However, he recognize the importance of being continuously identifying key research areas to study, to solve problems related to workers wellbeing, to develop organizations strategies and to design machinery and tools. Recently, Staton and Stamers (2008) recognized Sir Frederic Charles Bartlett contribution to the development of ergonomics as a discipline; saying that "... the contributions he made were vital for the discipline's development in many years".

At that time, people should be considered in the context of system operation as well as in the design of new working systems. These contexts should take into consideration the one man-machine relationship, as cooperation between two subjects: the men and the machine. Kukke (1959) suggests that, if human contribution to the system's effectiveness is to be achieved then the design of a man-machine system should take into account, both personnel and design considerations. Men and machines should be studied as a whole and integrated in a global system. This situation represents a new challenge in the ergonomic fields (Vogt, Leonhardt, Köper, and Pennig, 2010).

The decade of 1950 witnessed a dramatic expansion of ergonomics in the aircraft and missile industries, (Christensen, 1976). According to Kleiner (2004), ergonomics field began in response

to human-machine mistakes, especially in aviation. Two examples of published papers in Ergonomics Journal during this decade can give an evidence of this statement (Table 2.2).

Table 2.2. Research of Wood and Kraft (1958) published in Ergonomics Journal.

Author	Date	Title of the paper	Summary
Kraft, J. A.	1958	Industrial approaches to human engineering in America	Examples are given of the many different ways in which human engineering programmes are introduced, staffed and developed within industry. The present scope of such programmes in the aircraft industry is outlined, and the future expansion of human engineering studies is discussed.
Wood, C. C.	1958	Human factors engineering : an aircraft company chief engineer's viewpoint Ergonomics	Essential features of successful work on human factors in machine and equipment design are summarized and discussed.

Although early publications of studies conducted on this type of industries were dating back to the decade of 1950, the interest in investigating these contexts remains until present day, as it is possible to see in Table 2.3.

Table 2.3. Scientific papers related to aircraft industries published in Ergonomics Journal.

Author (s)	Date	Title of the paper	Summary
Stockbridge, H. C. W. and Lee, M.	1973	The psycho-social consequences of aircraft noise	Description and comparison of different methods used to investigating the social disamentity caused by aircraft noise
Edwards, E.	1977	Automation in civil transport aircraft Original	Study of the role of men in automated systems
Doll, T.J. and Folds, D.J.	1986	Auditory signals in military aircraft: ergonomics principles versus practice	Human factors research related to the perception of speech or non-speech signals
Rogers, S.P., Spiker, V.A. and Cicinelli, J.	1986	Luminance and luminance contrast requirements for legibility of self-luminous displays in aircraft cockpits	Study of the effects of the displays luminance in aircraft cockpits
Stålhammar, H. R., Leskinen, T. P. J., Kuorinka, I. A. A. Gautreau, M. H. J. and Troup J. D. G.	1986	Postural, epidemiological and biomechanical analysis of luggage handling in an aircraft luggage compartment	Study of the musculoskeletal symptoms related to loading and unloading luggage in a luggage compartmental aircraft
Stanton, N.A., Salmon, P. M.	2011	Planes, trains and automobiles: Contemporary ergonomics research in transportation safety	Contemporary overview of the status of ergonomics research in the area of transportation safety
Vink, P., Bazley, C., Kamp I., Blok, M.	2012	Possibilities to improve the aircraft interior comfort experience	In this study, passenger's opinion is used in order to design a more comfortable aircraft interior.

In the decade of 1990, the Applied Ergonomics journal published more than 100 papers related to this subject. Nowadays, the studies concerning the aircraft industries are related not only to

military domain but also to commercial use. It is important to notice that those studies are cross-sectional, i.e., they are developed regarding the physical aspects of the work, cognitive demands, inter communication decision making, safety, human factors and, more recently, comfort. According to Vink and Hallbeck (2012), comfort is a "pleasant state or relaxed feeling of a human being in reaction to its environment". Different dimensions for comfort analysis should be considered such as comfort related to the region of the body, the activity developed, sensory feelings or physical loading. Nowadays, the main research areas on the aircraft sector are related to subjective aspects of the human being.

Back to the 1950s, in opposition to the Tayloristic principle of selecting a few special individuals to match a pre-existent job, the European Productivity Agency (EPA), in 1953, launched the project 'Fitting the task to the worker' (Dul and Karwowski, 2004). In this project, employers, employees and experts collaborated to introduce human factors into productivity (Hermans and Peterghem, 2006). Even though the 1950 was the decade of military ergonomics, in Europe started the first ergonomics industrial applications focusing on the well-being and productivity.

A letter to the Ergonomics journal Editor dated from 1958, Rohles emphasized the interest or engagement of people (individual or organizations) in human engineering work. It is possible to read that,

> "In order to facilitate the exchange of information the Psychology Brand of the Aero Medical Laboratory is interested in discovering all individuals and organizations, both private and governmental, who are engaged or interested in human engineering work...." (Rohles, 1958).

Remark the expression "human engineering work", revealing a tridimensional perspective engineering/human and work. Engineering is considered on the one hand, an "art" contributing to the design of machines and workstations with a technological view and on the other hand, presents an integrated, global (technological and human) and multidisciplinary vision of a given problem. By reading this letter, it is possible to infer that engineering, as well as ergonomics (concept understood from the words work/human), must be seen as being developed for people. This seems to be a turning over in the Ergonomics concept.

Moreover, in 1958, the needs of specialized knowledge in the ergonomic field are recognized. The Editorial note of the Ergonomics Journal published the following words:

> "...the task of design work and equipment in such a way that they are best fitted to the capacities of the operatives concerned is a matter which demands specialized knowledge and experience and those very substantial advantages can be gained in many cases if persons possessing such knowledge are employed either directly or as consultants..." (in Editorial note, Ergonomics, 1(4), 1958).

It is possible to say that the decade of 1950 was an important time for the establishment of ergonomics in many countries, such as the United Kingdom. This country was a reference in ergonomics development and in its recognition as a science. Possibly, the largest number of research centers that arose in those years contributed to that reality ("Editorial note", 1958).

Important events took place in the next decade contributing to a holistic definition of ergonomics. In the 1960s, the United States' Apollo 11 was the first manned mission to land on the Moon on 20 July 1969. Despite having been in the decade of 1950 that nuclear energy was launched, it may be said that only later in the 1960s, nuclear power stations were widely operational. The sixties were an exciting and optimistic technological time. The three programmable digital electronic computers that launched the Electronic Computer Revolution were designed and built from 1943 to 1951, namely, the ENIAC (Electronic Numerical Integrator and Computer); the EDVAC (Electronic Discrete Variable Computer); and the Von Neumann, or IAS (Institute for Advanced Study). Despite this, the boom of computer advances and commercialization, only began in the decade of 1960 (Burks, 2002).

According to Kleiner (2006), in the decades of 1970 and 1980, simply because the boom in the computer and technological fields happened, it seemed that industries and other sectors were compelled to use them just because they existed. According to Rasmussen (2000), a large proportion of the population at this time, had been dramatically influenced by computerization. Diversification of work was the main effect obtained, defining a new era of cognitive work. Cognitive work changes the job contents to another level, characterized by problems-solving through creative improvisation. Boof (2006) remarked that futurists, at that time, predicted a new era, in which technology would relieve people from tasks that would be difficult, time consuming, and subject to error. Human engineering work previously mentioned, was placed behind the scenes. Organizations, in general, used the available technology without the proper adjustments to work in reality. This fact was responsible for the existence of cognitive, physical and psychological constraints.

An interesting definition of ergonomics, relating ergonomics to technological development, is presented by Norros and Savioja (2000). To these authors, ergonomics is an "interdisciplinary science of human conduct. It takes into account the fact that human beings use tools in interacting with the world, and, is especially focused to shape technologies to fit human purposes, conditions and values." Ergonomics aims to minimize negative effects of technology and to maximize the creative role of the human. The authors go on even further, stating that, the deeper the influence of ergonomics is on shaping the human and his environment, the more important the contextualization becomes to the ergonomic research and practice.

According to Wilson (2000), any acceptable definition of ergonomics must emphasize the need for, and the complementarily between, a fundamental understanding of people and their interactions and the practice of improving those interactions. Meister (1995) (as cited by Wilson, 2000), differentiates between the theoretical knowledge and the instrumental knowledge within

ergonomics. The theoretical knowledge explains people's interaction with other things and the instrumental knowledge can be utilized in design. With this dual contribution, Meister believes ergonomics to be the only discipline that relates humans to technology in a scientific manner.

A large number of ergonomics and human factors definitions exist; stressing the view of ergonomics as both a science, related to the knowledge field, and also as a technology by solving problems. Wickens (2008) emphasizes that the concept of human factors should also be taken into consideration. Human factors are related to people's interactions with work space and other individual or a group of people.

Helander (1997) presents a unitary ergonomics definition using the dichotomy ergonomics/human factors; “ergonomics and human factors uses knowledge of human abilities and limitations, to the design of systems, organizations, jobs, machines, tools and consumer products for safe, efficient and comfortable use”. Even though Helander tries to make an integrated definition, the use of the conjunctive word “and” can be reported to the reader in two distinct ways to define the worker in his environment: cognitive or physical; as if it were possible to make this distinction.

Wogalter, Hancock and Dempsey (1998), remark that the use of the term “Human factors”, is related to a North American phenomenon, used by individuals “who do work” with “above the neck” mental processes. In fact, Human factors include perception and cognition. According to the same authors, the problem was how to do the integration of human factors into the ergonomics definition. Based on their thinking, ergonomics and Human factors, although not synonyms, can complete itself providing a broader perspective of work. At this point of time, it appears to be a growing consensus that Human factors and Ergonomics refer essentially to a common body of knowledge.

During the mid-1990s, the Human Factors and Ergonomics Society (HFES) (main professional organization of this area originated in the United States) determined that, while the emphasis on particular facets or applications may differ from country to country, people who call themselves human factors professionals or ergonomists, are the same throughout the world (Hendrick, 2008). According to Dzissah, Karwowski, Rieger and Stewart (2005), ergonomics must be used synonymously with human factors, and denoted as HFE. This author defines HFE, as the discipline that focuses on the nature of human-artifact interactions, viewed from the unified perspective of the science, engineering, design, technology and management of human-compatible systems (Dzissah et al., 2005; Salvendy, 2006). Such systems include a variety of natural and artificial products, processes and living environments.

In the decade of 2000, in order to standardize and globalize the concept the International Ergonomics Association (IEA) (2000) formally presented the following definition:

> ''Ergonomics (or human factors) is concerned with the understanding of interactions among humans and other elements of a system, in order to optimize Human well-being and overall system performance.''.

According to Hermans and Peteghem (2006) comments, two main goals may be presumed from this definition: the improvement of human well-being and overall system performance. Dul and Neumann (2009) refers that ergonomics implies having both a social goal (well-being) and an economic goal (total system performance). Dul et al. (2012) refer that performance and well-being are outcomes of fitting the environment to human. Performance is related to productivity, efficiency, effectiveness, quality, innovativeness, flexibility, safety and security, reliability and sustainability. Well-being is concerned with health and safety, satisfaction, pleasure, learning and personnel development. These two outcomes may have influence on each other and must be understood as strongly connected. Organizations' strategies must considerer both goals as the optimization of the performance of the overall system (economical goal) and the human well-being (social goal) (Kogi, 2006). Young et al. (2012) emphasize the need of a balance in the relation design/optimization of a process or a system. Sometimes it will be considered as the design and other times it will be given more emphasis to the optimization of the process.

The professionals of the Human Factors & Ergonomics (HFE), around the world, should be concerned with the design of the interfaces between humans and other system components. These actions will be responsible for improving health, safety, comfort and productivity, including quality and reducing human errors induced in the design. As practiced universally, the overall goal of HFE is to improve the quality of human life. In fact, the growth of the ergonomics domain since the formation of the IEA (International Ergonomics Association) over the last 53 years, reflects the multidisciplinary basis of the core research areas. These primarily relate to the physical, cognitive, and organizational factors impacting on human wellbeing and systems performance.

In 2000, Wilson (2000) presented a more complete definition suggesting that the contextualization of ergonomics in real world situations is also important:

> "... it is the theoretical and fundamental understanding of human behavior and performance in purposeful interacting socio-technical systems and the application of the understanding to design of interactions in the context of real settings.".

Two observations are to be made; the first is related to the addition of the word "socio-technical systems" into the definition. The other is reflected on the concern about the study of real work activities. This definition places the individual into a system (not into a workplace), in which several interactions are defined. Parsons (2000) also included the word "system" into ergonomic definition recognizing its importance. According to this author, Ergonomics may be defined as the "application of the knowledge of human characteristics to the design of systems". So, interacting systems should be examined. These systems which are prevalent in the modern world represent

a holistic approach of ergonomics. Following this thinking, ergonomics should be regarded as "one of the truly multi-, inter- and cross-disciplinary subjects that the world requires if we are to understand and improve the lives of people and societies going into the 21st century.".

In a similar way, to Norros and Savioja (2007) ergonomics is an "interdisciplinary science of human conduct". This point of view, focuses on the human being as interacting with the world, and, is especially focused to shape technologies to fit human purposes, conditions and values. Ergonomics' principal role is to provide a normative basis for the evaluation of the appropriateness of the artifacts that are used in various human activities.

To Dull and Newman (2009), the value of ergonomics extends beyond health and safety. That is, while maintaining health and safety of consumers and workers, ergonomics may support a company's business strategy to stay competitive. Strategy and business goals are proposed to integrate ergonomics into organizations. In order to achieve this issue, authors proposed three main areas for action: (1) corporate, (2) business function and (3) cross-functional strategies. Corporate areas include the involvement of top management of the organization, as well as external stakeholders, including shareholders. Business function strategies are related to middle managers and workers representing the business function and workforce. They are considered primary stakeholders. Cross-functional strategies involve two or more business functions. In Table 2.4, some examples are presented suggesting that ergonomics may contribute for many different company strategies and can support the objectives of different business functions like production, marketing and human performance.

Table 2.4. Strategies and business goals to integrate ergonomics into organizations examples.

Areas for action	**Strategies**	**Ergonomics integration**
Corporate	Differentiation strategy	Ergonomics in product design
	Cost strategy	Ergonomics in production system design
	Product Design	Ergonomics in design for Assembly (DfA) and, design for Manufacturability (DfM)
Business function	Corporate communication	Ergonomics as an advertiser offering a sustainable economy
	Production Engineering	Ergonomics Integration into production engineering (improvement of engineering /ergonomist relationship
Cross-functional strategies	Total Quality Management	Ergonomics to promote people
	Service Profit Chain (SPC)	Ergonomics to improve employee and clients' wellbeing

Even though, ergonomists work within a wide range of different application domains, with different requirements and priorities, this situation emphasis the need for ergonomics to be recognizes as a clear defined subject. To achieve this issue, it is important to define a balance between ergonomics theory and practice, research and application, providing a continuous development.

Unfortunately, nowadays, in many countries, ergonomics is mainly (or even only) associated with the reduction of risks of work-related musculo-skeletal disorders (WMSD) (Hermans and Peteghem, 2006). Zink (2000) proposed that ergonomics should not be considered only as an

additive or corrective applied science. Instead, organizations must try to "have" ergonomics as an integrative aspect of system design. Based on Zink's (2000) research and looking to the past, it is possible to say that (1) most of the ergonomics approaches are focused on specific topics or ergonomic contexts, (2) most of the times ergonomics is developed under an outside-in approach concept, where problems are not properly analyzed and, (3) a balance between research and real work context is not always achieved.

Hermans and Peteghem (2006) suggest that ergonomic approaches should consider both economic and social dimensions of the organizations without forgetting the Occupational Safety and Health (OSH) policy. Indeed, many companies around the world consider ergonomics to be a part of OSH. The main focus of this corporate policy is the awareness of risks. The work by Caple (2010) showed that, ergonomics future depends on how well this science is able to study and develop new methodologies and to analyze emerging ergonomic contexts. The author also highlighted that methodologies developed in a research context must be able to be used in the real working world.

Koningsveld, Dul, van Rhijn, Vink (2005), identified several factors that should be taken into consideration to design a successful and effectiveness project, system or simply a work-station. To them, design should be focused not only on health issues. Briefly, "design" should be associated to a good inventory, should integrate direct workers' participation, should rely on a strong management support and must use a step-by-step approach.

Ergonomics has applied constructive intentions facing the difficult task of bridging between theory and practice. Scientific methodology and methods are therefore needed to recognize the value of practice (applied ergonomics) and accept new types of ergonomic methodologies (research on ergonomics) (Norros and Savioja, 2007). The existence of a good balance between research and application across ergonomics at all organizational levels, including military, industrial and consumer ergonomics, was emphasized by Waterson and Sell work (as cited by Caple, 2008). They highlighted that there has "never been a consistent interpretation of ergonomics by the public". The need for more public visibility is stated as a continuing challenge for the future, including the need to improve ergonomics marketing and to enable the public and industry to experience the value of ergonomics. Future research needs to extend the use of a macro-ergonomics focus which brings together these multi-disciplinary science elements into a holistic approach. The strengths of the multi-disciplinary approach that encourages a holistic evaluation of ergonomics issues, will enable an expansion of research and application to give impact on an increasing range of the human interface with work systems, processes and products.

Zink (2000) presented several reasons that can constitute challenges in the ergonomic field (Figure 2.2).

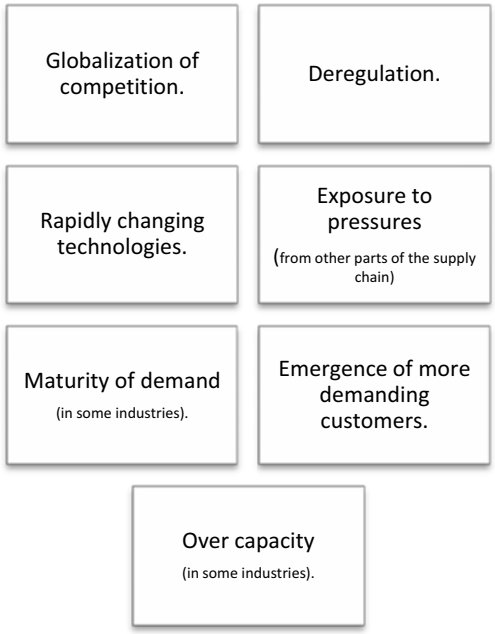


Figure 2.2. Ergonomics challenges (adapted from Zink, 2000).

Economic deregulation of an industry, based on Elvik (2006), can be defined as the removal of formal regulations that can limit the entry of people to the industry. The main purpose of deregulating an industry is to enforce competition, allowing anyone who wants to start a business, the freedom to do it at his/her own risk. Even though in a deregulated business safety regulations remain in force, the lack of knowledge of this "new ownerships" and competitiveness inherent to this philosophy can lead to carelessness with issues relating to other aspects of work, such comfort and well being.

Globalization may be understood under various aspects such as, economical, sociological, information and communication and mobility (tourism and migration). Wilpert (2009) refers to globalization, regarding the economical perspective, as the "closer integration of countries and people of the world". From a sociological point of view, the major problem relating to global people' oncoming, is the tension between "cultural homogenization" and "cultural heterogenization". That is, globalization creates on the one hand, large groups of people who have common interests, and on the other hand, accentuates the differences between each group. The development of new information and communication technologies, contributes to the spreading of knowledge, products and people connections and interrelation. According to Wilpert (2009), globalizing tendencies may have influence on all social levels: the individual, the family, the social community, the institutional and inter-institutional level. The proper study of the differences between people became more challenging, regarding the ergonomic issues as there are increasingly different people doing the same tasks. Another important issue reported by Zink (2000) and presented in the Figure 2.2 is related to the emergence of more demanding consumers and, in a narrow sense, to mass customization. The influence of these two aspects of organizations can be reflected on the development of new manufacturing strategies. As a consequence, new work organizations and new organizational policies are required.

According to this thinking, challenges can be transformed into opportunities or chances. Cacciabue (2008) also identified three decisive aspects that can define as new challenges on the ergonomics domain:

- the constant and continuous advance in technology;
- the variety of domains of application (ergonomic context);
- the diversity of users.

The advances in technology are related to several identified situations: production hardware and very powerful small components development of new software techniques, development of sensors and instruments to be used in the nanotechnologies field. Simulators and virtual reality are used to test new technologies, training and testing human interactions with control systems and new design concepts and solutions (Cacciabue, 2008). The main advantage of the use of virtual reality is to develop interfaces that are as much "user friendly and realistic" as possible. In both situations, the use of ergonomics is very relevant.

In a technological context, depending on the specificity and complexity of the interfaces and control systems developed, a variety of domains may be identified. The complexity of the systems may affect work organization, worker performance and worker interrelations with the environment. Another important issue to consider is related to the diversification of technology users. In fact, the general public is not trained to use the technology, interfaces are not standardized and the variety of users is enormous and should be considered. In both situations, the variety of domains of application and the variety of users, ergonomics has an important role to ensure the systems usability (Billie et al., 2003; Young and Stanton, 2003).

Cacciabue (2008) declared that, the challenges in ergonomic field must consider some special human features such as, motivation, emotion and feeling that may be associated to technology. In other words, the author named this situation as "adaptively of technology". The involvement of society became necessary. In a narrow sense, it is possible to say that the variety of ergonomic domains and the involvement of the public in general, are two challenges to the ergonomics research field.

With regard to the public engagement, Young (2012) pointed out that a science must be done to the public and with the public. It was also mentioned that the participation of non-specialist groups in science, open new avenues for research. The social responsibility argument for public engagement may be justified by those authors who support the ergonomics as multi-disciplinary science (Hermans and Peteghem, 2006; Norros and Savioja, 2007).

Ergonomics, as an applied science, has direct relevance to the public on a number of levels. The general public can be consumers, clients, workers, travelers, students, among others. Ergonomics may have an influence in the lives of the everyday public. It is a science that designs many things for many people. In an interview survey, conducted by Young (2012), perceptions of

ergonomics from people outside, as well as inside the field, were determined. Respondents were asked about their understanding of ergonomics, interest in ergonomics and their thoughts on ergonomics in design. Results showed that the majority of respondents relate ergonomics to comfort and usability. This knowledge allowed the understanding of which fields of ergonomics should be considered in the future of ergonomics.

Another important influence of public engagement may be stated in market analysis. Nowadays, competitive business strategies are changing and companies are no longer the economic centre of the market economy. According to Lindon, Lendrevie, Rodrigues and Dionisio (2000), corporations are constructed in such a way that it ensures an effective response to the marketing exigencies. Top management strategies are developed in horizontal collaboration, stretching from the different organization hierarchies. They became a scene for different 'actors' who, over time, have different roles within organizations. This whole process of change will have an impact in the distribution chain, where clients assume a vital role (Lindon et al., 2000). In this marketing context where competitive advantage and value creation are increasing, micro-marketing (customer specific marketing) is the driving force transforming retail competition (Zink, 2000; Ziliani and Bellini, 2004). According to Swann (2001), it is important to maintain a good relationship and effective communication with clients, identifying their needs and expectations. A great effort to improve organizational adjustments that correspond to clients' expectations is required from the organization. These adjustments may be related with issues, such as: utility, functionality and products' aesthetics, environmental adjustment, prestige, usability and pleasure (Kalid and Helander, 2004; Sojka, 2003; Tsao and Chan, 2010). Ergonomics may address issues at various system levels, resulting in an action known as ergonomic intervention.

Taking all the previous ideas into consideration, organizations must be studied as systems where different organization levels can be identified. The design or optimizations of these systems are important issues in the ergonomic field. The recognition of the public oncoming into the systems becomes a challenge being compulsory to understand the importance and the role of this new dimension: the public.

2.2. Ergonomics and the Concept of Work

According to Freeman and Louça (2000), the years between 1945 and 1973 were considered a long period of economic growth. In this period, the market economy was based on the use of inexpensive energy, broadening the range of transport generated by the invention of internal combustion engines and technology of petroleum refining. At that time, mass production was the dominant concept of organization of work activities. Virkkunen (2007) found that "this concept was applied, mutatis mutandis, in almost all areas of material production and services".

Taking into consideration the terminology of mass production, Victor and Boynton (1998), presented a model of the trajectory of work development. In this model, production of a given

product begins in an artisanal manner, as this kind of work has the necessary know how, moving subsequently for mass production by improving the manufacturing process.

The main features related to mass production labor are a sequential and specialized organization of work, a highly centralized sequential and hierarchical decision-making. Teamwork and decentralized decision making were introduced in the mass production work organization on an automobile industry named Toyota. These concepts were incorporated and assimilated on the working process over a period of thirty years (1945-1975).

In the decade of 1980, the development of new technologies contributed to market segmentation. The rapidly increasing implementation of information and communication technologies into all domains of human activity may have affected people's interaction with their environments (Norros and Savioja, 2007). According to Virkkunen (2007), at this point of time, production was carried out in a dynamic network of cooperation. The technological boom approaches the producer from the client; manufacturing process becomes more sustained. That is, sequential and rigid division of labor, typical mass production, are gradually being replaced or supplemented with different approaches to the same task, a more integrated view of knowledge and a more participatory dialogue among the process of participants. The aim of this new concept of work is to produce increasingly complex and specific objects that are not capable of being copied by business competitors, and that are consistent with the expectations of clients. As a consequence of this labor process, the oncoming of clients to the organization strategies is inevitable. An example of the labor process that allows the client participation, although in an indirect way, is the co-configuration process. In a metaphorical sense, Virkunnen (2007) makes reference to this process, pointing out that the concept of co-configuration results in a continuous dialogue and development-oriented between the producer and user. In his own words, co-configuration process is characterized by "(1) a customer-oriented product that can be adapted in an on-going basis, in part by the producer and partly by the user, changing conditions and customer needs, (2) a collaborative system of value creation, in which value is not produced in the activity of the producer nor the user activity, but in the interaction and collaboration between them, (3) the continuous adaptation: the producer does not fit the product or service on time but on an on-going basis, and updates, for example through software updates".

In another context, Mayer (2003) studied the influence of final consumers in the collective invention. Collective invention is a process of developing a new technology. Briefly, through collective invention, technology or in a wider sense, a product is developed and the final consumer, when using it in a different context and by the logic of functioning, discovers its limitations and tries to correct them through common sense. The final product is more robust and a greater variety of applications are generated. This thinking applies not only to the development of an object or technology, but also to the evolution of working organization concept. That is, the structure of work has to be more flexible allowing a continuous adaptation of the organization and the way of working to the needs and expectations generated by final

consumers. Organizations must be a dynamic structure and professionals' activities oriented to face market demands.

According to Carayon and Smith (2000), work organization is defined as the way "work is structured, distributed, processed and supervised". Several factors contribute to the way work is organized such as, management style (scheduling of work, job design, interpersonal aspects), types of products and services provided, workers characteristics, level of automation, organizational characteristics (climate, cultural and communications) and it is dependent on market economic conjuncture. Work organization may have psychological or physical impact on people. Psychological impact may result in strain and stress at work. Physical impact is related to postures, lifting, and restrictiveness work, among others.

Several theoretical approaches are described in the literature, defining strategies to study the working organization. Balance Theory of Job design, described by Smith and Carayon-Sainffor (1989), work organization results in the design of a work system that includes five elements namely, individual, tasks, tools and technologies, physical environment and organization. The interaction between these elements may produce a "stress load" situation bringing out the individuals' psychological and physical reactions that may have emotional behavior and biological consequences. Motivation, working conditions demand, stress individual status and individual capacity of reaction may have an influence in the individual ability to face a stressful situation. The effects of the five interaction elements may have influence in the quality of working life, performance, strain and health.

According to Carayon and Smith (2000), Balance Theory of job design emphasis a system approach in which all elements of the work system should be considered improving work performance, health and safety. The table below presents a brief identification of the factors that may have influence in each of the five elements according to this theoretical approach (Table 2.5).

Table 2.5. Definition of Job' stressors according to the Balance Theory of job design.

Work-system elements	**Job stressors**
Environment	Noise, lightning, temperature, air quality and workplace layout
Task	Job demands, Job contents, machine-pacing and job control and repetitiveness
Technology	Lack of adequate skills to use the technology, physical characteristics of the tools and technology
Organizational factors	work schedule, organizational context, training and time to job adaptation
Individual	Personality, physical health status, skills and abilities, physical conditioning, anthropometrics, prior experiences and learning, motives, goals and needs

It is important to have control of the five identified elements in order to provide the loads and the resources for achievement of individual and organizational goals. The perspective presented by the Balance Theory of Job design is based on an occupational one, i.e., cultural and social aspects are not emphasized as well as the influence of workers interactions with other elements

of the organization. It appears that organizations are studied as separated from the social context in which they are included.

A review of other approaches for the study of work organization was also carried out. Three theoretical approaches were considered: (1) behaviourist approach, (2) interactionist approach, and (3) "dialog" approach.

The behaviourist approach (1) studies the effects of working variables on the human behavior. It is based on observable characteristics of behavior, however insufficient to understand the cognitive and psychological process behind human behavior. Anderson (2005) presents an example of using a behavior modification (BMod) approach to safety. The key messages from this work are: Interventions that use a behavioural approach should be considered in just one of the aspects of human factors; safety practitioners toolbox should have more than one program to improve safety in an organization; safety practitioners must define limits of behaviorist interventions; and as the intervention is related to behavior, safety practitioners should be prepared to change resistance.

The interactionist approach (2) assumes that the success of the organizations is depended on interactions between the different groups of workers and therefore, is focused on the study of these interactions.

The "dialog" approach (3) places the user as an actor in a situation of co-configuration process. Lee, Jung, Kim, Lee and Lee (2007) used a dialog approach to study the usability of an interface related to an electronic appliance. In an electronic product development, users design considerations are very important issues to bear in mind. A dialogue approach is an effective way to understand the users' expectations about the analyzed product.

Carolly and Weill-Fassina (2007) integrated these three approaches on a quadripolar model (Figure 2.3).

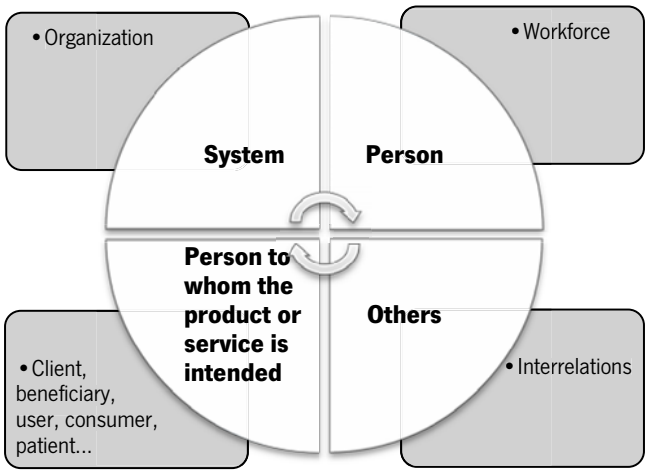


Figure 2.3. Quadripolar model for system approach (adapted from Carolly and Weill-Fassina, 2007).

The pole "system" represents what is provided by the organization for the development of an activity; material, equipment, procedures, decision making, among others. The pole "person" is related to workforce and it comprises of the worker skills and qualifications, the physical performance, the psychological status. The pole "others" represents the inter-relation with work colleagues, with the hierarchy structure of the organization and with the last identified pole "Person to whom the product or service is intended". This pole can be related to client, beneficiary, user, consumer, and patient. This model is a complex structure dependent on the social and cultural environmental where the organization is included. The interactions between the four poles are dynamic (assuming many directions) depending on the market context and not always easily identifiable.

By identifying "external" aspects of the work organization that may have influence in the work organization, it appears that the quadripolar model represents an evolution of the Balance Theory of Job previously mentioned. Such aspects are inter-relations identification and person to whom the product or service is intended. The quadripolar model represents a more integrated vision of work organization.

Rasmussen (2000) stated that "Any workplace is an integrated part of a complex, dynamic socio-technical system". This is a complex type of system were different levels may be identified, from productive process to normative governmental rules (Figure 2.4).

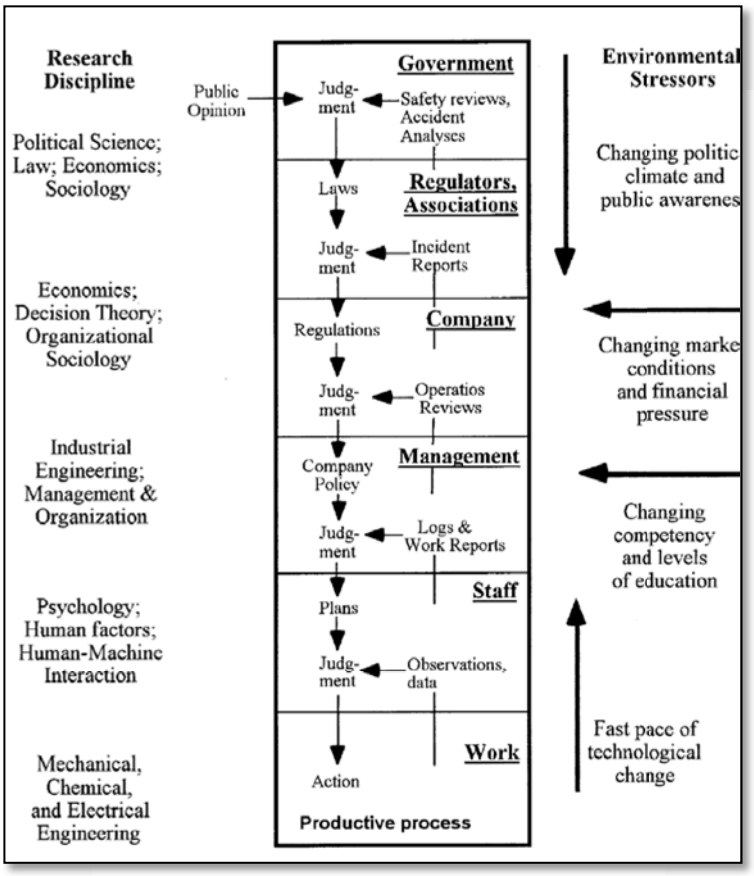


Figure 2.4. Levels of a Socio-technical system (reproduced from Rasmussen, 2000).

Each level is related to a research area (engineering, psychology, economics, political science), being study separately by different academic subjects. Several external conditions may have influence on each operation level affecting the system control. Rasmussen (2000) calls them "environment stressors". They may be changing the political climate and public awareness, changing market conditions and financial pressure, changing competence and levels of education and technological changes. Each of these stressors may have an effect on a particular system level. Usually, the different levels of the socio-technical system are studied separately by the decomposition of the system into their functional systems. Considering this point of view, the strategies of the managements are often dissociated from the productive process in terms of human factors, e.g., the situations where companies give too much importance to political changes. As a consequence, they implement several structural changes in the organizations like less payment or mass redundancies. In this case, workforce is directly affected and it is possible to assist to a reduction in the quality of work (in this case work must be seen from several dimensions: social, cultural and professional, among others). In these kinds of system-approach decisions (managers' decisions or supervisors' decisions) are usually separated from the working context and studied as an isolated phenomenon.

Rasmussem (2000) proposes that systems must be studied as an integrated whole, considering the work-system as a dynamic context where the different components are associated in a non-linear way. Inputs and outputs relations between the different components of the systems should be considered into the analysis of the system. A holistic and cross sectoral vision of the socio-technical systems is required without forgetting the technological basis of the lowest level (the production level). Cross-disciplinary studies of these systems are required. These studies should consider the investigation along with the present work situation, seeking to develop models of working analysis integrating all levels of the system.

A large system approach became necessary in order to understand the work organization, not only in an occupational point of view but also to understand the real activities of individuals. According to Dul et al. (2012), a system is a set of interacting and interdependent components that form an integrated whole. Kleiner (2006) proposes that a basic work-system model approach may be the answer to this problem. This model proposes that organizations must be integrated in an overall system, where different subsystems can be identified: the personnel subsystem, technological subsystem, internal environment, external environment, task, and organizational design all operate and interact within a work system (Figure 2.5).

Personnel subsystem is defined by those who do the work. It is related to humans' interrelation and communication. According to quadripolar model (socio-technical theory), this subsystem is a result of a commitment between the system (in this case, "system" is related to the different hierarchies of an organization), self worker, workers relations with other colleagues, and the person from whom the service is addressed.

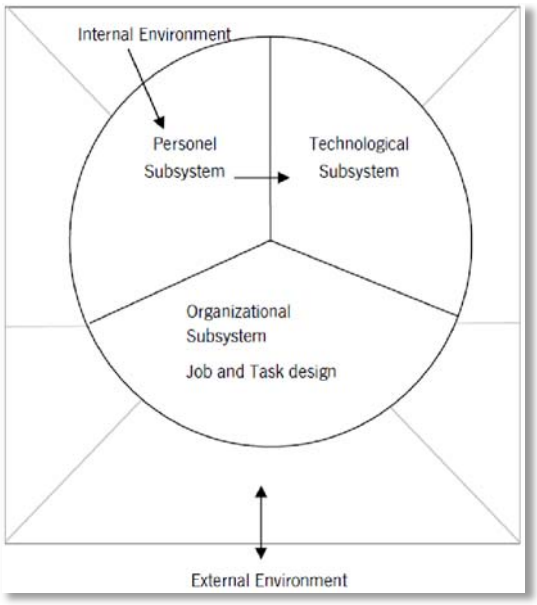


Figure 2.5. Work-system model (reproduced from Kleiner, 2006).

As technology becomes intrinsically linked to the organizations, interfaces design is necessary in order to simplify the human-machine relation. In fact, technological revolution boom, involving new communication technologies and information (Virkunnen, 2007), provided the oncoming between these subsystems. According to Karwowski (2005), "technology can be defined as the entire system of people and organizations, knowledge, processes and devices that go into creating and operating technological artifacts, as well as the artifacts themselves". Technology is related to both science and engineering. Science aims to understand the "why" and "how" of the process. Engineering is the "design under constraints" of cost, reliability, safety, environmental impact, ease of use, available human and material resources, manufacturability, government regulations, laws and politics. The last subsystem is composed by several sub-systems related to physical, social or informational aspects of the environment. It is more uncertain to define, because of the cross cultural changes and problems related with the economy globalization. Kleiner (2006) states that, "how well these subsystems are designed in respect to one another determines how effective the work system will be". If the organization is a fixed structure, when changes occur in one subsystem, one reaction is expected to stabilize the overall system. Therefore, it is important to study the complexity of all the identified subsystems with a more detailed analysis of the real activities of individuals. This study must take into consideration the changes and trends occurring in business, technology and society that may represent new forms of work organization. These changes may have impact on work system leading to re-structuring and re-organizing of companies, new forms of work organization, workforce diversity, and information and communication technology.

Recently, Cacciabue (2008) established and consolidated methods and techniques for analyzing and representing working contexts. These methods include task analysis, work and job analysis, human behavior modeling, leaving space to their evolutionary approaches focused on cognitive aspects. In order to study the different working contexts over the years a whole variety of new

methods were developed. For each method or group of methods, different objective for analysis or target groups can be identified and defined.

2.3. Ergonomic Approaches

According to Dul et al. (2012), HFE main issues are an oriented and purposefully design of systems consisting on interactions between people, products and environments. According to Wilson (2000) interactions must be studied, not simply to design artifacts, but to design a more diffuse, complex and multi-faceted interacting system. They presented a contemporary vision of the main focus for HFE, by saying that any work activity is as much part of a supply chain, in which each element is both a supplier and a customer for other elements. In such system, interactions and the total network, rather than the entities, should be considered into analysis. That is, ergonomists work must not be focused on a drawing of an activity or product, but in the set of interrelationships, which allow to achieve the organization mail goal. It is the understanding of the human role as the key-element in interacting systems that are the real contribution from ergonomics. In this way, an ergonomic analysis can be on specific aspects of people in a certain context and considering various system levels.

According to Rasmussen (2000) point of view, the traditional task analysis formulated in terms of a sequence of actions on the work objects and focused on normative work procedures must be replaced by a cross-disciplinary approach. This type of analysis recognizes the fact that worker has strategies behind organization roles and structure, not always visible, that he uses in his own benefits. Rasmussen (2000) call this type of analysis as being a part of a reactive research involving the study of the actual and real work situation, together with the identification of the actors' that play different roles in the organizations. A focus proactive system design is required.

Dul et al. (2012) identified three system levels: macro, meso and micro-level (Figure 2.6).

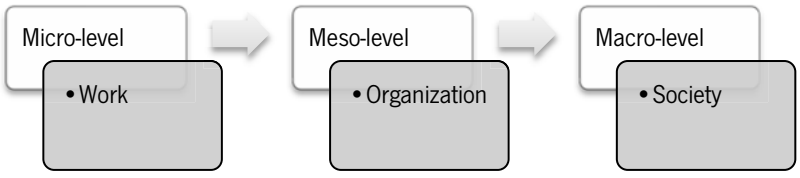


Figure 2.6. Micro, meso and macro levels focal points.

Micro-level is centred in single tasks or tools, while macro-level places the individual at the centre of the work, engaged with the network of organizations, society and the world. Meso-level is related to integration of the individual in the technical process. That is, general public integration as both users in the traditional sense as well as consumers of ergonomics science (Young, 2012). Kleiner (2006) defines a macro approach, as the design of work systems which is focused on organization-system interaction. A macro approach is considered to be a set of tools and methods which are combined in order to analyse a system organization. Indeed, macro-

ergonomics is concerned with the optimization of work-systems by considering all components of the systems and their interactions as well (Kleiner, 2004).

Macro, meso and micro approach are linked and must be used in an integrated ergonomic approach. That is, a macro-ergonomic approach allows the identification of variables that may affect the socio-technical system and their implication on the overall functioning. Then, micro-ergonomics assessments allow the identification of more specific and individual problems allowing the implementation for example, of machine/man adjustments. It is important to notice that, the use of a micro method for a system approach is subject to failure, since it does not do the integration of all the system levels. Kleiner (2004) warned that external environmental inputs in the system are often not considered into the analysis and may have a major influence on the micro level which is to be analyzed. Changes or adjustments on the process of production may also be required after a micro intervention. It is important to notice that, the adopted approach (micro or macro) should also be properly considered since many times it is unsuitable. Hendrick (2002) suggested that ergonomic interventions failed due to a focus on micro-level problems to the exclusion of macro-level problems and barriers. Kleiner (2004) proposed that macro and micro-ergonomic approach may lead to a large-scale organizational change, creating positive organizational change. This point of view may create an open-mind context to more targeted ergonomic assessments, ergonomics interventions and respective improvements. Zink (2000) point out that coming from a socio-technological macro-approach, it is possible to better explain the need of micro-ergonomics interventions. Kleiner (2004) propose that a system approach should be done as follows: firstly a macro-ergonomic is performed with an assessment of relevant socio-technical variables and their implications for the design of the work-system and process. Once the overall system is evaluated, micro-ergonomics interventions can be accomplished. An orient approach connecting micro-ergonomics design topics and macro-ergonomic field of action is presented by Zink (2000) (Figure 2.7). To be successful, this perspective implies a focus on the complex and real-life provided by a multidisciplinary analysis.

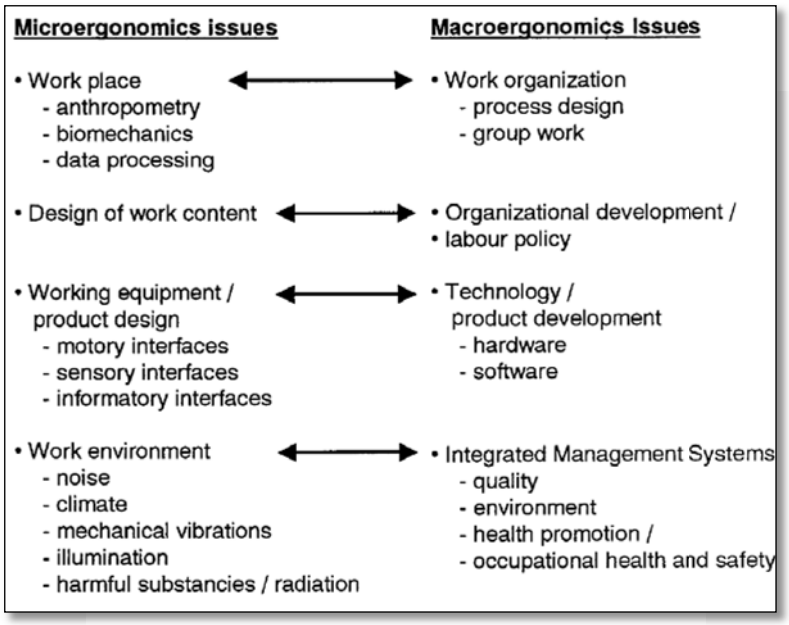


Figure 2.7. Micro to Macro connections (reproduced from Zink, 2000).

According to the field of ergonomics and the object/subject/system that will be analyzed it is possible to select a methodology to perform ergonomic assessments. Regarding the identified interaction, Staton, Hedge, Brookhuis, Salas and Hendrick (2005) grouped the available methods into four major groups: (1) Interaction of the individual with the world; (2) Interaction of a social group with the world; (3) Interaction of the environmental with people; (4) Interactions related to socio-technical system.

Physical, Psycophysiological, Behavioural-cognitive methods are included on the first group. The second group is related to team methods. Macroergonomics methods are included in the fourth group.

It is important to notice that the selection of an ergonomic approaching (micro or macro) is related to the previous definition of the analysis aim, how deep the analysis should be and the time available to perform the analysis. The available tools to support the analysis should also be considered. Hakkarainnen, Ketola and Nevala (2011), point out reliability as an important issue to be considered in the selection of a method. In fact, to be interpretable, a method should be reliable. If the purpose of the analysis is the systems design, then reliability should be strengthened offering to the analyst a structured approach on the analysis and evaluation of design problems.

In order to illustrate the amount of available ergonomic methodologies, regarding micro and macro analysis, several examples are presented in the following subsections.

2.3.1. Physical methods

Several methods of assessment are used to evaluate the amount of discomfort and/or strain caused by different body postures. Literature presents a set of methodologies to assess postures and movements regarding different ergonomic contexts (McAtamney and Corlett, 1993; Dockrell, 2012; Kivi and Mattila, 1991; Hakkaraiben, Ketola and Nevala 2010; Lima, Jungb and Konga, 2011), such as the Rapid Upper Limb Assessment (RULA), Ovako Working Posture Analysing System (OWAS), Portable ergonomic observation method (PEO) and Rapid Entire Body Assessment (REBA). RULA is a subjective observation method of posture analysis that focuses on the upper body and includes the lower body. OWAS is a simple observation method for postural analysis. PEO provides an acceptable observation method to record adopted postures in real time context. REBA considers as activity factors to assess whole-body postures: repetitiveness, coupling, static posture and task time were, and the knee flexion angle.

2.3.2. Psycophysiological methods

Several factors are responsible for the increasing use of psycophysiological methods in the HFE field. Staton et al. (2005) identified some of these factors, such as the nature of work, the increasing number of accidents in workplaces and the human errors related to mental workload. As explained before (see section 2.1), as a consequence of technological advances, physical

work gave rise to a kind of cognitive work demands. In fact, these demands are highly associated with increased task complexity in operations that is the multitasking work (Di Stasi, Antolí, Gea, Cañas, 2011). This type of work is prevalent in our society and is responsible for aggravating the labour situation and consequently mental demands. The concept of mental workload is not new, indeed during the decade of 1970, Moray published a research book related to mental work, which points out that humans have limited mental resources that may be affected by the demand imposed by tasks considered as single or multiple (as cited by Wickens, 2008). Brookhuis et al. (2008) also referred to the influence of mental workload on human error.

All these factors together with the possibility that workplace accidents may be attributable, in part, to personality differences, may contribute to the increasing number of accidents (Forcier, Walters, Brasher and Jones, 2001).

Even though, psycophysiological cause/effect relation is not always easy to define; important implications for organizations interested in promoting a safe work environment are identified. Staton et al. (2005) basically identified three global categories of psycophysiological methods: measures of task performance, subjective reports and physiological methods. The first one is related to the measurement of worker performance with respect to acceptable low accident likelihood. Subjective reports may be observer reports or self-reports. Both must be used under restricted situations to eliminate all possible biases. Physiological measures are the most used to assess workload demands. Several physical measurements may be considered, take for example, the blood pressure, heart rate variability, respiration, speed of saccadic movements among others. The development of techniques for measuring workload has been a fundamental research topic in psychology and applied ergonomics over the last three decades Stasia, Antolía and Cañasa (2011) gave as example of cerebral activity measurements, the functional magnetic resonance imaging or electroencephalography. Obtained results may provide an opportunity for a more direct and sensitive assessment of mental workload.

2.3.3. Behavioural-cognitive methods

Stanton and Young (2003) proposed a division of the methods that are used to evaluate human–machine performance as follows: Heuristics, Checklists, Observation, Interviews, Questionnaires, Link analysis, Lay out analysis, Systematic human error reduction and prediction approach (SHERPA), and Repertory grids and Keystroke level model (KLM). They may provide a general analysis of human factors (Checklists, Observation, Interviews, Questionnaires and Repertory grids), or they can be related to cognitive task analysis (Link analysis, Lay out analysis). Methods such as SHERPA (Lane, Stanton and Harrison, 2005) may be based on the human prediction or on workload and situational analysis (KLM). A briefly explication of each group strengths and disadvantages is presented on Table 2.6.

It is important to notice that these methods are mainly used in human-machine assessments.

Table 2.6. Behavioural-cognitive methods: strengths and disadvantages.

Methods		**Strengths**	**Disadvantages**
Heuristics		Use of analyst judgment, intuition and experience. Quick and easy to use.	Subjective analysis and variability of the output.
Checklists		Quick and relatively easy method	Items selection depends on the analyst expertise.
Data collection	Observation	Easy way of collecting information about a person's interaction with a device.	Intrusiveness of observation massive data.
	Interview, questionnaire	Flexibility and thoroughness of data collected.	
Interface analysis	Link analysis and Layout analysis	Improvements suggestions for interface layout. in terms of frequency of use, sequence of use and importance of the element.	Time required.
SHERPA		Identification of human error based upon hierarchical task analysis (HTA) and an error taxonomy allowing a reasonable predictions of performance.	Dificculties in obtain a global vision of workplace.
Repertory grids		Model used to determine people's perception of a device. Provides information about consumer perception of a device.	Difficulties in obtain predictive information.
Keystroke level model (KLM)		Allows predict a task performance time for error-free operation of a device by breaking tasks down into component activities.	Ambiguity of activities division into operations.

2.3.4. Environmental methods

Physical environmental conditions may influence work performance. This subject has been studied by ergonomics, since the beginning of this discipline. Ergonomists realized that the human ability to develop an activity depends on the environmental condition that it is subjected to (Parsons, 2000). Human body may develop adaptive Physiological mechanisms to tolerate some inadequate environmental conditions, but extreme situations conditions can be fatal. According to Staton et al. (2005), creating ambient conditions that are comfortable, acceptable, and do not compromise work performance or work health is the main goal of design of the workplace environment.

Assessing the physical environment is a complex task since several variables must be measured sometimes using equipment that requires expertise. Ken Parsons, an expert in environmental ergonomics, made a review of the principles, methods and models used in environmental ergonomics (Parsons, 2000). He pointed out that variables which may affect work performance are related to heat and cold, vibration, noise and light on the health, comfort and performance of people. These factors should be considered for analysis as influencing health, comfort and performance of the occupants of the ergonomic context. In opposition to a product or manufacturer-oriented perspective, a human-centered ergonomic approaching is required. According to Parsons (2000), this approach should consider both intra and inter human differences. Intra differences are related to the differences which occur in the same person over

the time, whereas inter differences are those between people. It is important to notice that the human interaction to the environment is dynamic. That is, human is an active system that responds to environment inputs and reacts with outputs providing environment changes that may affect other occupants of the ergonomic context. Taking the lighting conditions as an example, these conditions may affect the workers' performance (environment input). By responding to this environmental condition, the worker may change (if allowed) the lighting intensity to his own benefits (human output). This output may affect other existing colleagues in the same area (environment input). In response, these colleagues will also send their own outputs to the environment, and so on. Considering the system organization as a whole, a sequence of inputs/outputs is expected. This situation may be responsible for certain constraints in the organization.

Ergonomists are usually aware of the human influence on the system organization and particularly on the environment sub-system. In most cases, they use more than one method to assess environment conditions and human responses to environment. These methods can be subjective, objective, behavioural methods and, models of human responses. Table 2.7 presents the objectives and disadvantages of using each method for assessing human responses to environment.

Table 2.7. Environmental methods: strengths and disadvantages.

Methods	**Objectives**	**Disadvantages**
Subjective	Assessments of human psychological responses such as comfort and annoyance. Easy to be used.	Possibility of methodological biases. Not to be used to measure health' effects. A representative sample of the population is required.
Objective	Used to direct measures of human responses, such as body temperature.	Not to be used to design. A representative sample of the population is required. Possibility of measuring interferences.
Behavioral	Used to study people with disabilities, children or context were other methods are misadjusted.	Observer training is required. Difficulties in determine cause/effect relations.
Models of human response to environment	Use to design and evaluation. Easy and quick to be applied.	Possibility of not include all the environment factors into the analysis.

2.3.5. Team methods

As global competition and a more sophisticated and demanding workforce are taken place in market economy, current organization environment is more receptive to worker participation through teamwork (Holden, Or, Alper, Rivera and Karsh, 2008; Kogi, 2006). Taveira (2008) pointed out that the main arguments for increased worker involvements are: improved productivity, quality, job satisfaction, organizational commitment, and better acceptance of change among others. Teamwork is related to a number of elements of a work system affecting human performance, well-being, and health. According to this author, participation of all organization elements should be considered in the following situations:

- situations related to staying ahead of change,
- to gain new sources of expertise,
- to involve all the knowledge about the subject,
- to achieve consensus in controversial matters,
- to build commitment,
- to deal with problems that no one owns by organizational assignment,
- to balance vested interests,
- to avoid hasty decisions,
- to handle conflicting views,
- to develop and educate people through their participation.

Situations such as time to discuss an identified problem, a pre-existing solution and the lack of motivation of workers, are inadequate for a teamwork approaching.

Measures of the performance of a team must consider all the aspects related to both individual per se, and integrated in a team. In this case, activities process must be described as well as strategies, responses and behaviours relevant to the human that are used to accomplish a certain task (Rothrock, 2009). Several instruments are available to assess worker activities at both individual and team level. Sequenced Actions and Latencies Index (SALI), Behavioral Observational Booklet (BOB) are related to individual measures while Anti-Air Teamwork Performance Index (ATPI) and Anti-Air Teamwork Observation Measure (ATOM) are used to evaluate team level outcomes and performance. The main disadvantages of using "team level instruments" are related to the need of expertise knowledge, possibility of an inter intra-rater bias and low reliability of the obtained ratings. Additionally, the subjective analysis provided by experts may be decoupled from the objective measures of team performance.

Relative Accuracy Index (RAI) it is another example of a methodology used to evaluate and compare team performance (Thiruvengada and Rothrock, 2007). It provides an objective assessment of process and outcomes measures and it is based on a well known situation named time windows. Time windows define objective limits on what action could be taken based on the operator environment. When the operator identifies the correct time to execute the task, then it is said that the window is opened. The actions are then measured in a six-point scale terms of execution of the task (from missing an execution or earlier execution to "on time" or late execution of the task). The main advantage of RAI use is the elimination of the inter- and intra-rater reliability presented in the aforementioned instruments. This is achieved through the study of the interactions between the between-subject variables using a generalized mixed linear statistical model (Rothrock, 2008).

In a related work, Rothrock et al. (2008) stated that "Team Measures research is a critical area that requires further exploration due to the complexity and nature of individual and team processes that affect teamwork and team outcomes.".

2.3.6. Macroergonomic methods

Macroergonomics domain is built upon socio-technical theory. Haro and Kleiner (2008), stated that macroergonomics is a "top-down socio-technical system approach to the design of work systems and the application of the overall work-system design of the human–job, human–machine, and human–software interfaces". Comparing to a microergonomic approach, it is possible to say that macroergonomics integrates organizational design and management factors into the analysis. Holden et al. (2008) pointed out that for an ergonomic systems approach to be successful, it must be integrated in management's procedures organizational changes and innovation, technology implementation, and macroergonomic redesign must be brands of a ergonomic system approach. Based on this author research, it is possible to define a systems, or holistic, approach as being the way to change considering the diversity of elements in the organization and its environment, as well as the diversity of interactions between these elements. Diversity of elements is an important issue to be considered in a system approach (Cao, Clarke, and Lehaney, 2003).

Macroergonomic main issues are the analysis, design and evaluation of work-systems. Staton et al. (2005) described several of the macroergonomic methods most commonly used. Three different groups may be identified: (1) methods adapted of well-known organizational and behavioural research methods, (2) methods adapted from micoergonomics methods and, (3) methods developed exclusively to perform a macroergonomic approach. In the first type (1) it is possible to identify, Macroergonomic Organizational Questionnaire Survey (MOQS), Interview methods, Focus groups, Laboratory experiment, Field Study and Field experiment and Participatory Ergonomics (PE). In the second type (2) for example, the cognitive walk-through method and Kansei-engineering. The first one is an usability inspection method used to identify usability problems related to product or system learn ability. It is based upon an exploratory methodology assuming the existence of schemes and mental models that can affect the way that a person uses a certain product or technology. In a narrow sense, Kansei-engineering may be defined as translating affective consumers' responses to new products into design specifications or the translation of workers responses to proposed changes in the system, into micro or macro ergonomic approaches (Staton, 2005). Finally, in the third type (3), few methods were developed exclusively to perform a macroergonomic approach presenting an overview of the organizational system. In this case, the analysis goes from the individual team or/and environment level to the working system. The analysis may be focused in just one level or considering all the system as a whole.

Staton et al. (2005) identifies two major groups of these types of macroergonomics methods: those that are addressed to the study of the relations organization/people/technology and, those who related to socio-technical systems. Take as example of the first group, the Computer-Integrated Manufacturing Organization and People (CIMOP design). This type of method is related to the implementation of technology into the organizations therefore, its application is restricted to this organizational purpose. Related to socio-technical systems analysis, several

methods can be identified: System Analysis Tool (SAT), Macroergonomics Analysis Structure (MAS) and, Macro Ergonomics Analysis and Design (MEAD). These methods are based upon the work-system analysis, being developed in the last decade (Staton et al., 2005). A briefly definition of these methods is presented hereafter.

- SAT may be described as an adaptation, elaboration and extension of the basic steps of the scientific method. It is mainly used when a strategy for making work-system changes is required.
- MAS is also considered as an macroergonomic approach where the four socio-technical systems elements (environment, personal , technological and organizational) are analysed and evaluated in terms of their importance to the overall system. According to this procedure, the design of the work-system is then determined.
- MEAD is a 10-step methodology used to evaluate and design work-systems (Hendrick and Kleiner, 2001) and it is based on socio-technical systems. Briefly a schematic vision of the 10- step methodology MEAD is presented in Figure 2.8. In this Figure, it is also possible to identify the environmental, technological, and personnel subsystems. The interrelation of these subsystems is responsible for an optimization of work conditions and ultimately, for the overall system operation.

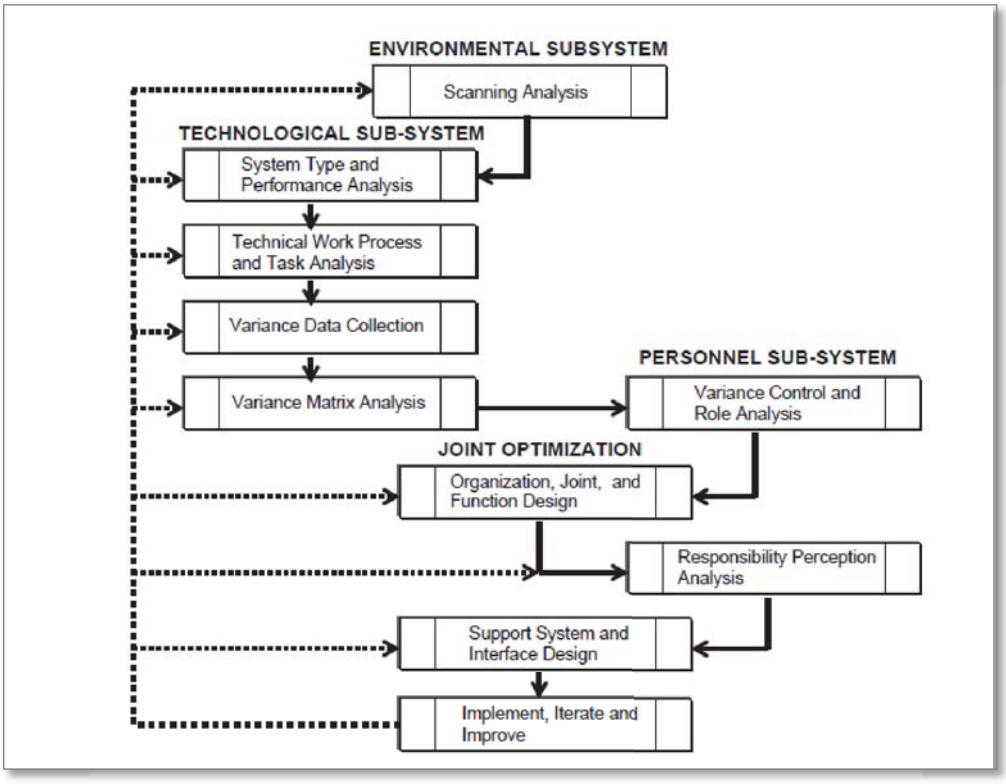


Figure 2.8. Macroergonomics Analysis and Design (MEAD): 10-step methodology (reproduced from Kleiner, 2006).

The integration of macroergonomics approaching into organizations is not easily achieved. A management oncoming to the ergonomics issues is a good strategy (corporate strategy) by promoting an empowerment of all the participants of the organization. The question is “how can

ergonomics improve quality management?", or "is quality management only focused on productivity and quality service placing the ergonomic issues in background? Considering the organizations built upon a socio-technical perspective, it seems obvious the need to use a participatory approach to provide macroergonomic integration into an organization (Zink, 2000).

According to Kogi (2006), participatory methods are increasingly used improving ergonomic aspects of work and workplaces. Several participatory methods are used to facilitating work redesign. These methods place a particular emphasis on creating initiative of people through participatory, solving workplace problems. Kogi (2006) supports that, in the process of improvement, modern ergonomics issues are related to the involvement of as many people as possible. To him, participatory ergonomics is described as ''the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals''. Cutton et al. (1988) pointed out that, ideas should be developed by both workers and managers in cooperation. The advance related to participatory approaches in workplace is dated since the mid-1980s. Organizations may use different processes to implement a participatory approach such as self-assessment of working conditions. Usually, the participatory approach requires an action-oriented training of the local people who plan and implement improvements in their own workplaces.

Kogi (2006) presents a review of several programs developed around the world that use a participatory approach:

- Training workshops for farmers applying work improvement in neighborhood development (WIND), developed in Thailand, the Philippines and Vietnam;
- Work improvement in small enterprises methodology (WISE), developed in Philippines, Thailand and Vietnam;
- Participatory action training for home workers using work improvement for home workers (WISH);
- Action training of trade union members through national trade union centres by applying participation-oriented safety improvement by trade union initiative methods (POSITIVE). This work was conducted in Bangladesh, China, Mongolia, Nepal, Pakistan, the Philippines, Thailand and Vietnam.

Methodological differences between WIND, WISE, WISH and POSITIVE methods can be identified. These differences are related to the groups for which the program is targeted (target groups), and the time it takes the program to be implemented. For example, the WISE methods are a 4–10 day course consisting of a checklist exercise, sessions on practicable improvements and group work on implementation, while WISH methods are usually 1-day workshop including home visits and group discussions on good examples and action plans. The focus target of WISE methods are the small enterprises as WISH methods targeted the contractors and home workers and it is focused on low-cost improvements.

Total Quality Management (TQM) is a participatory approach related method that is commonly used to implement macroergonomics improvements. According to Törnoström, Amprazis and Chrirmansson (2008), TQM philosophy is related to standard and improvement work. Taveira et al. (2003) stated that TQM is an approach for continuously improving the quality of goods and services delivered through the participation of individuals at all levels and functions of an organization, from top management to the shop floor. TQM is a mixture of normative assumptions, concepts, techniques and models.

Briefly, it is possible to say that it is a four phase model consisting of quality inspection, quality control, quality assurance and (Total) Quality Management. Its development is related to two different schools of thought called the Deterministic School of Thought and the Continuous Improvement School of Thought (Klefsjö, Bergquist and Edgeman, 2006). The Deterministic point of view is related to a relationship of cause and effect meaning that work improvements is based on a set of standards. The main goal of a deterministic approach is maintain the conformance with the defined standards. According to Klefsjö et al. (2006), conformance is the way to meet costumers' requirements. This school is originated in Tayloristic principles being considered as a standardizing point of view. Continuous Improvement School considered all aspects of work to reduce the impact of external or internal variables in work performance. Lillrank, Shani and Lindberg (2001), defined Continuous improvement as ''a purposeful and explicit set of principles, mechanisms, and activities within an organization adopted to generate ongoing, systematic and cumulative improvement in deliverables, operating procedures and systems''. Although different approaches are presented currently, there is a tendency for using those two perspectives in conjunction. Taveira (2003) goes further and state that "while continuous improvement is likely to promote creativity, work standardization requires adherence to established procedures and leaves little latitude for ingenuity".

The concept of TQM has dominated the management scene for some decades. Many organizations all over the world have tried to use TQM to achieve increased competitiveness and improved financial results. Some organizations have succeeded. However, many organizations also have failed because changes are required in every aspect of an organization: its workforce, its management, its structure, and its culture. In a narrow sense, it is expected that an organization (A), which uses the TQM, become a different organization (B), meaning that organizations must be prepared to deep transformations. Opposition to change may be identified as a cause for unsuccessful application of the model. It is important to considerer and integrate total customer satisfaction as a part of this model implementation. Often this issue is not used contributing to failure of the TQM implementation.

BME model, also called Ergonomic Assessment Model (free translation from Swedish) and New Public Management (NPM) are two examples of a macroergonomic approaching based on a TQM philosophy. BME model is based on a continuous improvement philosophy demanding cooperation between several hierarchies of the organization such as the engineer, safety representative and an operator on the production line. This collaboration contributes to different

kinds of knowledge and experience. It was developed by Volvo Car Corporation during 2002 and 2003 and its use allows the assessment of musculoskeletal risks in car manufacturing. It is meant to be used by ergonomics experts. Törnström et al. (2008) describes the BME Model as containing both criteria and limits for posture, force requirements, and frequency. Ergonomics experts and experienced operator analyze the work situation using a defined protocol which includes measurements of posture (back, neck, shoulder, elbow, hand/fingers, hip joint, knee and ankle), force (measurements in kilos and Newtons) and frequency (a table is used to identify the number of repetitions for dynamic work or the time in seconds for static work). Results are expressed in terms of risk values. The final classification is based upon a cube model that calculates a risk value for each assessed task for each car model, each work task and for each balance. A computer program was developed to facilitate this task. According to Törnström et al. (2008) research, based on BME model application on Volvo Car Corporation, an improvement participation and collaboration among stakeholders was achieved providing a more effective ergonomic improvement process. Results also allowed the identification of the weaknesses of the method. Briefly, the model was found to be rather a resourceful demand and dependent on support from management and unions.

New public management (NPM) is used to improving service quality and a more efficient and effective service production into the public sector. KorunKa et al. (2007) identified the citizens as customers (clients) of the administration, therefore, it is important to use them to redesign public administration. Indeed, several published papers show that costumer orientation is an important issue to measure service quality. Using costumers' orientation has been all over the years neglected from macroergonomic perspective in both private and public sectors.

The main purpose of NPM is to study customer orientation among employees. By studying the factors that can affect costumer orientation, such as, job and organizational work, it is possible to contribute to the successful implementation of ergonomic measures. Customer orientation is characterized by bilateral relationship between the costumer and the organization, being restricted to individual customers' expectations and needs. According to Bruhn (1999) (as cited by Korunka, 2007), customer orientation is based on three perspectives namely, (1) costumer expectations, (2) company philosophy, and (3) quality of services provided. Customer orientation may be related to company's ability to collect relevant information about their expectations. This is dependent on company's concerns and priorities to meet customer expectations. This is called "information-based interpretation".

In a wider sense, general corporate philosophy, such as values, norms and convictions may also have a contribution to customer orientation definition. This is called a "culture and philosophy-based interpretation". Korunka (2007) goes further stating that "customer orientation is part of corporate culture and characterizes not only the company's opinions but also its employees' behaviour in dealing with customers.".

Quality of the services is considered the last form of customer orientation. This is a service and interaction-based customer orientation that considers the customers' perspective while information-based interpretation and culture and philosophy-based interpretation address customer orientation from the standpoint of the organization. These different, although related, levels of costumer orientation are presented on Figure 2.9.

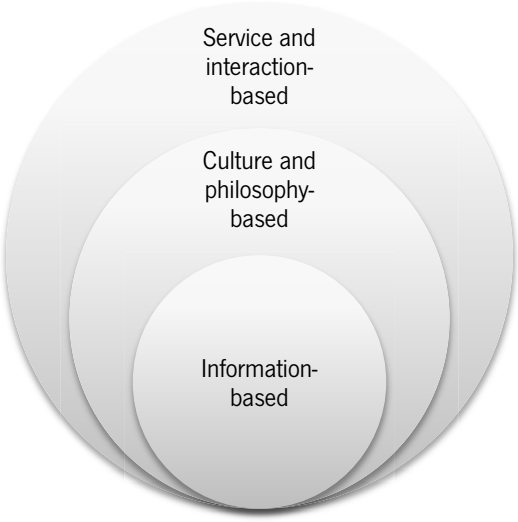


Figure 2.9. Levels of customers (clients) orientation.

Customer orientation may be responsible for internal and external changes in organizations services and interactions. It may be affected by institutional procedures or it may be employee-related. In the case of employee-related, costumer orientations seems to be related to the employee's ability to meet customer expectations.

Various predictors of customer orientation are presented in Table 2.8.

Table 2.8. Predictors of customer orientation.

Structural factors	**Climate of change**	**Transfer climate**
Leadership style	Stress	Workload
Teamwork quality	Resistance to change	Management
	Role conflicts	Colleagues and corporate policy

These predictors may have influence on quality of working life, affecting the overall employee satisfaction, the relation employee/costumer and consequently the customer orientation. Because of the increasing importance of customer orientation, studies in this area have been carried out in a variety of fields by developing models and scales to measure the perceived customer orientation. An example of that are the longitudinal studies carried out in Austria and in the US developed by Korunka et al. (2007), in which a short scale to measure perceived customer orientation was developed to analyze customer orientation resulting from the introduction of NPM. Predictors of customer orientation were identified as affecting the organizational environment and the quality of the employees' working life in a positive manner.

Results may indicate the importance of the customer orientation on the organizations structure contributing to its success.

As clients are intrinsically linked to the organizations, the Total Quality Management philosophy must be focused not only in the satisfaction of the workforce, but also in clients' expectations and satisfaction. Processes of improvement are often multidimensional (considering all the organizational participants), cross and serially correlated (Jarrett and Pan, 2007). That is, quality of goods and services are improved through the participation of individuals at all organization levels (Taveira et al., 2003). In fact, Robertson et al. (2008) proposed that enhancing workers' control over their work environment allows them to influence decisions about where and how they might lead to improved physical health and performance. They also refer that teamwork is a fundamental mean by which corporations conduct organizational activities and meet business goals in a global economy.

Clients' interrelation with professionals may be a consequence of Meso and Macro actions. In fact, on the one hand organisations may define the clients/professionals interrelation and on the other hand this may be a confidence based personal relation. As previously mentioned, it is not new the involvement of clients within the ergonomic issues. Take for example, the design of consumer products. Ease-of-use of a product, the so-called usability of a device, is increasingly important, as consumers become less tolerant with poor design and devices become, potentially, more complex to operate. It is obvious that in this subject, client benefits from early intervention of ergonomics, as well as the company. Everyone would like well-designed consumer products, designers, manufacturers, and consumers.

According to Dul et al. (2012), HFE main issue is an oriented and purposefully design of systems consisting of interactions between people, products and environments. These interactions must be studied not only to design artefacts but also, to design a more diffuse, complex and multi-faceted interacting system. A contemporary vision of the main focus for HFE, by saying that any work activity is as part of a supply chain, in which each element is both a supplier and a customer for other elements is also presented. In such system, interactions and the total network, rather than the entities, should be considered into analysis. That is, ergonomists work must not be focused on a drawing of an activity or product, but in the set of interrelationships, which allow to achieve the organization main goal.

The real contribution from ergonomics is related to the understanding of the human role as the key-element in interacting systems. In this way, an ergonomic analysis may be made on specific aspects of human being in specific context and considering various system levels. The traditional task analysis formulated in terms of a sequence of actions on the work objects and focused on normative work procedures, has been replaced by a more cross-disciplinary approach. This type of analysis recognises that worker has strategies, behind organization roles and structure, not always visible, which are used to achieve personal goals. So, a focus proactive system design is required. Indeed, successful organization-level change requires a holistic, systems approach. All

levels of the system including macro-level elements such as culture, management, and the environment, as well as to the interaction-rich system as a whole. In the future of ergonomics, it is important to define a balance between the applied ergonomics which is problem-oriented, and the academic ergonomics which is discipline-oriented.

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PART II

Developed Work

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Chapter 3. Research Approach

One of the main goals of an ergonomic approach is to define the work situation. Usually, an analysis based on the evaluations of the analyst and professionals (workers) is used. It is considered that professionals' evaluation is a subjective analysis. In fact, as Human Being is a bad estimator of itself, this evaluation may not match the vision of real work life. Therefore, they may overestimate or underestimate the evaluation according to their personal needs. In areas where professionals and clients circulate simultaneously, clients' opinion may be used to correct these deviations resulting in a more objective analysis. Research shows that ergonomics internal change agents can be more effective if all the organization levels are empowered (Pascale, 2010). This issue requires a more business-oriented ergonomics approaching (Dul and Neumann, 2009). Dul and Newman (2009) state that, by contributing to strategical goals of business performance, ergonomists will also be able to reach the ergonomics traditional objectives of well-being, health and safety. This line of research is an evolution of the traditional ergonomic occupational analysis evolving all the system participants. In order to achieve this issue, a system approach is then necessary (see chapter 2). Following this line of thought, workplaces must be analyzed as an integrated part of a complex and dynamic socio-technical system where all the participants should be well identified, as well as the interrelations of which they are a part of.

3.1.Research Problem

In modern society, the ergonomic contexts' differentiation is the result of a market customization where clients are becoming intrinsically linked to the organizations. The advances in the Market trade economy is characterized by a transformation in the behavior of clients that is, in the traditional business clients assume a passive behavior in the product transaction, being the employee that executes all the tasks related with it. Nowadays, most of the traditional commercial activities are replaced by common areas. These areas may be defined as a single area of products and services supply, characterized by large open spaces where professionals and clients share the same space and have different interactions. Client's interactions are related not only to professionals but also to other levels of the socio-technical system such as: organization levels, manager level, technological level and governmental level. If clients have some sort of influence on the layout or work organization, then it is implicit that they ought to be involved on ergonomic issues.

The ergonomic analysis described in literature present some limitations when applied in these commercial areas. The main limitation s that those methods are subjective analysis based only in analyst and professionals evaluations and just focused on occupational environments.

The development of new ergonomic approaches is required. These should allow a more detailed analysis of the real activities of individuals, by considering common areas with free circulation of people not only in an occupational perspective, but also from a usability point of view. In these common areas, human well-being is related to its users, both clients and professionals. Effectively, clients and professionals that circulate freely and interrelate on these areas may equally be exposed to the same ergonomic risk factors. As a consequence of this interaction, clients may equally be exposed to the same occupational ergonomic risk factors already identified for professionals. Several examples may be cited: sharing the same space and doing the same "task" as professionals do, for example, reaching products from the shelves; clients can be also exposed to musculoskeletal injuries. Considering this, it is possible to define a few relevant questions, such as: "What is the impact of this exposure on the health and well-being of the clients?"; "Will it be valid to measure this risk?"; "Will it be valid to use clients as a vector in the ergonomic analysis?"

Therefore, it is important to study and characterize, not only the situation and working conditions related to these areas (occupational goal), but also from the clients comfort and wellbeing perspective, as well as professionals attendance on the area (usability goal). In these situations, ergonomic approaching must also recognise that clients are an active part of the ergonomic context.

In general terms, it is proposed a further study of this dynamical and complex ergonomic context were several participants may be identified. The following research questions are the starting point to understand the mechanisms that regulate this type of work systems:

- What should be the contribution of each of the participants, analysts, professional and clients, to the ergonomic analysis of common areas with free circulation of people?
- What is the meaning of the relationships between analyst/professionals/clients/manager on the ergonomic analysis and intervention?
- Are the results of the analyst/professionals/clients ergonomic analysis independent of the socio-economic sector?
- Are the results of the relationship analyst/clients significantly different from the analyst professional?

3.2.Conceptualization: From the Binomial to Trinomial Analysis

In a narrower sense, it is possible to say that an ergonomic approach aims to characterize the working areas, by identifying risk factors, establishing priorities list for intervention, making changes proposals, and giving the diagnosis of studied conditions (Stanton, Hedge, Brookhuis, Salas and Hendrick, 2005).

In order to provide an effective system approach in terms of ergonomic analysis, it is important to characterize the ergonomic context. This can be made by:

- describing the workers activities and the work organization;
- identifying the system participants and;
- defining the importance of the relations between the different levels of the system.

By studying and understanding the real work activities, it is possible to see clients influence on many aspects of the worker performance. Considering a system approach, clients may interact directly with the personal subsystem, may have influence on the environment subsystem and, in a certain way, they command the organizational subsystem strategies. The strategies defined by managers will certainly have influence on workers' activities. Clients, consumers, patients, students, must be integrated in a system approach not only from an organization management perspective but also as being a part of the system per se.

Taking this into consideration, organizations must have both social and economical goals to achieve the optimization of the performance of the overall system. Being clients, consumers, patients, students, considered as an important part of the overall system, it is important to study its influence in the proposed actions to improve the quality of the system per se.

This integration of the clients in a system approach constitutes a challenge to the ergonomic domain (see chapter 2). Considering that an ergonomic approach is required to be performed on a certain area where professionals' activities are related with clients or consumers' service provide or products sales, the human well-being (social goal) is related to its users, both clients and professionals. Therefore, it is important to study and characterize not only the situation and working conditions in these areas, but also in the areas where clients freely circulate, in

accordance to the minimum of comfort and well-being. In these situations, the considered ergonomic approach must also recognise that clients are an active part of the ergonomic context.

In conclusion, it is possible to say that the binomial constituted by the dimension of the ergonomist (analyst) and employee gives place to the trinomial composed by the dimensions of the professional, analyst and clients (Loureiro, Leão and Arezes, 2010) (Figure 3.1).

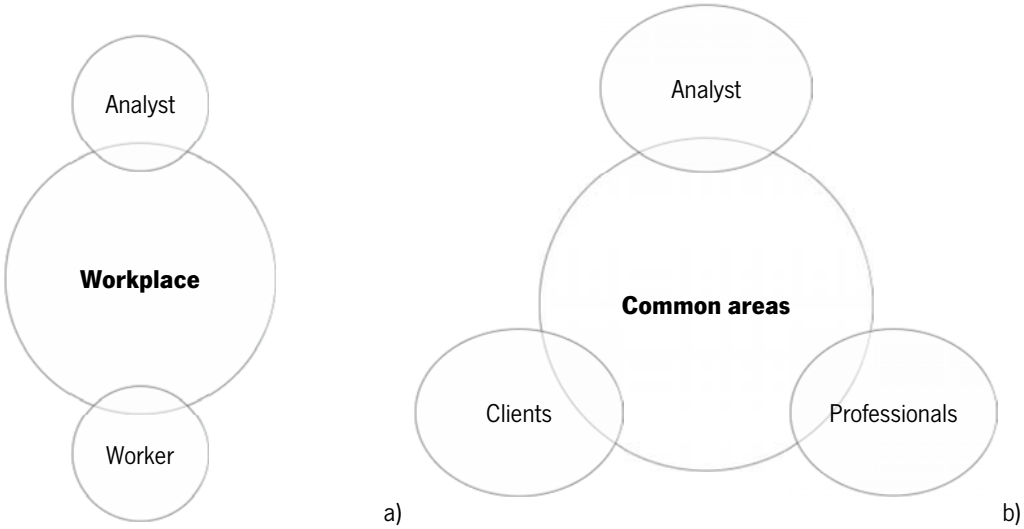

Figure 3.1. Binomial (a) versus Trinomial (b) ergonomic approach.

A tri-dimensional analysis named Ergonomic Tri-dimensional Analysis (ETdA) is proposed.

According to Loureiro (2008), the development of the ETdA model was based on a hypothetical-deductive interpretation. Medawar (1964) stated that "hypotheses are what one deduces from" and that hypothetical-deductive process is a strictly logical and rigorous process based upon deductive arguments. This is based on an idea or thought, then concepts are developed, dimensions to the use of the analysis are identified, indicators which represent the measurable part of the model are identified and selected. At the end, data is collected in order to test the hypothesis and validate the model framework (Figure 3.2) (Deshaies, 1997).

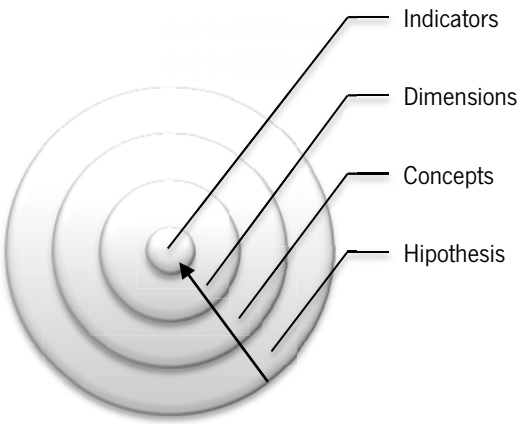

Figure 3.2. Hypothetical-deductive process.

3.3. Research Goals

In the development of this thesis, two main goals were identified. In the theoretical field and following a system approach, it is the evidence that the client should be included on ergonomic analysis. In practical terms, it is the development of a tool that allows the ergonomic analysis of areas with free circulation of people (professionals and clients), helping the analyst in the decision-making to ergonomic intervention, ETdA (Ergonomic Tridimensional Analysis). This is a tri-dimensional approach since the evaluation of the ergonomic context is done under three dimensions: user population of the area, clients and professionals, and the analyst (ergonomist).

To accomplish the proposed main goals, several steps can be identified:

- Definition of the socio-technical system' participants that should be considered into the analysis: ETdA dimensions;
- Definition of the variables that will be analyzed;
- Adaptation of the observation tools used by the Analyst and professional from the EWA methodology: Ergonomic checklist and Evaluation form;
- Development and validation of the observation tool in clients dimension: ETdA questionnaire;
- Identification of the system level relationships that can have influence on the ETdA implementation;
- Simplification and summarization of the ETdA dimensions results through a weighting table matrix, helping the Analyst in the decision making for ergonomic intervention;
- Development and validation a computer software to be used as a support tool in the ergonomic analysis.

A full description of these steps will be presented in the following Chapter.

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Chapter 4. Methodology

According to Deshaies (1997), an investigation is by definition something that is required. It is a way to solve deviations and uncertainties. Wilson (2000) supports the idea that, using an ergonomic context of real settings, facilitates the establishment of a bridge between theory and practice. Therefore, by testing the conceptualization of the model in a real-life ergonomic context it is possible to verify the ETdA operability. Trough the results of the ETdA observation tools it is possible to test the research questions allowing the validation of the model.

4.1.Introduction

In order to develop a tridimensional approach and perform an ergonomic analysis in common areas with free circulation of people, a development of a case study is presented on the following sections.

The main objectives of this case study were:

- To develop and test the Ergonomic Tridimensional Analysis, ETdA, in a real-life situation and,
- To answer the research questions presented on Chapter 3 using database collected through the ETdA application on a given ergonomic context.

This research method was conducted according to Quivy and Campenhoudt (2008) methodology. The steps of the procedure were adapted to this research field and are described as follows (Figure 4. 1).

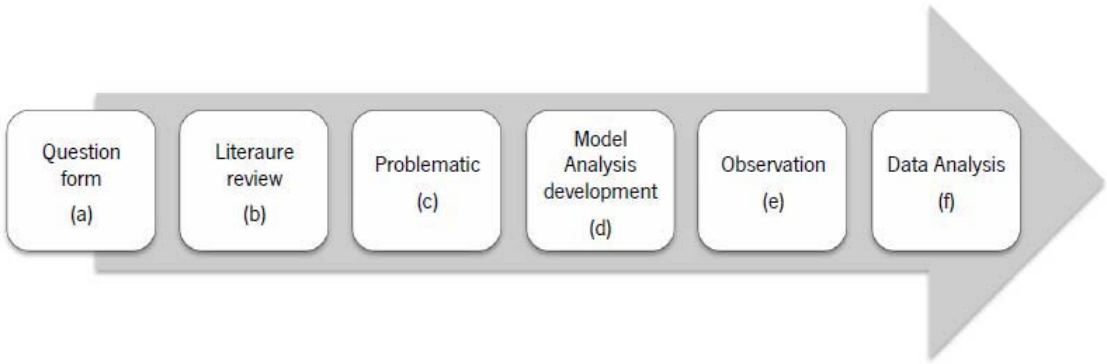

Figure 4.1. Research methodology steps.

To establish a guiding principle for the study, a starting point was defined and named Question form ((a) in Figure 4.1). The question is:

> "What is the role of Clients, as an integrated part in the system, in the ergonomic analysis performed in common areas (areas designed for Clients and Professionals)?"

From Chapter 2, Literature review ((b) in Figure 4.1), it is suggested that:

- organizations come to be seen as a socio-technical systems;
- quality management philosophy must be focused not only in workforce satisfaction, but also in Clients' expectations satisfaction and wellbeing;
- processes of improvement must be multidimensional that is, considering all the organizational participants;
- macroergonomic approaches must recognise that customer, client or user is an active part of the ergonomic context.

The recognition of the public engagement on ergonomic issues becomes a challenge to ergonomics, being compulsory to understand the importance and the role of this new dimension on a system approach. Therefore, ergonomics challenges must be focused on the study of the interrelations that comprises all system levels. From literature review (see Chapter 2), different approaches were presented allowing the integration of the problem in a theoretical framework, leading to a fundamental resolution. Usually, the main focuses of the occupational ergonomic methodologies are the workers' performance and wellbeing. But that is not always the case, for example, in situations where design of interfaces or highly specific equipments and tools, are studied. In these situations, the main target of researchers is the product usability. Several ergonomic contexts can be identified where Clients and Professionals interrelate. Most of the times, these ergonomic contexts are designed for clients' attendance and not for Professionals to develop their activities. Is this case, Client's point of view, as an integrating part of the system, is not considered on the ergonomic analysis, as primarily they are focused on the professional environment (occupational ergonomic analysis).

The problematic ((c) in Figure 4.1) of a tridimensional ergonomic approach is reflected in a cycle in which the assumptions together with the evaluation of the indicators to be used in the ergonomic analysis (Loureiro, Leão and Arezes, 2009) allow the operability of the proposed model (Figure 4.2).

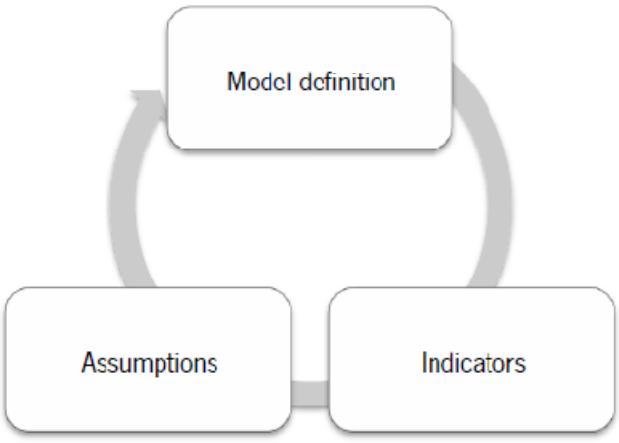

Figure 4.2. Ergonomic Tridimensional Analysis problematic.

According to Loureiro (2008), three assumptions were considered to develop an ergonomic approach based on a tridimensional perspective: (1) Clients are considered as system integrated part, (2) Clients and Professionals circulate in common area and, (3) the ergonomic intervention is a result of the participation of all system levels.

In order to develop a tridimensional approach, the identification of the indicators to be used in the analysis was required. This contributed to assess risk situations and, consequently, to implement processes of improvements. In the limit, these indicators can be used by Managers,

to establish criteria for quality of service and information provided to Clients. These indicators can be divided into two major groups: ergonomic factors (EFs) and Clients operationally characteristics. The EFs that allow the ETdA operability are intrinsically (individual ergonomic factors) or extrinsically linked to Professionals. In this case, they are divided in environmental or occupational EFs. If they are inserted in the organizational schemes of the social-technical systems they will be occupational, otherwise, environmental, when related to the physical aspects of the work (Table 4.1).

Table 4.1. ETdA ergonomic factors.

Environmental	Occupational	Individual
Noise	Professional training quality	Postures
Illumination	Decision making	General physical activity
Thermal environment	Restrictiveness	Communication/inter-relation
Risk of accident	Job content	Attentiveness
	Work space or common area	

Operational characteristics are related to a group of Clients' characteristics that may have influence on the ergonomic analysis, namely age and gender, professional occupation, education level or the knowledge about ergonomics.

The development of an ergonomic tridimensional analysis, should take into consideration the assumptions and the indicators, above mentioned ((d) in Figure 4.1).

At this point, in order to bring the theoretical assumptions to a real-life context, the identification of the cases used on this study was required. Even though the criteria for case selection were related to the above mentioned assumptions, other factors were also considered, namely, location, availability, contact and accessibility. Institutional contacts were established with several companies and as result, three commercial areas were selected to perform this research study. These areas presented an open space where a wide variety of products are displayed. Each commercial area presented different ergonomic contexts where specific Professionals' activities were developed. In these ergonomic contexts, Clients could circulate freely contacting with Professionals when required. These areas were identified with a short name, CAFCP, meaning commercial areas with free circulation of people (Table 4.2).

Table 4.2. Short name of the commercial areas.

Commercial area	Short name
Entertainment retail chain	CAFCP 01
Wholesale retailer	CAFCP 02
Sports store	CAFCP 03

These commercial areas worked under a franchise concept. This could be defined as a method of collaboration between a major company, the Master, and several minor companies, the franchise. This marketing concept was represented by three main elements: the right to use a brand and its identity, a shared experience or know-how and, a set of products, services and technologies (http://www.apfranchise.org). The Master defined the type of furniture and lay-out,

products selection, and the work organization, which could be applied in all stores belonging to the group. This marketing strategy, in some way, implied rethinking the occupational issues on the ergonomics. For that reason, it was important to study and characterize not only the situation and working conditions in these commercial areas, but also the areas where Clients freely circulate, in accordance with the minimum of comfort and wellbeing.

A brief description of the areas is presented below.

The CAFCP 01 was related to an international entertainment retail chain founded in France. The store offered cultural and electronic products, from Audio, Books, CDs, Computer software and hardware, DVDs, Televisions and Video games. Some of the stores also presented services of photography and ticket sales. The company also offered a wide selection of higher-end consumer products positioning themselves above discount retailers. The CAFCP 02 was related to a Dutch cash-and-carry chain. Cash-and-carry is an important retailing sector in market. This kind of business is characterized by large open spaces where different sections with food and non-food services could be identified. The CAFCP 03 was related to one of the largest chains of sports shops in Portugal. By starting its international expansion on May 2008, this commercial area took a step forward. In this commercial area, a wide variety of products related to different sports, could be identified. Comparing the target market of the commercial areas, some differences were identified: Clients' population of the CAFCP 01 and CAFCP 03 were undefined covering a wide range of Clients, from unemployed persons to students. In opposition, the market target of the CAFCP 02 was very well defined and identified. It could be business owners, self-employed professionals, freelancers or institutions.

A change in the store' management of the CAFCP 03 happened throughout the implementation of the methodology. The new Manager commitment with this research project was inexistent. Therefore, it was not possible to perform data collection for analysis during the period intended for that purpose. In order to uncompromise the success of the ETdA development, this area was excluded from the study.

In the step of observation ((e), Figure 4.1) the model analysis and hypotheses were confronted to the real-life context. To make this possible, a correct definition of the observation tools for each ETdA dimension (Analyst, Professionals and Clients) was done. The implementation of the observation tools has allowed the construction of a database, important not only for the definition of the ETdA model but also to the final ergonomic intervention decision. A set of statistical techniques were used to do data analysis helping in decision making ((f), Figure 4.1). In this step the obtained results were also used to answer the research questions (see Chapter 3).

Taking into consideration the proposed research methodology, the present work was conducted based on four stages as illustrated in Figure 4.3.

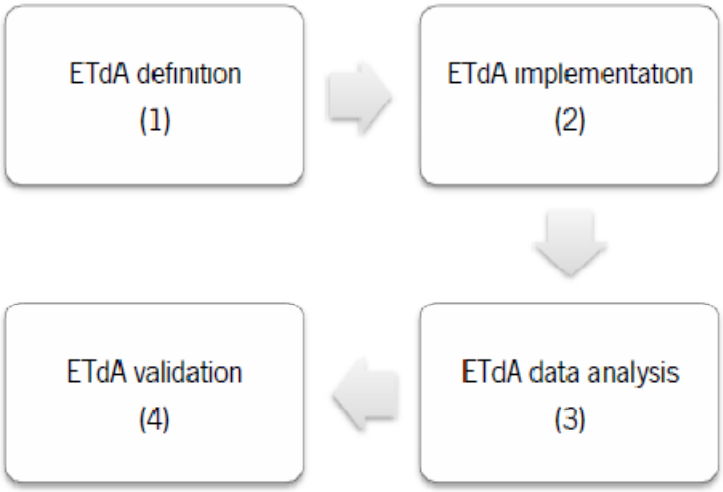

Figure 4.3. Main stages for the ETdA methodology definition.

The first stage, the ETdA definition, was related to the identification of the ETdA dimensions and development of the correspondent ETdA observation tools. At this stage, the definition of the ETdA variables (indicators) was also performed.

The second stage, the ETdA implementation, was related to data collection in the field. ETdA planning is an important step to normalize the data collection.

The third stage, ETdA data analysis, was related to data analysis of the ETdA observation tools results.

Finally, at the last stage, ETdA validation, by weighting the dimension results, Clients' impact on the ergonomic intervention was checked as well as research questions presented on Chapter 3 were answered.

The ETdA Methodology General Guidelines will be presented in order to perform the ergonomic analysis in common areas with free circulation of people.

In order to help the Analyst in the implementation of the ETdA model in common areas, a software was developed. It is important to note that software design occurred simultaneously with ETdA development. For this reason, the software was considered to be a product (result) of the ETdA development and not an input to ETdA development. A description of this software development is presented in the Chapter 5 (Results and Discussion).

4.2.ETdA Definition

As above mentioned, ETdA development was based upon a system approach. Therefore, the identification of system participants and their interrelations was an important issue to consider. In the following sections, system participants are identified as well the observation tools used to

collected data upon a tridimensional perspective. The variables that were used in the study were also defined.

4.2.1. ETdA dimensions and interrelations

In this type of business context, commercial areas, the participants of the systems were identified as Clients, Professionals and in an implicit way, the business Manager. Obviously, that Analyst was also considered, since he/she was the one who was responsible for the ETdA implementation. However, it is not expected any interference with the normal operation system. Taking into account that Clients are assuming a growing role in the business context (market customization), organizations strategies are focused in the identification of their needs and expectations. In fact, it was assumed that Clients can have influence on the different levels of the socio-technical system. Figure 4.4 illustrates the idea of a system where Clients can be the main focus (centre) of an organization.

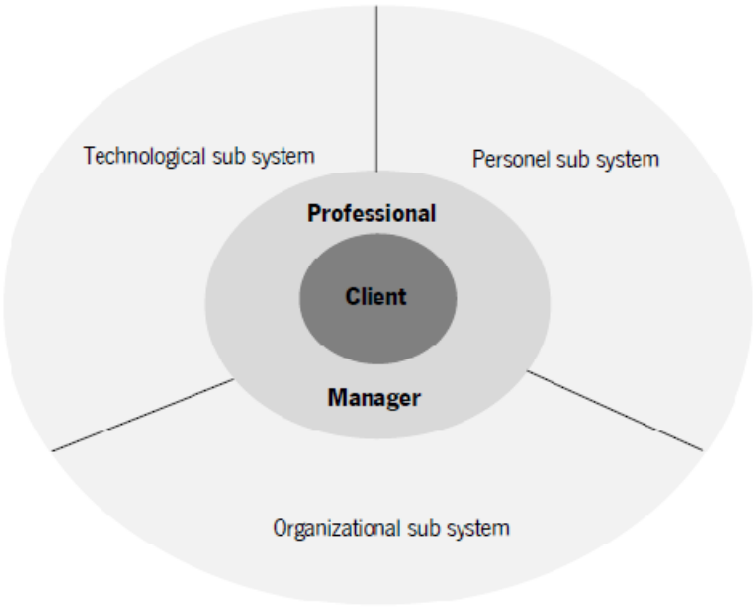

Figure 4.4. Clients as the main focus (centre) of an organization.

In this approach of organizations as system, it was fundamental to understand people interactions and related mechanisms of regulation, as they could be responsible for maintaining the system balance. A balanced system means that economic goals, as well as social goals, were achieved. By improving those interactions, client quality service could also be enhanced, contributing for the total system performance (Loureiro, Leão and Arezes, 2010a). The interrelations identified that were considered in this system approach were: Analyst/Professionals (AP), Analyst/Clients (AC), Clients/Professionals (CP) (Figure 4.5).

In economics terms, the existence of a CP relationship has become very important to the organizations, since its success contributes to increasing the organization' profits. This

relationship could be defined as bilateral since it based on a trust relation, depending on professional skills, professional training, empathy and mutual understanding.

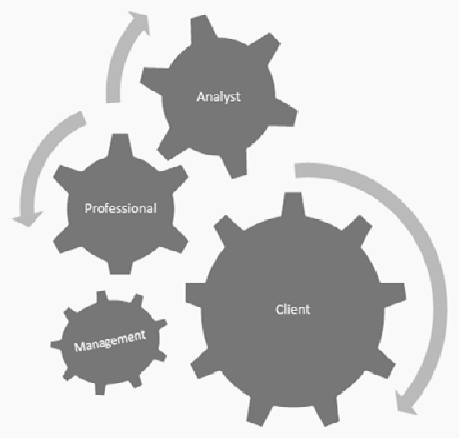

Figure 4.5. Interrelation mechanism.

Usually, AP relationship has been surveyed in occupational ergonomic analysis. Taking this into count, the main focus of the Analyst has been the workplace environments. Research on this subject, revealed that, subjective Professionals' assessments, training and experience of the Analyst could contribute to a more effective analysis. In fact, Analyst lack of knowledge and experience can lead to a less effective ergonomic analysis, mainly if complex methods that require specific equipment were used.

The AC relationship was identified as unilateral, since no interaction (contact) between Analyst and Clients was defined. It was important to emphasize that as result of an ergonomic analysis, Clients as well as Professionals, could benefit from the improvements made in common areas.

Different connections between the Manager and the three dimensions were identified. Most of the times, the interaction between Managers and Professionals had to do with solving problems concerning certain aspects of the work, in terms of social, environment, physic or psychological, issues, that could influence Professionals' performance. As it was mentioned on Chapter 2, top management strategies have been developed in horizontal collaboration stretching the organization hierarchies. This issue largely contributed to Managers' oncoming to Clients. As companies are under pressure to remain competitive, Managers targeted their actions on Clients' demands and wellbeing. Therefore, Managers/Clients interrelation could be used as an advantage, to ergonomic strategies for the design of effective interventions. That is, if the Analyst identified a critical situation where Clients and Professionals could be engaged, in terms of ergonomic risk, it was expected from the Managers, just because Clients were a part of the identified problem, a better commitment on solving the problem. Therefore, it is expected that improvements proposed by the Analyst will be more effective if Clients' wellbeing, health and safety are referred to the Manager. It is also expected that the relation Clients/Manager/Analyst creates co-responsibility in the changes to be implemented.

4.2.2. ETdA observation tools

Observation tools can be defined as a set of tools used to perform the data collection. In the ETdA model, different observation tools were used: a questionnaire, an evaluation form and direct and indirect observations (ergonomic checklist) for Clients, Professionals and Analyst dimensions (Table 4.3).

Table 4.3. ETdA observation tools.

Dimension	Observation tool
Clients	Questionnaire
Professionals	Evaluation forms
Analyst	Direct and indirect observation

Professionals and Analyst observation tools were defined as in the Ergonomic Workplace Analysis, EWA (Ahoen et al., 1999), and were correctly adapted to be applied in ETdA model. EWA methodology allows a systematic and careful description of the task or workplace and has been planned to serve as a tool to help the Analyst to form a foundation of the work situation. According to Hakkarainen, Ketola, and Nevala (2011), EWA is suitable for observing the ergonomics of sedentary, standing and physically active work. Due to its simplicity, its guidelines were used to help the Analyst and Professionals in the ergonomic factors' assessments. To complete the tridimensional analysis, a questionnaire was developed and validated for Clients' dimension.

4.2.2.1. Analyst dimension: ergonomic check list

Direct (directly in real work conditions with particular attention to the interrelations AP an CP) and indirect (video recordings or photographic material) observations, "auto-confrontation" interviews (Mollo and Falzon, 2004) with supervisors, professionals and safety staff, and simple measure devices, were used by the Analyst, providing the necessary information to characterize certain aspects of professionals activities and the way they interrelate with Clients. Reliable background data, available from the records of the organization were also collected. In order to help the ergonomic factors evaluation, Analyst used the EWA guidelines (Ahoen et al., 1989).

Through a general checklist with criteria for ergonomic evaluation, the Analyst rated the ergonomic factors using a 4-point scale representing health risks (Annex 1). A rating of (1) indicated a negative evaluation representing a critical situation with no health risk to the user population of the common area; (2) represented an acceptable situation but with suggestions to be implemented and, (3) was related to a positive evaluation with not relevant risk. At this point, it was important to mention that not only the workplace was under analysis but also Clients' attendance in the area. If a situation representing health risk to Clients or Professionals were identified, the Analyst should immediately reported it to the Manager, and work should not continue, until that situation was properly evaluated.

Analyst defined the area for analysis according to work organization. In order to achieve this issue, a general description of CP interaction was also done. Potential risk situations to Clients were identified and evaluated. Two situations were identified:

- If Professionals' activities were developed across the common area then the ergonomic analysis should be performed according to the Professionals' activities that provide a CP interaction. Examples illustrated in Figure 4.6 colour this idea. As it is possible to see, Professionals' activities, identified as PA1 and PA2 are developed across the common area providing a CP interaction in several points within the area. In this case, the analysis must be done considering Professionals' activities and CP interaction (Figure 4.6a);
- If Professionals' activities were developed in a particular area and the interaction CP is limited to that area then common area should be divided into sections. In this case, Analyst must ensure that a proper identification of the Professionals' activity was done (Figure 4.6b).

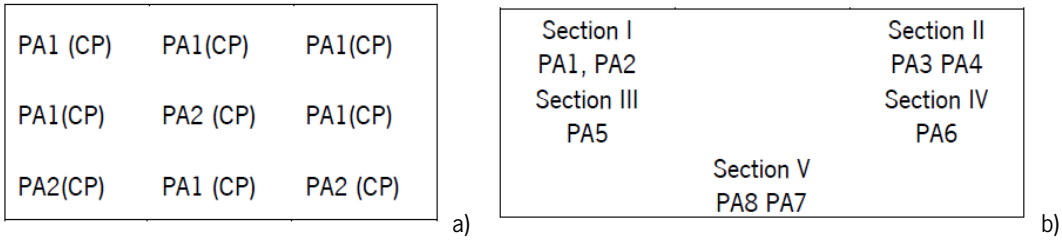

Figure 4.6. Definition of the analysis according to a) common area or b) Professionals' activities.

4.2.2.2. Professionals dimension: evaluation form

Professionals used the evaluation forms to carry out the assessments of the commercial area. The Professionals' evaluation form used in this case study is presented on Annex 2. As it is possible to observe, a code identification of the activity was placed in the front page of the evaluation form. The main purpose of this code was to identify the section were the Professionals developed their activities. This way, the Analyst could associate if necessary a critical situation to the Professionals activities.

The form was a simple sheet on which Professionals marked his/her evaluation of the EFs as very poor (- -), poor (-), fair (+), or good (++). Following the Hakkaraine et al. (2010) recommendations, a place in the evaluation form was provided, allowing Professionals to identify the critical situations related to the common area.

4.2.2.3. Clients' dimension: ETdA questionnaire

A questionnaire was the observation tool used to collect data from Clients' dimension. Three main steps were identified in the drawing up of the first version of the ETdA questionnaire: (1) development, (2) pretest and, (3) validation. This version was developed and pretested in the framework of the Master thesis (Loureiro, 2008) (Annex 3). Although the validation of the ETdA

questionnaire did not present a new statistical methodology, in order for it to be used accurately, and in the framework of the present thesis, this step was essential.

(1) ETdA questionnaire development

Deshaeis (1997) considered that, the only reliable way to measure the extent of Clients' perception in relation to a particular issue was using a technique of direct observation. This technique should also be an extensive one. That is, focused on large groups such as clients, costumers, users, among others. Thus, it was possible to infer the results more accurately.

This type of tool is defined as a direct administration tool, which presents, as main advantage, the possibility to quantify a variety of data and consequent establishment of multiple correlations.

Previously to the development of the ETdA questionnaire, objectives to be achieved were defined. ETdA questionnaire should allow, in one hand, the socio demographic characterization of the Clients dimension and, in other hand, the assessments of the ergonomic factors. It is expected from the ETdA questionnaire results, the identification of the reasons that might affect Clients' wellbeing.

The ETdA questionnaire was divided in three major parts: (1) Clients' characterization, (2) Clients' ergonomic evaluation, and (3) open question (Hill and Hill, 2008).

In the first part, two groups of questions were identified:

. Questions clients (Qc),
. Questions clients/store (Qcs).

The first one, Qc questions, was related to Clients' socio-demographic characteristics. Variables such gender, age, qualifications and professional activity were used. In order to contextualize Clients on the ergonomic analysis, they were asked about their knowledge on ergonomics. The Qcs questions were related to service quality and reasons why Clients' choose the establishment for shopping. Service quality was accessed through a set of multiple questions related to professionals' kindness, cost/quality ratio and hospitality.

The second part consisted on the evaluation of Clients' perceptions regarding the ergonomic factors. This evaluation was done through a set of ergonomic questions named clients' ergonomic questions (Qe questions). This group of questions included noise, lighting quality, thermal environmental and accident risk EFs. The service balcony dimension and the height of the shelves were used as indicators for the evaluation of Clients' postures and movements. The restrictiveness was also accessed through a question that evaluates the software efficiency when a Clients/Professionals interrelation is implicated. The existence of a question where Clients must evaluate the general appearance of the establishment, intended to focus their attention on

the commercial area. This question is named a filter question. Clients were also asked to express their opinion about the quality of the professional training and the physical effort regarding the Professionals activities. The group of questions used in the ETdA questionnaire, are presented in Table 4.4.

Table 4.4. Type of questions used on ETdA questionnaire.

Question	Description
Questions client (Clients characterization)	Age
	Gender
	Profession
	Education level
Questions clients/store	Reason for choosing the store
	Regularity
	Visited sections-
	Quality/price ratio
Clients' ergonomic questions	Postures and movements
	Lightning quality
	Lifting
	Noise problem
	General physical activity
	Restrictiveness
	Decision making
	General opinion about the commercial area
	Accident risk
	Thermal environment
	Work communication and personal contact

The evaluation of the ergonomic factors was done using a three to five-level scale (frequency, probability and opinion scales) (Loureiro, 2008).

In the third part it was set an open-ended question where Clients express their general opinion about the commercial area. Respondents could declare in their own words, what could be improved in the service provided. This issue is very importance for total quality management strategies as results can indicate if the establishment strategy is in line with Clients' expectations.

It is expected that although the first version of the questionnaire was developed in the health sector, its use can be generalized. Probably, an adaptation to each type of business may be necessary. For instance, an adjustment of the areas' specifically terminology might be required. By Managers, Analyst or Professionals' suggestions, questions relevant to the analysis could also be included. For instance, Managers may have wanted to use this questionnaire to do a further study concerning Clients' complaints about the area.

(2) ETdA questionnaire pre-test

According to Khalid and Helander (2004) a questionnaire must be previously tested in order to be used in a survey. Pre-test is an important step as it allows seeing the questions'

appropriateness and whether the questions are correctly interpreted by the respondents (Hill and Hill, 2008). This step was developed in the framework of a Master thesis (Loureiro, 2008). Results of the pre-test allowed the development of a final version of the ETdA questionnaire presented in Annex 3. This version was used as the starting point for the final version of ETdA questionnaire used in this study case.

(3) ETdA questionnaire validation

Dzissah et al. (2005) refer that a reliable survey questionnaire should be consistent in its successful measurements of a given phenomenon. The ETdA questionnaire validity, reliability and feasibility were tested following the standard guidelines for quality measurement psychometric properties evaluation of observation tools (Ribeiro, 1999).

Validity refers to whether an instrument measures what is designed to measure. There are different criterions of validity: construct validity, criterion related validity, construct and content validity (Vieira, Maia and Coimbra, 2007). The factorial structure of ETdA questionnaire was analyzed assessing the theoretical construct validity (Usher and Pajares, 2009). This approach originates a mathematical model from which factors are estimated. The ETdA validity construction was evaluated by performing a factor analysis, using principal axis extraction with orthogonal (Varimax) rotation method. The factorial analysis was conducted on the 12 items included in the ETdA questionnaire, the Qe questions. The decision to use a Varimax rotation was related to ETdA theoretical conceptualization (see section 3.1, Chapter 3), which assumes that the ergonomic factors are independent and can be analyzed separately. Therefore, it was used the Varimax rotation to maximizes the factors' independence. In order to perform the factors' extraction: scree plot interpretation, Kaiser criterions and ETdA theoretical framework, were considered. Although Kaiser's criterions can overestimate the number of factors to retain, the other options above mentioned outline this issue. After the analysis was run, results were given in terms of the percentage of variance obtained, regarding the eigenvalues for each component.

According to Field (2009), validity is a necessary but not sufficient condition of a measure. Reliability is another quality of measurement that accesses the ability of the measure, to produce the same results under the same conditions. To be valid, the instrument must be, firstly, reliable. Nowadays, extent methods are used to access this measurement propriety. These methods include the internal consistency technique called Cronbach's Alpha. This measure is the most common measure of scale reliability used in most researcher studies. However, the Cronbach' guidelines should be used with caution mainly since the alpha value is related with the number of items considered in a questionnaire and when the measure scale is heterogeneous its value can underestimate the true reliability of the questionnaire (Maroco and Garcia-Marques, 2006).

Regarding the ETdA questionnaire validity, the reliability was assessed in terms of the internal consistency of the ETdA subscales. Chronbach's alpha statistic measured the overall correlation between items within a scale (Bosman, 2008).

Additionally, the operational qualities or the feasibility of ETdA questionnaires were investigated considering the Clients response in all categories of the questions (Salaffi, 2006).

In order to perform a questionnaire validation sample size should be taken into consideration. According to Pestana and Gageiro (2005), the sample size should have at least ten participants per variable (Equation 4.1).

$N = 10K$, if $5 < K < 15$ (K = variables number and N = sample size) Eq(4.1)

Regarding the validation of the ETdA questionnaire, this issue was considered as well as the Kaiser-Meyer-Olkin (KMO) statistic. KMO represents the ratio of the squared correlation between variables to the squared partial correlations between variables (Field, 2009) and it is currently used to measure the sampling adequacy. This statistics varies between 0 and 1 (Table 4.5).

Table 4.5. Values for sampling adequacy according to Kaiser-Meyer-Olkin statistics (KMO).

Adequacy	Statistics value
Mediocre	[0.5, 0.7[
Good	[0.7, 0.8[
Great	[0.8, 0.9[
Excellent	>= 0.9

Field (2009) recommends that KMO statistic should be greater than 0.5 as bare minimum. To access correlation variables it was used the statist from Barlett's test of sphericity. According to this test, hypotheses are defined as follows:

H_0: II = I vs. H_1: II 6= I (H_0 be the correlation matrix and H_1 the identity matrix)

A significance test could mean that the correlations between all variable were significantly different from zero. Therefore, it is possible to have an identity matrix different from the correlation matrix. The obtained Barllet' test of sphericity value should be less than 0.05 (Field, 2009).

4.2.3. ETdA variables

ETdA data gathering was obtained through the dimensions' observation tools (ETdA questionnaire, evaluation form and ergonomic checklist). According to the observation tool, data collected was available in different ways reproducing different variables. Therefore, regarding the ETdA dimension, it was important to identify and define these variables.

According to their relevance in the ergonomic analysis, several variables were defined, namely: ETdA variables, temporary and supplementary. A concept map was developed to illustrate the set of variables obtainable through the ETdA questionnaire (Figure 4.7).

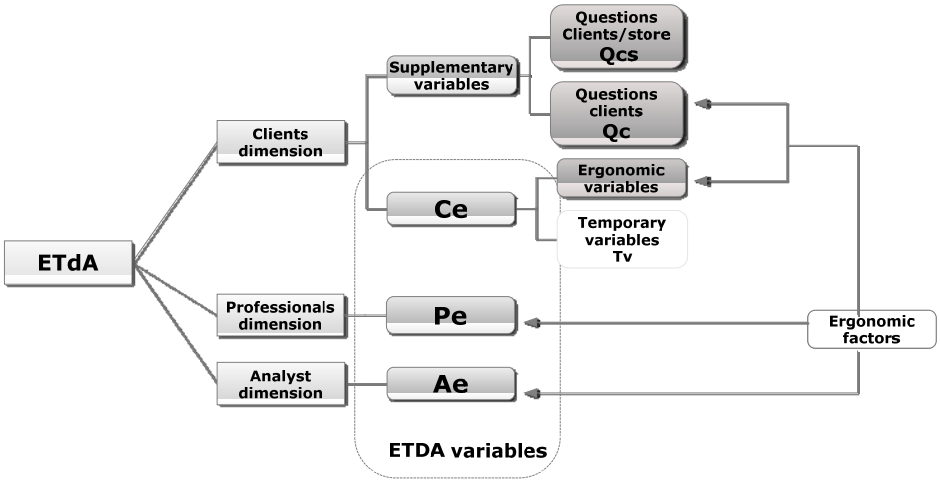

Figure 4.7. Supplementary, Temporary and ETdA variables (Ce, Pe, Ae).

According to the ETdA dimension observation tools it was possible to define three types of variables: Ae, Pe and Ce variables. Ae and Pe variables were directly obtained from the ergonomic checklist and evaluation form. Ce variables were related to Clients' evaluation of the ergonomic factors, the Qe questions in the EtdA questionnaire. Through these questions, two different types of variables were identified:

. ETdA variables (Ce),
. Temporary variables (Tv).

The differences between these two variables were related to the number of questions used to evaluate an ergonomic factor. That is, when a single question was used to evaluate an ergonomic factor, Ce variables are obtained directly from the analysis of the results (see question 13 in Annex 3).. If more than one question was used to analyse an ergonomic factor then temporary variables (Tv) were obtained (regarding lighting quality evaluation, see questions number 9 and 19, in Annex3). In this case, a combined analysis of the Qe must be done, in order to obtain a single ergonomic variable (Ce). This obtained ergonomic variable must be representative of Clients' evaluation.

The ETdA questionnaire was developed to allow, not only the Clients evaluation on ergonomic issues, but also to collect information about factors, even though not directly related to work, but which might be used to define this dimension profile, including Clients' age, education level, gender and professional activity (Macdonald and Bendak, 2000). These issues are named supplementary variables (Loureiro, Leão, and Arezes, 2011) and can be obtained from Qc and Qcs questions (see section 4.2.2.3).

A study regarding the influence of the supplementary variables on the evaluation of the ergonomic factors was done, although it was expected that the supplementary variables do not

have a main role on the analysis, as the results of Clients dimension evaluation were directly obtained from Ce variables.

4.3.ETdA Implementation

Regarding the ETdA implementation on the CAFCP 01 and CAFCP 02, the following general guidelines for ETdA use, were defined: (1) definition of the purpose of the analysis with CAFCP Managers, (2) Study and characterization of the common area and work division, (3) application of the ETdA observation' tools: ETdA questionnaire (Clients' dimension), Ergonomic checklist (Analyst dimension) and Evaluation form (Professionals' dimension) and, (4) data collection of the observation tools.

Based on theses general guidelines the analysis of the *modus operandi* was defined. Two steps were identified: (1) definition of the procedure for analysis and (2) data collection (Figure 4.8).

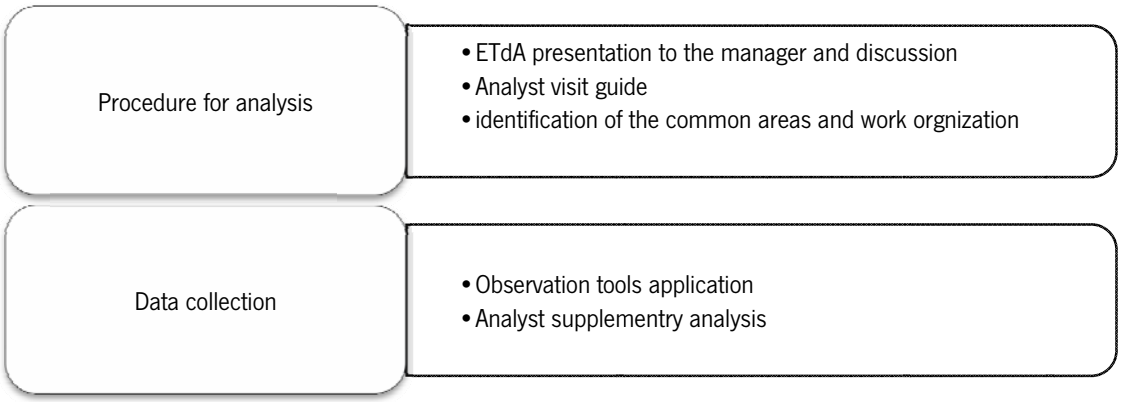

Figure 4.8. ETdA *modus operandi*.

In step one, ETdA was presented to Managers. They were asked about the main interest of participation in this research project. Clients' complaints were also identified by Managers and discussed with the Analyst. The recognition of the commercial areas was also made by the Analyst, identifying common areas (areas where a CP relation can be identified). Each section was assigned with an identification code.

Step two was related to the data collection on the field. This was accomplishing through the ETdA observation tools. Due to the different type of business, the Analyst checked if any adjustments in the terminology were required. It should be considered, if requested by Managers, the inclusion of questions related to problems identified through Clients' complaints. The identification code related to each section must be placed in the front page of the Professionals' evaluation. Although being anonymous, the code allowed the Analyst to make an association between a given critical situation and the section where this issue was identified.

The *modus operandi* for Clients' and Professionals observation tools application was defined as follows:

. Evaluation form (Professionals dimension): delivered during the payment day, allowing a response rate of 100%,
. ETdA questionnaire: applied randomly during three months. "Field force" available in the store was used contributing to the success of this particularly task.

Through the Ergonomic checklist (Annex 2), the Analyst rated the ergonomic factors in a four point scale. Relevant remarks regarding Professionals/Clients interaction were included for analysis (see right column in the checklist presented in Annex1). EWA guidelines were used in order to help the evaluation of EFs. A proper adaptation to this ergonomic context was made (Table 4.6).

Table 4.6. EWA guidelines adapted to the analysis of the common areas.

Itens	Procedure for analysis
General arrangements of the commercial area and work site	Evaluation of the horizontal work area and common Working height Viewing Leg space Set Hand tools; Other equipments
General physical activity Lifting	Observation of the level of physical activity required by the job Check the height at which the lifting occurs Weigh of the load measurements Horizontal distance of handholds measurements
Postures and Movements	Assessments of the work postures and movements ,separately, for different parts of the body: neck- shoulders, hips-legs and elbow-wrist Measurements of the time used to sustain the adopted postures
Accident Risk	Assessments of the probability and severity of an event
Job content and work tasks	Determination of the number and quality of the individual tasks included in the work
Restrictiveness	Identification of any condition that can limit the activity of the professionals or clients' attendance in the area.
Worker communication and personal contacts Decision making	Check the possibility of professionals freely communicate with superiors, colleagues or clients Determination of the degree of complexity of information needed to perform the work and if the qualifications and skills are in line with the work demands. Check the ability of the professionals in solving clients' problems.
Repetitiveness of the work	Determination of the length of the repetitive cycle.
Attentiveness	Calculation and observation of the period/demand for attentiveness Check the influence of clients' attendance in the area on professionals' attentiveness
Lighting conditions	Measurements of the Illuminance of the area Calculation of the ratio measure/recommended Determination of the amount of glare
Thermal environment	Measurements of the air velocity, temperature and relative humidity
Acoustic environment	Noise level measurements in the area/section The average of the obtained values should be considered if no differences are obtained.
Comments	This item can be used, by the professionals, to express his/her opinion about the workplace or prioritize the needs for development

The ergonomic factors that needed supplementary analysis were identified with a (×) mark. Previous work related to the ETdA application in parafarmacies was used (Loureiro, 2008) to facilitate the supplementary analysis development. Simple measure devices were used to noise, thermal environmental and lightning evaluation. Equipments used to perform the measures are presented in Table 4.7. All material was provided by Human Engineering Laboratory at the University of Minho.

Table 4.7. Equipments.

Ergonomic factor	Material
Noise	Integrating Sound Level Meter Quest Technologies 2800
Lighting	Luximeter Delta Ohm, HD9221
Termal environemental	Thermo-anemometer Velocicheck 8330
	Globe thermometer Cassela HB 3135
	Psychrometer sling Cassela HB 3158
	Software PHS (from Malchaire, 1999)

4.4.ETdA Data Analysis

Two main steps were identified at this stage: (1) data normalization and analysis and, (2) weighting table development. The first step was related to data analysis. This analysis comprised the study of the ETdA variables (Ce, Pe and Ae variables) and the supplementary variables. Taken into consideration that ETdA model was based upon a system approach, where different participants were identified as playing different roles in system balance, and based on previous work results developed by Loureiro (2008), it was proposed that the results that leads to a decision-making to ergonomic intervention, should be a weighted average, instead of an arithmetic mean, of the three dimension results. That is why the decision-making to ergonomic intervention was related to a weighting result.

In the following section the process of data analysis is described.

4.4.1. Data normalization and analysis

A three level analysis of the results from the ETdA observation application was proposed as indicated in Figure 4.9.

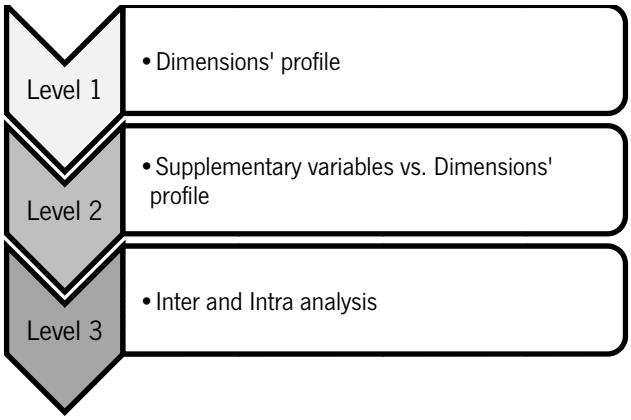

Figure 4.9. Three level analysis of the ETdA results.

Professionals and Clients dimensions are characterized through an exploratory analysis, using a set of graphs or frequencies tables, allowing the dimensions' profile definition. In Clients' dimension, the supplementary variables (Questions clients, Qc, and questions clients/store, Qcs) help to create the Clients' dimension profile. The characterization of Professionals dimension is limited to the study of the distribution of Professionals according to the activity developed (Level 1). With the defined Clients profiles several correlations can be studied. For instance, it is possible to study the influence of Clients' gender in the decision making (Level 2).

Finally, using an inter and intra dimension analysis an ergonomic factors' multivariate analysis is then made (Level 3). The main purpose of the intra dimensions analysis is the ergonomic factors relevance and intensity study, i.e., to understand how the different ETdA dimensions perceive the ergonomic factors and, to measure the intensity of the ergonomic perception in each ETdA dimension. The inter dimension analysis, allows the understanding of the ETdA dimensions' relationships importance helping the results' weighting.

In order to test the viability of this three level analysis, an initial experimental study was conducted in a Wholesale retail store (Loureiro et al., 2011). This study was based on data collected from the ETdA application and it is presented in Annex 4. Briefly, results show that from level 1 analysis it was possible to characterize the user population. Level 2 allowed studying the influence of people on the analysis. Level 3 was useful for the Analyst understand whether the differences in evaluation of Clients and Professionals are statistically significant. In conclusion, this experimental study showed that by using three levels of analysis it is possible to systematize the collected information helping the Analyst on the results' weighting and on the decision make to the ergonomic intervention

According to Lindsay (2004), data collection planning is a very important issue for the collection, exploration and analysis of data sets. Regarding the ETdA datasets, the analysis of the results can be a very complex process as at least, 14 EFs were to be analyzed by the three dimensions. A total of 58 variables plus the supplementary variables and results of the open questions can be obtained for pooled analysis. A normalization of the scales of evaluation, regarding the three observation tools used to collect data was required, as different scales were used to access the EFs:

- a 4-point scale in the ergonomic checklist plus what was obtained through observation;
- a 4-point scale in the evaluation form;
- a 3- to -5-point scales in the ETdA questionnaire (frequency, probability or opinion scales).

In order to simplify and summarize the results of the three dimensions ergonomic analysis, a pre-processing of the data was done. At the end of this task, the results were presented in a single matrix, helping the Analyst in the pooled analysis.

As mentioned above, according to the observation tool, different scales were used to access the EF. Data normalization was required in terms of pooled analysis. Therefore, it was important to consider how to make the normalization of the data, maintaining the sensitivity (psychometric property) of the ETdA questionnaire. In this particular case of data analysis, the normalization was achieved through data recoding. According to Saunders, Lewis and Thornhill (1959) the main purpose of recoding data, is to obtain new variables that are more straightforward without losing the meaning of the question.

Following this thinking starting point, to address this problem in the following question was considered:

> "When performing a rescaling, which categories of the scale could be associated without changing the accuracy of the results?"

For example, Loureiro, Leão and Arezes (2010b) considered the possibility of clustering or excluding the categories that presented low feasibility, in order to increase the significance of the obtained results. As it was mentioned on Chapter 3, the existence of a low number of answers in a given category does not necessarily mean that the category is not important. In fact, this could lead to the wrongful exclusion of categories that have proven later to be important. Indeed, this group of categories can be used as indicators, highlighting some kind of ergonomic problems. Accordingly, this should be considered when rescaling, by grouping different categories of answer.

A further study on this subject was conducted, on data collected during the Master thesis development (Loureiro, 2008; Loureiro et al., 2010b). Suggestions obtained from this study helped the Analyst on the rescaling process. Even though an extended version of the study is presented in Annex 5, given the important contribution that it had on data analysis, a brief description is presented below.

Based on the chi-square test, a proper analysis of the rescaling was done. Two factors contributed to the selection of this test: the sensibility of the test and the type of variables that can be used. Indeed, when applying to frequency tables with small expected cell counts, Pearson chi-squared test statistics may be asymptotically inconsistent demonstrating high sensitivity to the frequency of answers (Haberman, 1988). Due to the fact that ETdA variables are discrete, the number of cells is large and the expected cell counts are quite variable. The chi-square test statistic is given by a quadratic form based on the square residuals: differences between the square of the observed and the square of the conditionally expected number of outcomes in each cell (Andrews, 1988). It seems reasonable to assume, by looking at the individual standardized residuals, that it is possible to check each contribution to the test statistics and, consequently, infer about its importance. For this reason, the chi-square test was selected, to perform the study on rescaling categories, without changing the accuracy of the results. It is important to notice

that, in the present work, chi-square test was used so as to understand how the rescaling should be done, and not for the purpose of studying the relationship between two variables.

According to Field (2009), there are two important assumptions to be considered in the chi-square test described as follows:

(1) To chi-square test be meaningful, every person item or entry must contribute to one cell of the contingency table, and
(2) Regarding the chi-square statistic, the expected frequencies on the contingency table should be greater than five. In larger contingency table, it is acceptable to have 20% of the excepted frequencies bellow five; although the results obtained could be inaccurate.

In the following developments, one of the contingency tables presented on Annex 4 is used as an example - existence of a noise problem × Clients' perception of risk accident. Noise problem has two categories of answer and Clients' perception of risk accident is represented by five categories. Even though the sample size adequacy, a large amount of cells (50%), with expected frequencies bellow five was counted within the contingency table.

The values of the standard residuals were used to obtain a new chi-square statistic, regarding all the cells that infringed the second chi-square assumption. The statistic test was calculated from Equation (4.2)

$$\chi^2 = \Sigma \text{ (std residuals)}^2 \qquad \text{Eq.(4.2)}$$

The number of cells with expected frequencies bellow five was weighted. To achieve this issue, a comparative analysis was done, using the chi-square value for this group of cells and the value of the same test considering all cells. Results of this procedure are presented in Table 4.8.

Table 4.8. Chi-square statistic *vs.* Chi-square statistic using the cells with expected frequencies bellows five.

	Chi-square	
Contingency table	Statistic test	Statistic (cells with expected frequencies bellow five)
Risk situation × Noise problem	9,018 (a)	8.380 (b)

It was possible to see the significance of the contribution of the cells with expected frequencies bellow five (b in Table 4.7), when a comparison with the statistic test ((a) in Table 4.7) was made. The existence of these categories had to be considered relevant as it could represents an indicator for a supplementary ergonomic analysis. Taking this into account, it appeared unreasonable to exclude those categories from the data analysis.

Another important issue was the dispersion in the contingency table, of the cells with frequencies above five. That is, the identification of the cells with frequencies below five, not always corresponded to the same category, they were distributed over more than one category. This

observed situation impaired the elimination of a given category from data analysis. In consequence, a deeper analysis was done weighing the value of the chi-square statistic calculated for each category. A compared analysis was done between:

a) the results from the chi-square test calculated from the standard residuals values, regarding the categories that presented expected frequencies bellow five and,
b) the value of the same test, considering all the cells related with that category.

Results of this procedure are presented in Table 4.9.

Table 4.9. Contingency table Accident risk×Problem noise: standard residuals analysis.

		Problem Noise		Chi square	
		No	Yes	(a)	(b)
Accident risk	Impossible			0.01	0.01
	Unlikely			0.49 (f)	0.5
	Likely		2.8 (e)	**7.84 (c)**	8.2
	Very Likely			0.04	0.04
Chi square	**(a)**	0.0	**8.38 (d)**		
	(b)	0.74	8.38		

The results showed that the biggest contribution of each cell with expected frequencies bellow five (see (e), rows and columns) in the chi-square result [χ^2 (3)= 9.018., p< 0.05], was related to "Likely" perception of a risk situation ((c) in Table 4.9) and the existence of a problem noise source ((d) in Table 4.9). If all the cells related to that category were considered ((b) in Table 4.9), it seemed reasonable to assume that the same remarks could be made. In fact, the largest standardizing residual value was associated with both categories of answer (Z=2.8, p<0.05, (e) in Table 4.9). This suggested that, when Clients thought that an accident was likely to occur in the commercial area under study, more Clients than expected considered that this accident was due to the existence of a noise problem in that commercial area.

Results from this study, suggested that the analysis of the chi-square statistic, cell by cell or category by category, can help to understand witch categories contribute to the overall association that chi-squares statistic measures. In this case, it was observed that the major cells' contribution to the overall chi-square statistic was related to the "likely" category ((c) in Table 4.9). The second big contribution was related to the "unlikely" category. That suggested that the data related to the accident risk evaluation, should be rescaled in two new variables: Unlikely and Likely. Regarding the question related to the accident risk evaluation, it was proposed that "impossible" and "unlikely" categories were included on the first group. The Likely group was related to "likely" and "very likely" categories.

New analysis was run (analysis 2) and a 2×2 contingency table was obtained. It was expected that by using a 2×2 contingency table, the percentage of cells with expected frequencies bellow five was lower than the results obtained from the first analysis (analysis 1). Comparative results are presented in Table 4.10.

Table 4.10. Percentage of cells with expected frequencies above five by analysis.

Analysis	% of cells with expected frequencies above five (Crosstabs Risk situation × Noise problem)
1	50.0%
2	12.5%

Results showed a decrease on the percentage of cells with expected frequencies bellow five. The significance value obtained from the analysis 2 is p=0.013. Comparing this result with the first analysis result (p= 0.029), it is possible to say that, with this scale recoding, the accuracy of the result was maintained, as the significance level remains the same. Regarding the obtained results, two final considerations were made:

(1) the existence of a low number of answers in a given category can be used as indicators, highlighting some kind of ergonomic problems;
(2) to assist the Analyst in the proper rescaling of the ETdA variables, the estimation of the standardize residuals from a contingency table, may be used. It seems reasonable to assume that this procedure do not affect the accuracy of the results.

Through the normalization of the data, obtained from the application of the ETdA observation tools, it was possible to perform a pooled analysis of the ETdA dimensions results.

4.4.2. Weighting tables

The final task of the ETdA methodology was the weighting table assembly to support the Analyst on decision to ergonomic intervention. The needed to develop these tables supported the Analyst in his/hers final task: real perception of the ergonomic situation and elaboration of the priority list of changes to be implemented, according to the severity of the identified situations. The process involved exploratory data analysis, inference and decision-making.

Firstly, it was calculated the average of each ETdA variable (Ce, Pe and Ae variables). Then, a weight was assigned to each dimension and finally, a weighted value was obtained through the sum of the previous results. The sum of the weights was considered to be equal to 100%. After weighting the ETdA variables, the obtained value was associated to a colour within the weighting table, representing the decision making to intervention. A 3-point scale was used: red (R), representing a critical situation, yellow (Y), representing a medium-term intervention, and green (G), identifying a non-critical situation. Since the scores were integer numbers and the individual results were higher or equal to 1 and lower or equal to 3, the values ranged between 1.5 and 2.5 were considered as score 2, values between 1 to 1.5 were scored as 1, and values higger than were scored as 3.

Several factors were identified as being responsible for the weighted decision. These factors are presented as follows:

. The strength of the interrelation CP;

. The type of business;
. The value that Clients have to the organization;
. The identification of the dimension involved on a given critical situation;
. The supplementary variables (see section 4.3.2.2).

In order to illustrate the possible influence of these factors, an example is provided in the following lines.

Considering an analysis ergonomic in a library, the Analyst defines a common area where a relation CP is identified. Clients are the main users of this area, as professional activity is further related to the task of allocating books on shelves. It is assumed that, the interrelation CP is not too narrow, as Clients require professional assistance, to demand information about the location of a book. Regarding lighting quality and noise evaluation, the Analyst should give a greater weighting to Clients' evaluation. However, regarding the "anthropometric limitations related to the design of the shelves", Professionals dimension should have a greater weight. Following this thinking, it should be emphasize the importance of studying the system in terms of work organization, identification of participants and their interrelations. A proper study on this subject contributes to a more effective decision making.

Regarding the weighting tables development, it is important to underline that, when there is existing legislation or governmental recommendations, its fulfilment should always be ensured, and only after this situation is achieved, is then considered the weight of the obtained results. The process used to obtain the decision-making result is presented in Figure 4.10.

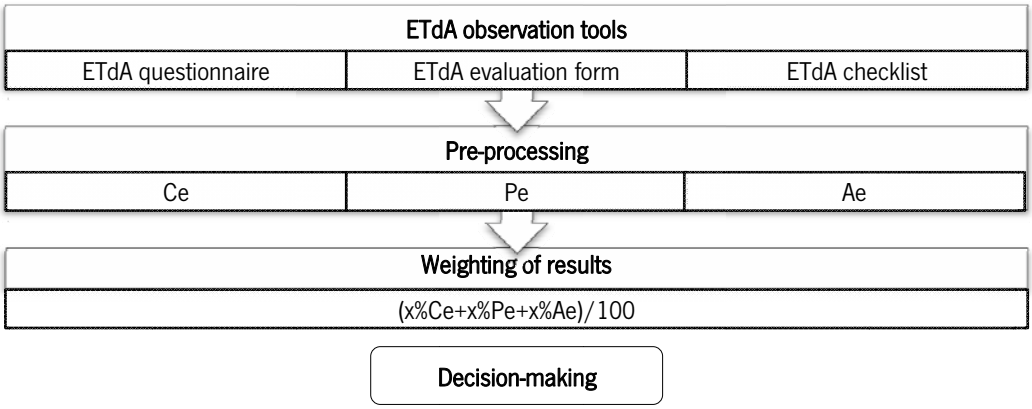

Figure 4.10. Process used to obtain the decision-making.

The influence of the supplementary variables on Clients' ergonomic analysis was assessed, as well as the study of the Clients influence on the decision making process. The latter, was accomplished by the quantification of the number of changes on the decision making (Red to Yellow; Yellow to Green, Green to Yellow and Green to Red), under different weights, according to the criteria presented on Table 4.11.

Table 4.11. Number of changes on the decision making, by weight.

Weighting table	Dimension		
	Clients	Analyst	Professionals
1	0	50	50
2	0	25	75
3	0	75	25
4	5	47,5	47,5
5	10	45	45
6	25	37,5	37,5
7	1/3	1/3	1/3
8	40	30	30
9	50	25	25
10	70	15	15
11	50	50	0

The weighting tables' number 1, 2 and 3 are related to an occupational analysis where Clients are not considered. In order to study the Clients influence on the analysis, different weights, regarding Clients' dimension, were studied. This situation is represented in Table 4.11, by the weighting tables 4 to 11. To ensure that the study was focused on Clients' influence, equal weights were assigned to Professionals and Analyst dimensions.

The influence of the type of CAFCP on the decision-making process was also studied, using the same procedure as described previously.

4.5.Final Considerations

The general guidelines for ETdA use on common areas with free circulation of people are presented as follows.

ETdA methodology (general guidelines)

1- ETdA planning
   - . Definition of the purpose of the analysis with CAFCP Managers;
   - . Study and characterization of the common area and work division

2- ETdA implementation
   - . adjustments on the ETdA questionnaire

3- Data collection:
   - . application of the ETdA observation tools

4- Data analysis:
   - . Level 1: definition of the dimensions profiles (supplementary variables' exploratory analysis)
   - . Level 2: evaluation of the ergonomic factors
   - . Level 3: intensity of the ergonomic perception in each ETdA dimension (inter and intra dimension analysis) measurement
   - . Weighting tables:assembling of the ETdA dimensions results

5- Decision making

The main steps for ETdA use are illustrated in the Figure 4.11.

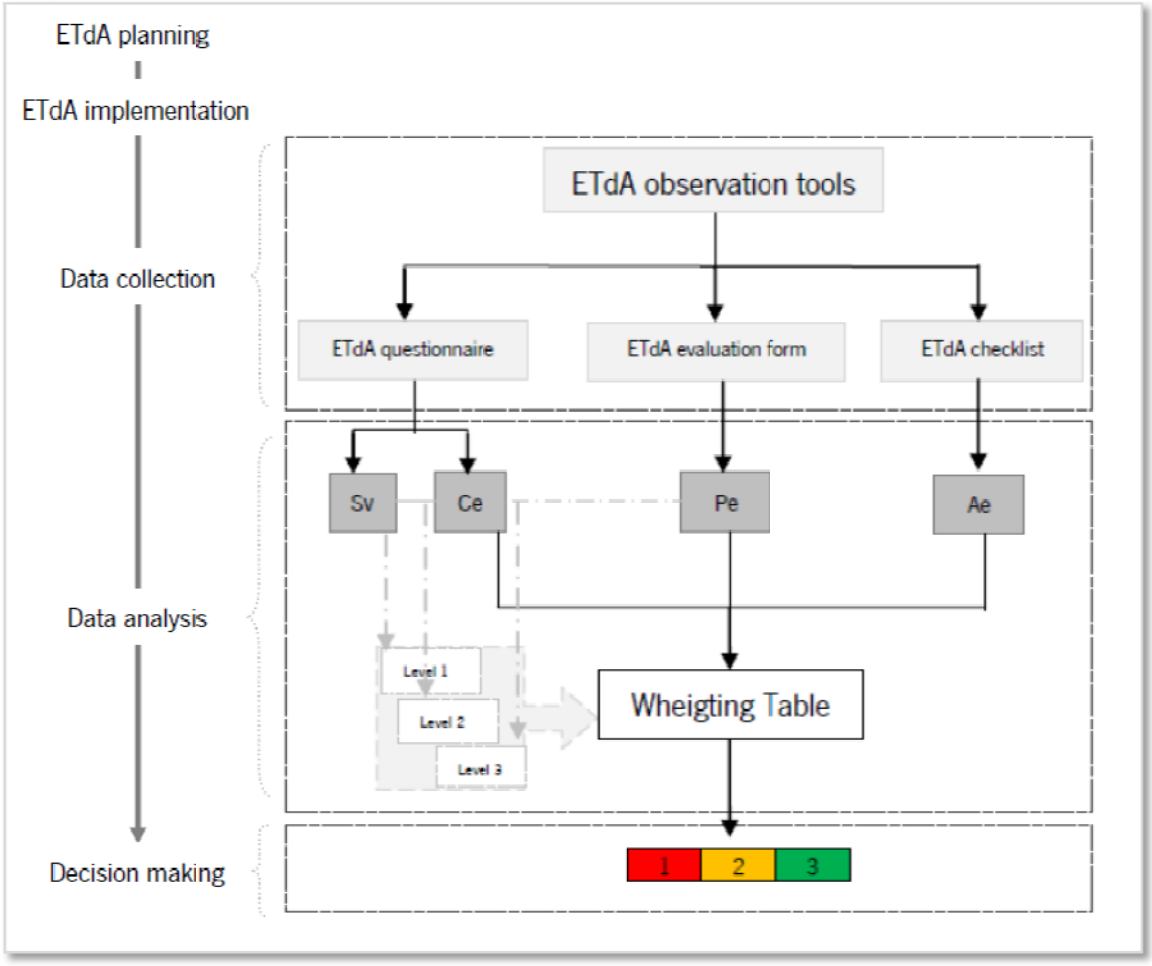

Figure 4.11. Main steps of ETdA implementation.

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Chapter 5. Results and Discussion

This Chapter describes the results revealed by the current research. A factual presentation of the findings will be presented. Discussion will be provided, as results are stated and, when necessary, its significance are highlighting. The ETdA was implemented in the two commercial areas (CAFCP 01 and CAFCP 02), following the methodology described on Chapter 4. General guidelines presented in Figure 4.10 (see Chapter 4) were used to achieve this issue. Results of its application will be presented on the following's. In order to study the Clients influence on the ergonomic analysis, an analysis of the results of the weighting tables will be performed. This analysis will also be used to study if the type of common area can have influence in the decision making process.

5.1.ETdA Questionnaire: The Process of Validation

As it was mentioned on Chapter 4, although the validation of the ETdA questionnaire did not present a new statistical methodology, this step was essential in order to obtain an observation tool (questionnaire) that could be used accurately. For this reason, the ETdA questionnaire was validated prior to its application on this study case. Results of the validation' process will be briefly presented in this section.

The validation was performed on a database obtained through the application of the ETdA questionnaire (Annex 3) on six commercial areas during the development of a Master thesis (Loureiro, 2008). In this research, the ETdA questionnaires were available to Clients of the six CAFCP during 2 months. Each questionnaire was directly delivered in hands by the Professionals and was completed in loco or at home.

From the total delivered questionnaires, 206 Clients participated in the study-case. It is considered that a 206 respondents' sample should not be a problem in the validity observation tool (Cohen, 1923; Chuan and Penyelidikan, 2006; Field, 2009; Hill and Hill, 2000; Horn and Salvendy, 2009; Pestana and Gageiro, 2005). According to Field (2009), in order to study 12 variables it is necessary a sample with 120 cases. According to Hill and Hill (2000), 100 subjects is the minimum simple size recommended for the application of statistical techniques. Authors suggest the use of the statistical estimation of sampling size using Cohen Statistical Power Analysis. In fact, Chuan and Penyelidikan (2006), remark that this analysis is one of the most popular approaches to calculate the sampling size. Research by Field (2009) and Baguley (2004), and based on Cohen (1923) guidelines for calculating the number of participants for a given level of power of 0.08, conventional level of significance of 0.05 can be used and 85 participants will be needed, in order to detect a medium effect size. This effect size (r) corresponds to a value equal to 0.3. Cohen et al. (2003) proposed a medium size effect to be desirable; as it may represent a large enough effect to be detected.

Taking these factors into consideration, the amount of 206 questionnaires is considered to be sufficient to perform the validation of the ETdA questionnaire.

Results of a descriptive analysis made on the questions showed that the ETdA questionnaire was correctly completed by the majority of the respondents. Less than 3% of each item had missing values. This result seems to indicate that the EtdA questionnaire was a feasible observation tool.

To test the ETdA questionnaire, the psychometric properties of the questionnaire, such as validity, reliability and feasibility, were evaluated.

KMO statistics was used to measure the sampling adequacy. Results showed a KMO statistics equal to 0.83. According to Field (2009), this value is "great". It is important to notice that only KMO related to restrictiveness ergonomic factor is less than 0.5. The KMO statistics, regarding the remain EFs were above the acceptable limit of 0.5. Therefore the analysis was practicable

(Field, 2009; Maroco, 2010). Bartlett's test of sphericity indicated that correlations between items were sufficient large to use a factor analysis [χ^2 = 2633.5, p< 0.001]. Based on these results, it was assumed that variables were significantly correlated and, consequently, factorial analysis was adequate (Salaffi, Stancati and Grassi, 2006).

A preliminary analysis was run in original data under the following conditions: Varimax rotation with Kaiser Normalization. Seven factors were obtained with eigenvalues over Kaiser's criterions of 1. Together, these factors explained 69% of the variance.

A question arrises: "Can each of these seven eigenvalues represent a meaningful factor?" By graphing eigenvalues, a scree plot was obtained where the relative importance of each factor becomes apparent.

Field (2009) considers that the point of inflexion of the descending curve represents the cut-off point for selection factors. Taking this into account, the number of factors to retain should be equal to the value immediately above the point of inflexion. According to Stevens (2002), for samples with over 200 respondents, a scree plot provides a fairly reliable criterion for factor selection. In this study case, as the sample size is equal to 206 respondents, this issue should not pose a problem. In Figure 5.1 it is possible to identify where the slope of the line changes dramatically. That occurs at the third data factor (see the horizontal line (1) in Figure 5.1). This indicated that two factors should be retained. Although not so evident, it is possible to observe another point of inflexion (see the horizontal line (2) in Figure 5.1). In this last case, three factors should be retained.

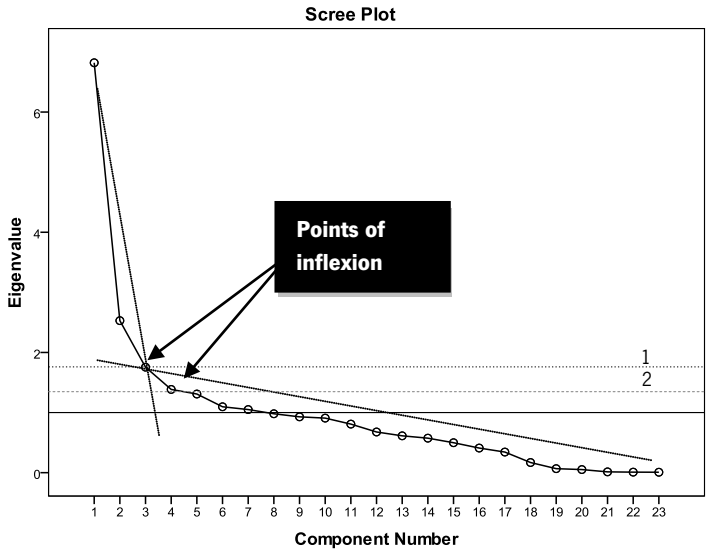

Figure 5.1. Data scree plot: underling factors according to point of inflexion (1) and (2).

Due to the restrictive number of questions that were analysed, twelve Qe questions, it was hypothesised that each of the obtained factors will contained a very few number of questions. Therefore, the first hypothesis, that considered two as the number of factors to retain, instead of

three, was considered. The size of the sample and Kaiser's criterions contributed to this decision. The retaining of both factors, 1 and 2, it is also suggested by the conceptualization of the ETdA model. In section 4.2.2.3, two major groups of questions within the questionnaire were identified: the Qcs and the Qe questions. Both groups contained questions used to evaluate the EFs, for example the noise factor. The question related to noise factor evaluation, regarding the first group was comprised in a multiple set question. The aim of these questions was to assess the service quality of the commercial area. In the second group, the same EF was assessed but in terms of the evaluation of Clients' perceptions. Taking this in consideration, it was expected to obtain two factors from the factorial analysis: one presenting the questions related to service quality and the other related to the evaluation of the ergonomic factors in term of Clients' perceptions.

A following analysis was run, using the same conditions as in the first one (Varimax rotation with Kaiser Normalization), but with anticipated solutions for two factors, with a 41% of the variance explained. Table 5.1 shows the loading of each question after Varimax rotation with Kaiser Normalization.

Table 5.1 ETdA questionnaire: summary of exploratory factor analysis (N=206).

Parameter	**Factor 1**	**Factor 2**
Description of Variables	Others recommendations Temperature Noise* Sympathy Lightning Cost /quality Relation Hospitality Restrictiveness	Clients' considerations on ergonomic design Regular Client Residence proximity Work proximity Trust in service provided to Clients Anthropometric dimensions Anthropometric limitations Lightning quality Accident risk perception Noise problem* Establishment General appearence General physical activity Professional training
% of variance	24.85	13.21
Cronbach's alpha	0.968	0.603

Results showed that each of the obtained factors, as expected, comprised the two groups of questions (Qcs and Qe). The noise factor, marked with an "*" (asterisk), in Table 5.1, emphasizes this observation. Factor 1 (see Table 5.1) explained 25% of the total variance and was named "Clients' wellbeing", since it included the Qcs questions. Factor 2 (see Table 5.1) explained 13% of the total variance and was named "Clients' ergonomics perception" being related to the Qe questions.

Cronbach's alpha result was 0.968 for the first factor and 0.603 for the second factor. These results revealed satisfactory to good internal consistency.

The study of the psychometric proprieties of the ETdA questionnaire showed differences between Clients' wellbeing and ergonomic perceptions. This fact indicates that the ETdA questionnaire allows Clients in the differentiation between issues that are relevant to the ergonomic analysis and those that related to the characterization of their wellbeing.

5.2.Characterization of the CAFCP 01 and CAFCP 02

The first contact with the manager is a very important step of the ETdA implementation. It is considered that the success of this contact might have influence on the ETdA implementation. Important remarks on this institutional contact are presented in the following lines.

Managers of CAFCP 01 and CAFCP 02 where asked about the main interest of participation in this research project. Both of them reported the satisfaction of Clients' expectations. This is in line with the ETdA assumptions, which consider Clients as a part of an integrated system and centre of the organization. Through this first conversation, the Analyst observed that both organizations strategies were focused on Clients' requirements, needs and expectations. Taking this into consideration, Clients' complaints were identified by managers and discussed with the Analyst. Briefly, the complaints related to the Clients of the CAFCP 01 were the excessive and constant number of people in line at the cash payment and high number of product returns; complaints regarding annoyance due to noise and, complaints related to the reason for not using the shopping bags available in the store was also discussed. Regarding the CAFCP 02, the identified complaints were related to the thermal environmental conditions and the difficulties felt by Clients in operating the shopping trolleys, especially when they are fully loaded, i.e., when the total weight can reach values of approximately 600 kg (1322 lbs).

The Analyst explored and made the identification of the common areas within the commercial area, which are those where a Clients/Professionals (CP) interrelation can be identified. Back office areas were not included in this study as no CP interaction was identified. Despite the fact that the CAFCP 01 presents two sections that were exclusively designed for Clients, these areas were also considered on this study, as they were a part of the common area. Therefore, it was important to clarify if those areas were designed taking into consideration aspects such as: Clients' wellbeing and comfort. The common areas identified for each CAFCP are presented in Table 5.2.

Table 5.2. Common areas identification (CAFCP 01 and CAFCP 02).

Common Areas	
CAFCP 01	**CAFCP 02**
Front office, Clients' reception, freezing area, fruits and vegetables, butcher's area, fish area, beverage areas, office media, electrical appliance, grocery charcuterie and dairy sections.	Books, music, informatics and software, gaming, TV/video, photo, front office, Clients' reception, kids' area and cinema.

Through direct observation, some differences between the lay-out of CAFCP 01 and CAFCP 02 were remarked by the Analyst, suggesting the need for two different approaches in the ergonomic analysis.

Briefly, an explication of the identified differences is provided.

Even though different Professionals' activities were identified on CAFCP 01, workstations and work organization were similar between some of the identified common areas, namely, books, music, informatics and software, gaming, TV/video, photo and kids common areas. These areas were divided in two different sections. One section had workstations with a central processing unit (CPU). These workstations were designed to Professionals to consult the existent stocks, and help them to provide information to Clients. Despite not having been specifically designed for this purpose, they were also used to make the orders conference. The other section was a corridor where products were displayed. The Kids' cinema and gaming areas were designed to Clients' exclusive use. Finally, this CAFCP presented a traditional Clients' service balcony where the cash registers were positioned and where exchange of products could eventually be performed.

According to the presented lay-out, different CP interactions were also identified. Taking this into account, in order to facilitate the implementation of the ETdA methodology, the CAFCP 01 was divided into subsections as suggested in Table 5.3. An identification code was assigned to each section of the common area (sections 1 to 5).

Table 5.3. Sections of the CAFCP 01.

	Identification code				
	Section 1	**Section 2**	**Section 3**	**Section 4**	**Section 5**
Interrelation CP	Interrelation in Clients' service balcony	Interrelation where products are displayed	Clients exclusive area	Clients exclusive area	Interrelation in Clients' service balcony
Description	This balcony was design to allow the consult of stocks by Clients' request. It is also used by Professionals to order receipt.	This subsection has a column where the gamming software is displayed, enabling Clients to test it.	This subsection has a column where the gamming software is displayed to Clients to test.	Lounge area for reading and watching TV.	Clients' reception and payment area
Related common area	Books, music, informatics and software, gaming, TV/video, photo and kids areas	Books, music, informatics and software, gaming, TV/video, photo and kids areas	Gaming section	Kids' area	Front Office , Clients' reception

The Analyst suggested that the CAFCP 02 was divided into sections according to the type of activity developed by Professionals division, as Professionals' activities and the related CP interaction were limited to a particular section. Taking this into account, an identification code was assigned to each section of the common area (code 1 to 11) (Table 5.4).

Table 5.4. Sections of the CAFCP 02.

Sections	Interrelation CP	Identification code
Fruits and vegetables	Interrelation where products are displayed	Section 1
Fish section	Interrelation where products are displayed	Section 2
butcher's section	Interrelation in an attendance balcony	Section 3
Charcuterie/ Dairy	Interrelation where products are displayed	Section 4
Beverage section	Interrelation where products are displayed	Section 5
Office media	Interrelation where products are displayed	Section 6
Electrical appliance	Interrelation where products are displayed	Section 7
Clients' reception	Interrelation in an attendance balcony	Section 8
Grocery	Interrelation where products are displayed	Section 9
Front office	Interrelation in an attendance balcony	Section 10
Freezing area	Interrelation where products are displayed	Section 11

5.3.ETdA Questionnaire Adjustments

The original version of the questionnaire was developed in a commercial context (Annex 3). Nevertheless, it was necessary to make adjustments to the commercial areas under study. ETdA questionnaires were suitably adapted to each commercial area and a final version was obtained: ETdA questionnaire 1 for CAFCP 01 and ETdA questionnaire 2 for CAFCP 02 (Annex 6). Specific terminology related to each CAFCP was used. Taking question number 16 (which are the most requested products?) as an example, for both questionnaires, the presented list of products was obviously related to the goods supplied by each store.

The inclusion of questions related to Clients' complaints and mentioned above was also considered. These questions are presented below.

ETdA questionnaire 1:

- Q#13 "In your opinion, does the background music contributes to an atmosphere of wellbeing?"
- Q#21 "Have you ever felt that background music disturbed verbal communication?"
- Q#22 "Have you ever used the shopping bag provided by this establishment?"
- Q#23 "Have you ever proceed to exchange or return a product? Please indicate what the product was and the reason for exchange/return it."

ETdA questionnaire 2:

- Q#13 "Have you ever felt difficulties in maneuvering the shopping trolley?"
- Q#21 "Have you ever found any obstacle that hindered the maneuvering of the shopping trolley?"

It is important to point out that these questions were included in the ETdA questionnaire, to collect information in order to aid managers in solving Clients' complaints. Obviously, they can also be used as an indicator of the Clients' perceptions about a particular issue. Considering

questions 13 and 21 included in the ETdA questionnaire number, results enlighten Clients' perceptions regarding the exposure to noise levels that were not considered as hazardous.

In order to establish a correspondence between the variable to be analysed and the question number, a data sheet was developed considering both ETdA questionnaires (Table 5.5). Notice that the ergonomic factors "postures and movements" and "repetitiveness" were not considered in the analysis performed on the CAFCP 01.

Table 5.5. ETdA questionnaire data sheet.

Question	Description	CAFCP 01	CAFCP02
Clients characterization (Qc)	Age	Q1	Q1
	Gender	Q2	Q2
	Occupation	Q3	Q3
	Qualifications	Q4	Q4
	Clients' considerations on ergonomic design	Q5	Q5
Clients/store (Qce)	Regular client?	Q6	Q6
	Reason for visiting the shop	Q7	Q7
	Shopping preferences	Q16	Q16
	General evaluation	Q20	Q20
Clients' ergonomic evaluation(Qe)	Lifting	Question 8	Question 8
	Lightning quality	Question 9	Question 9
	Noise problem	Question 10	Question 11
	General opinion about the store	Question 11	Question 11
	General physical activity	Question 12	Question 12
	Postures and movements	Question 13	Not applicable
	Work communication and personal contact	Question 14	Question 14
	Decision making	Question 15	Question 15
	Accident risk	Question 17	Question 17
	Restrictiveness	Question 18	Question 18
	Thermal evaluation	Question 19	Question 19

5.4.Characterization of the Dimensions

This section is related to the characterization of the Clients and Professionals dimensions. The Analyst dimension is not characterized since the analysis was conducted by a single technician. Professionals and Clients dimensions are characterized through an exploratory analysis, using a set of charts and frequencies tables, allowing the dimensions' profile definition (Level 1 of the three level analysis, presented on Chapter 4).

5.4.1. Clients' dimension profile

The profile for Clients dimension is obtained through the analysis of the ETdA supplementary variables. An exploratory analysis was made on collected data from the application of the ETdA questionnaires regarding CAFCP 01 and CAFCP 02.

In CAFCP 01, nearly half (50%) of the sample were male (Figure 5.2).

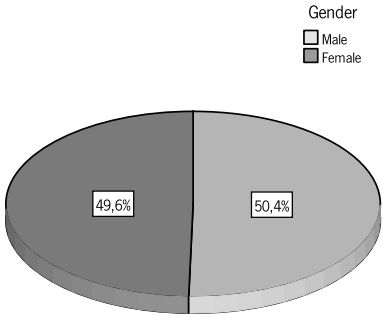

Figure 5.2. Clients' gender distribution (CAFCP 01).

On average, Clients' have 29 years (SD=11.37; interval range 15-62 years old). The majority of women was less than 20 years old, while most men had ages in the category [21, 35] years old (Figure 5.3).

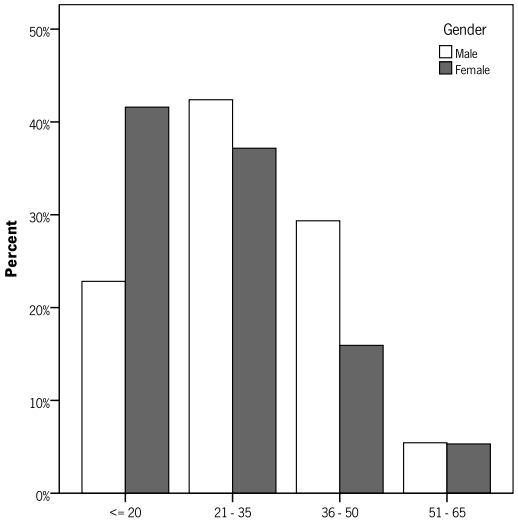

Figure 5.3. Clients' age distribution (CAFCP 01).

Regarding their education background, most of them received senior high school education (44%), 19% received graduation education, and 32% received an unspecified type of qualification. These results somehow are expected, given the Clients' age distribution. In fact, the existence of a cluster concerning senior high school education was related to the fact that the Clients' age was clustered at the youngest scores [$\chi^2(30) = 72.846$, $p \leq 0.001$] . Comparing qualifications regarding Clients' gender, men presented high education than women (Figure 5.4). However these differences are not statistically significant [U= 5.200, Z= 1.452, p>0.05, r=-0.11]. Overall, a vast majority of 95% of the Clients considered having much knowledge about ergonomic issues. Clients' gender [U= 4.777, Z=–1.308, p>0.05, r= -0.09] and education level [H (2) = 1.530, p>0.05] do not have influence on this issue.

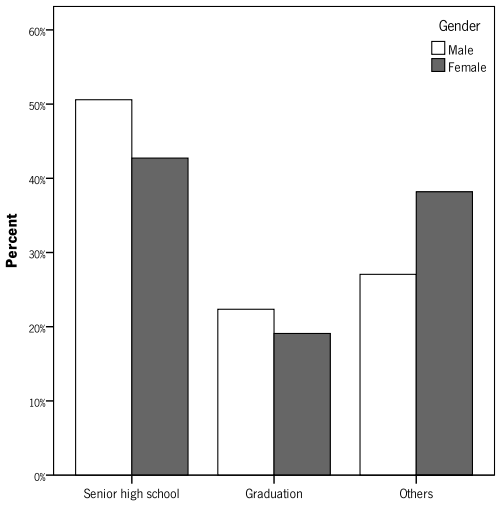

Figure 5.4. Clients' education level (CAFCP 01).

Most of the Clients were regular visitors of the establishment (65%) and about 96% shop in the establishment at least once a week. The regularity of the Clients visits can help to obtain more reliable information as it can be related to Clients' CAFCP recognition and, consequently, to their different ergonomic factors knowledge.

Clients were asked about the main reason for choosing this CAFCP. Even though they were allowed to select more than one option, results show that Clients' main choice was based upon a trust relationship in products and services provided (34%). Residence proximity was reported by almost 15% of the Clients, as well as work proximity, occasional reasons and other reasons. Finally, 8% of the Clients' reasons for choosing this CAFCP was related to others recommendation.

Clients' gender and age do not have influence on this trust relationship. Mann- Whitney U test [U= 2.094, Z= -0.605, p> 0.05, r=0.05] and Kruskal-Wallis test [H (3) = 4.690, p>0.05] were used to follow-up this findings. Female's second most reported choice is work proximity while the second choice of male is the residence proximity.

Clients were asked about CAFCP 01 general appearance. Generally, this commercial area has a good evaluation (80%) (Figure 5.5).

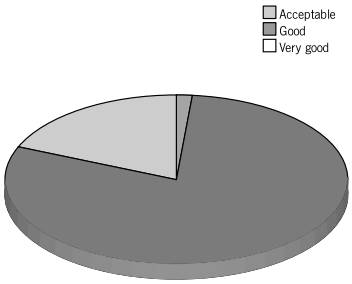

Figure 5.5. Evaluation of the general appearance of the CAFCP 01.

In order to access service quality, a set of multiple questions related to Clients' wellbeing was applied, namely Professionals' kindness, cost/quality ratio and hospitality. Clients evaluated those issues through a 5-point rating scale. The categories associated to this scale are: (1) very bad, (2) bad, (3) acceptable, (4) good and (5) very good. A re-codification of the scale was done in a 3-point scale: categories (1) and 2 were related to a negative evaluation, category (3) represented a satisfactory evaluation while categories (4) and (5) were related to a positive evaluation. Cleanliness of the commercial area was also assessed. Full answer distribution is presented in Table 5.6.

Table 5.6. Clients' wellbeing evaluation (CAFCP 01).

	Clients' wellbeing evaluation (%)		
	Negative evaluation	**Satisfactory evaluation**	**Positive evaluation**
Professionals kindness	0.0	7	93
Cost/quality ratio	4	66	32
Hospitality	4	3	93
Cleanliness	0.0	8	92

Professionals' kindness and cleanliness of the establishment are positive evaluated by 93% of the Clients. The cost/quality ratio has an acceptable evaluation by 66% of the Clients. It is important to notice that 4% of Clients rated this issue negatively. A following study on this subject was carried out. Results showed that, regarding gender, men seems to be more demanding than women (Figure 5.6).

Those who negatively evaluated this subject, usually buy products from the following sections: gaming and TV/photo.

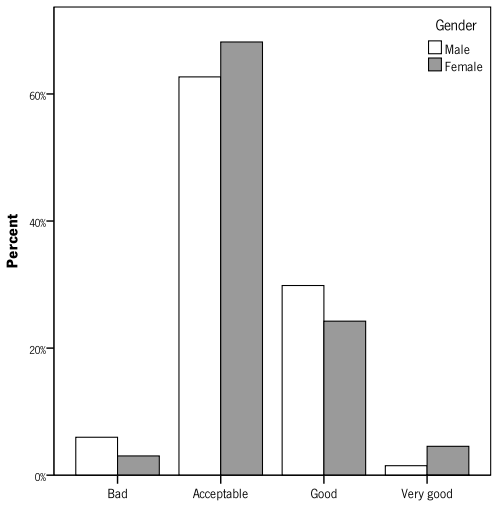

Figure 5.6. Evaluation of the cost/quality ratio by gender (CAFCP 01).

Hospitality also had a negative evaluation by 4% of Clients. Concerning this issue, men and women share the same opinion (Figure 5.7). Mann- Whitney U test was used to follow up this finding [U= 2.228, Z= 0.097, p> 0.05, r=0.08].

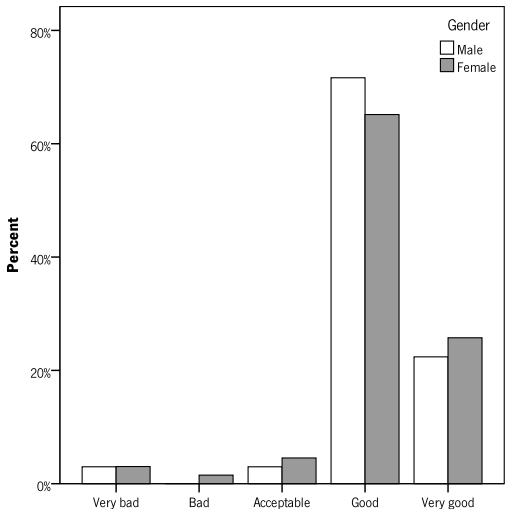

Figure 5.7. Hospitality evaluation, by gender (CAFCP 01).

Both evaluations of cost/quality ratio and hospitality must be taking into consideration on the organization marketing strategies.

In CAFCP 02, Clients' age ranged between 17 years old and 76 years old, with a mean age of 49 years old (SD =15). About 65% of the respondents were male. Most male have between 49 years and 57 years while the majority of female is clustered by two age intervals: [21, 29] years and [58, 67] years old. In Figure 5.8 it is possible to see Clients' age distribution by gender.

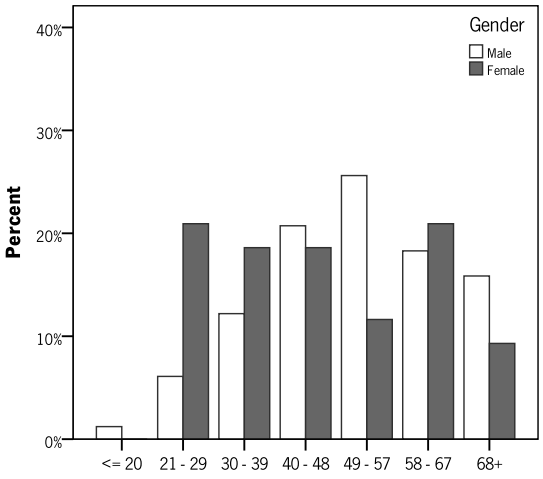

Figure 5.8. Clients' age distribution, by gender (CAFCP 02).

In general terms, Clients were businessmen or retired. Most of them (68%) reported a senior high school qualification (Figure 5.9). It is possible to observe that women have higher qualifications than men. The observed difference proved to be statistically significant, [$t(169)= 39.156$, $p< 0.001$].

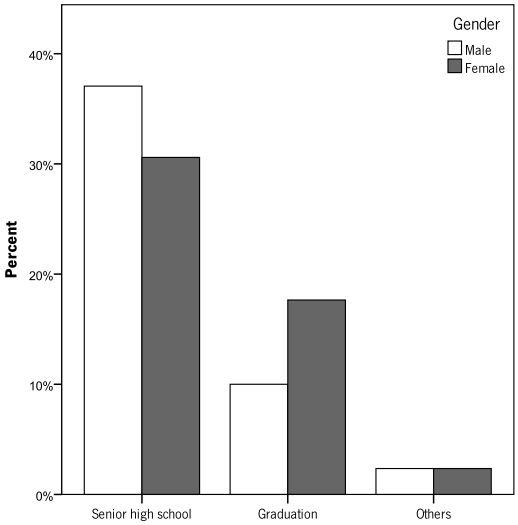

Figure 5.9. Clients' qualifications distribution by gender (CAFCP 02).

In order to see if there is a relation between Clients' qualifications and their Professional occupations a deeper study was conducted. Results revealed that these two variables are strongly associated [$\chi^2(155) = 192.212$, $p \leq 0.001$] In fact, some Clients' occupations do not require special qualifications, such as the businessmen and retirees. Clients who presented higher qualifications have Professional occupations related to education, law, or health. This fact is important since it appear to be directly related to the main market's target of this type of business: business owners, self-employed Professionals, freelancers or institutions.

It is interesting to observe that Clients have a considerable knowledge regarding ergonomic issues and emphasizes ergonomic aspects of the workspaces design. Clients' gender [U= 1.641, Z= -1.255, p>0.05, r= -0.11] and qualifications [H(2)= 4.728, p>0.05] do not influence this issue.

Clients of CAFCP 02 are regular visitors of this establishment (87%) and approximately 57% of them shop in this establishment, at least, once a week. Clients were asked about the main reasons for choosing this CAFCP. As regard the visit preferably reasons, results show that in a slight majority (54%), Clients' based their choice on the trust relationship in products and services provided (Table 5.8). Residence proximity was reported by 37% of them and work proximity presented 22% of the responses. The occasional visits (16%), recommendation by others (6%) and others reasons (9%) were the less frequently reported.

The percentage of participants that based its preference reason on a trust relationship did not differ by gender [U= 1.914, Z= -0.639, p< 0.05, r=0.06]. The results suggest that men and women, in average, have similar opinion on this issue. It is important to notice that, women and men second most reported choice, is residence proximity.

When asking Clients about the general appearance of the CAFCP, "acceptable" classification was used by the majority (85%) of the respondents. Only men reported the "bad" category.

As in CAFCP 01, service quality was accessed through a set of multiple questions related to Professionals' kindness, cost/quality ratio, hospitality and cleanliness. Full answer distribution is presented on Table 5.7.

Table 5.7. Evaluation of Clients' wellbeing (CAFCP 02).

Service quality	Clients' well-being satisfaction evaluation (%)		
	Negative	Satisfactory	Positive
Professionals kindness	2	18	80
Cost/quality relation	6	42	51
Hospitality	2	23	76
Cleanliness	2	15	83

Results show evidence that the majority of the Clients rated positively Professionals' kindness, hospitality, and cleanliness of the establishment. A slightly majority (51%) rated positively the Cost/quality ratio while 42% gave a satisfactory evaluation. In turn, 6% of the Clients rated negatively this issue. These results might be important in terms of marketing strategies.

A comparison of the Clients' profile from CAFCP 01 and CAFCP 02 (Table 5.8) reveals some pronounced differences regarding age. On average, Clients' age in CAFCP 01 is lowest than in CAFCP 02. Furthermore, through skewness Z-scores, it is possible to observe that age distribution of the CAFCP 01 Clients has too many low scores. In opposition, Clients of the CAFCP 02 shows frequent scores clustered at older people.

Regarding the analysis of both group of Clients by gender, results shows that in both commercial area, male population prevails.

Table 5.8. Clients profile (age and gender), by CAFCP.

ETdA supplementary variables	Descriptive statistics	CAFCP01	CAFCP02
Age	Mean	28.91	49.03
	Std. Deviation	11.371	15.001
	Z-score of Skewness (Skewness:Std. error)	3.13	-0.28
	Z-score of Kurtosis (Kurtosis:Std. error)	-2.335	-2.43
Male	(%)	50.38	65.1
Female	(%)	49.62	33,3

A few questions were included in the original version of the ETdA questionnaire in order to understand some of the Clients' complaints. These questions were suggested by managers (see section 5.2).

Regarding the evaluation of the Clients of the CAFCP 01, the results of the analysis concerning those questions showed that 79% of Clients found that background music has a positive contribution on people's wellbeing. Clients were asked if the music level, in some way, did have influence on their verbal communication, and 32% felt that background music did affected their verbal communication. Other indicators assessed trough question number 20 shows that,

Clients' awareness about noise is highly associated with Clients´ annoyance due to background music level [$\chi^2(8) = 41.540$, $p<0.001$]. The main reasons stated by Clients as being responsible for this annoyance are: alarms, console and monitors used by Clients in gaming area, advertising and warnings that pass through the intercom and the noise caused by the entertainment performances that occur on the forum shop section.

A further study was done, regarding the other Clients' complaints. Namely, the complaints related to excessive and constant number of people waiting in the queue at the checkout and high number of product returns. In this regard, results show that 13% of Clients usually return products back to this store. Product returns and payment of purchases is done on section 5 (front office and Clients' reception). Results shows evidence that the Clients that returned products under these conditions found the software to be restrictive. When managers were asked about this process, higher performance from the software on the returning products was also referred. In addition, the waiting time and the excessive and constant number of people in line at the checkout is highly associated to the used software [$\chi^2(9) = 23.352$, $p<0.05$]. Due to this, it might be important to consider the hypothesis of a separate section for returns with more skilled Professionals on these matters.

Regarding the evaluation of the Clients of CAFCP 02, 22% had difficulty to reach products on the shelves and just over half (51%) of them had difficulties to operate the shopping trolleys when they are fully loaded. Results show that shopping trolleys evaluation is highly associated to Clients' difficulties in operating the shopping trolleys [$\chi^2(25) = 80.891$, $p<0.001$] and the existence of obstacles in the passage [$\chi^2(4) = 37.162$, $p<0.001$]. This suggests that, when Clients think that the shopping trolley quality is "bad", more Clients than expected have difficulties to operate them. The existence of obstacles seems to contribute to an inadequate posture and movements of the Clients.

5.4.2. Clients' dimension profile influence

With the definition of client profiles mentioned in previous section, several correlations were studied (Level 2 of the three level analysis, presented on Chapter 4) namely, the influence of the supplementary variables on the ergonomic factors evaluation (Table 5.9 and Table 5.10.)

The influence of the supplementary variables on the ergonomic evaluation is highlighted in grey in Table 5.9. In terms of ergonomic evaluation, the results clearly show where the influence is more important:

- Clients' gender affects significantly the evaluation of lighting quality, thermal environment and lifting EFs. Regarding this subject, men are more demanding than women (mean rank for men > mean rank for women) (Table 5.11).

Table 5.9. Influence of the supplementary variables on clients' ergonomic analysis (CAFCP 01).

	Noise	Lighting	Thermal envir.	Workplace	Risk accident	Communication	Decision making	Physical activity	Lifting	Restrictiveness
Age	H(3)=4.061, p>0.05	H(3)=1,478, p>0.05	H(3)=3,615, p>0.05	H(3)=2,786, p>0.05	H(3)=4.061, p>0.05	H(3)=8.800, p<0.05	H(3)=1.168, p>0.05	H(3)=0.946, p>0.05	H(3)=3.113, p>0.05	H(3)=5.895, p>0.05
Gender	U=4.518, z=-1.900; p>0.05, r=-0.13	U=4.823, z=-2.414; p<0.05, r=-0.17	U=4.335, z=-2.33; p<0.05, r=-0.16	U=4.962, z=-0.078; p>0.05, r=-0.005	U=5.593, z=-1.710; p>0.05, r=0,12	U=4.544, z=-1.422; p>0.05, r=-0.10	U=4.305, z=-2.061; p<0.05, r=-0.14	U=4.886, z=-0.062; p>0.05, r=-0.04	U=5.927, z=-3.509; p<0.001, r=-0.21	U=4.319, z=-1.920; p>0.05, r=-0.14
Occupations	H(4)=5.338, p>0.05	H(4)=3.759, p>0.05	H(4)=5.454, p>0.05	H(4)=8.480, p>0.05	H(4)=5.454, p>0.05	H(4)=8.037, p>0.05	H(4)=1.194, p>0.05	H(4)=5.871, p>0.05	H(4)=4.804, p>0.05	H(4)=3.418, p>0.05
Qualifications	H(6)=2.104, p>0.05	H(6)=8.598, p>0.05	H(6)=5.590, p>0.05	H(6)=16.531, p<0.05	H(6)=13.151, p<0.05	H(6)=8.731, p>0.05	H(4)=5.499, p>0.05	H(6)=4,466, p>0.05	H(4)=2.347, p>0.05	H(4)=10.687, p>0.05
Regularity of visits	U=5.046, z=-0.602; p>0.05, r=0.04	U=4.595, z=-2.021; p<0.05, r=0.14	U=4.802, z=-0.397; p>0.05, r=-0.03	U=4.693, z=-0.610; p>0.05, r=-0.64	U=4.653, z=-0.503; p>0.05, r=-0.04	U=4.909, z=0.320; p>0.05, r=0.04	U=4.812, z=0.164; p>0.05, r=0.01	U=4.857, z=-0.59; p>0.05, r=-0.04	U=4.672, z=0.057; p>0.05, r=0.00	U=4.801, z=0.053; p>0.05, r=0.00

Table 5.10. Influence of the supplementary variables on clients' ergonomic analysis (CAFCP 02).

	Noise	Lighting	Thermal envir.	Workplace	Risk accident	Communication	Decision making	Physical activity	Lifting	Postures and movements	Restrictiveness
Age	H(6)=14.000, p<0.05	H(6)=6.839, p>0.05	H(6)=11.723, p>0.05	H(6)=6.634, p>0.05	H(6)=4.028, p>0.05	H(6)=5.216, p>0.05	H(6)=6.014, p>0.05	H(6)=4.244, p>0.05	H(6)=12.469, p<0.05	H(6)=8.389, p<0.05	H(6)=9.516, p>0.05
Gender	U=1.535, z=-1.901; p>0.05, r=-0.17	U=1.764, z=0.00; p>0.05, r=0.00	U=1.713, z=-0.177; p>0.05, r=0.10	U=1.528, z=-1.237; p>0.05, r=0.11	U=1.428, z=-1.135; p>0.05, r=0.10	U=1.993, z=1.363; p>0.05, r=0.12	U=1.704, z=0.029; p>0.05, r=0.00	U=1.712, z=1.218; p>0.05, r= 0.11	U=1.587, z=-1.055; p>0.05, r=0.09	U=1.604, z=-0.824; p>0.05, r=-0.07	U=1.334, z=-2.166; p<0.05, r=-0.19
Occupations	H(4)=4.144, p>0.05	H(4)=8.465, p>0.05	H(4)=1.882, p> 0.05	H(4)=1.864, p>0.05	H(4)=1.727, p>0.05	H(4)=3.548, p>0.05	H(4)=0.846, p>0.05	H(4)=6.939, p>0.05	H(4)=2.729, p>0.05	H(4)=1.551, p>0.05	H(4)=4.645, p>0.05
Qualifications	H(2)=2.642, p>0.05	H(2)=6.457, p<0.05	H(2)=2.908, p> 0.05	H(2)=0.657, p>0.05	H(2)=1.727, p>0.05	H(2)=0.066, p> 0.05	H(2)=0.269, p>0.05	H(2)=4.615, p>0.05	H(2)=2.293, p>0.05	H(2)=1.983, p>0.05	H(2)=0.950, p>0.05
Regularity of visits	U=909 z=-0.392; p>0.05, r=-0.03	U=937, z=-0.058; p>0.05, r=0.0	U=686, z=-1.979; p<0.05, r=-0.18	U=859, z=-0.651; p>0.05, r=-0.06	U=990, z=0.863; p>0.05, r=0.08	U=1.043, z=0.804; p>0.05, r=0.01	U=1.058, z=1.729; p>0.05, r=-0.15	U=621.5, z=-2.356; p<0.05, r=-0.21	U=903.5, z=-0.288; p>0.05, r=-0.03	U=770, z=-1.331; p>0.05, r=-0.12	U=1.043, z=1.398; p>0.05, r=0.12

Table 5.11. Mean rank of lighting quality, thermal environment and lifting EFs, by gender.

	Mean rank	
Ergonomic factor	**Women**	**Men**
Lighting quality	99.68	106.00
Thermal evaluation	95.21	111.38
Lifting	91.20	112.84

. Clients who evaluated the lighting quality EF are regular visitors (65%), [$\chi 2(1)= 4.103$, $p<0.05$];
. Clients who found the area to be uncomfortable are students from senior high school. The most visited areas were the gaming and the music sections.

Results obtained from Table 5.10 showed that:

. Both noise [$\chi^2(12)= 23.558$, $p<0.05$] and lifting [$\chi^2(12)= 22.578$, $p<0.05$] were significantly affected by Clients' age. On average, the most representative group of Clients, aged above 45 years old rated these EFs negatively.
. Regarding restrictiveness' evaluation, men are more demanding to situations that may cause some restrictiveness than women (Mean rank men=66.53> Mean rank women= 53.26).
. Regular Clients consistently rated more negatively the thermal environment EF. A further study on this subject showed that Clients with ages above 42 years old rated negatively this EF and that women are more sensitive to temperature variations than men [$\chi^2(2)= 7.154$, $p<0.05$; $z=1.6$].

In both CAFCP, the importance and knowledge that Clients have about the ergonomics issues were not affected by any of the studied characteristics (supplementary variables).

Accident risk – some considerations

Considering the cost of workplace accidents, organizations should evaluate all the possible options for accident prevention. This must include not only the work accidents probability, but also the hypothesis of the Clients' engagement in situations that might lead to the occurrence of accidents. Forcier et al. (2001) findings demonstrate that workplace accidents can be attributable, in part, to personality differences. If these differences can be measured, then organizations can reduce the risk of workplace accidents by making more informed decisions. These decisions must consider both Professionals' and Clients' safety consciousness or awareness.

The Analyst's risk assessment of CAFCP 02 take into consideration both Professionals' and Clients' attendance in the area. The risk assessment process allowed the identification of critical situations that need continuous supervision (see section 3; Annex 7): (1) existence of an elevator serving different levels and (2) potential fall of tools, machine parts, equipments or products and (3) Clients' difficulties in maneuvering the shopping trolleys. The Analyst considered that

situations 1 and 2 can be related to both Professionals' and Clients' behavior. Situation 3 was also considered as a potential situation that might affect Clients' wellbeing. A research by Kwong et al. (2010) presents a few recommendations regarding trolley specifications and customer expectations of trolley features. These recommendations must be considered in the development of a customer-oriented shopping trolley, minimizing the risk of accidents related to musculoskeletal disorders.

In this CAFCP, accident risk is highly associated with both Clients' age [$\chi^2(5)= 21.020$, $p<0.001$] and gender [$\chi^2(2)= 12.059$, $p<0.05$]. The possibility of occurrence of an accident as "likely" was reported by the most representative group of Clients, those with more than 66 years old. The physical performance of older Clients is expected to be responsible for their difficulties on driving the trolleys. Regarding gender differences, women gave the lowest score (the lowest is the score; the higher is the probability of an accident occurs). This suggests that they felt none unsafe than men. Wester-Herber and Warg (2002) research suggests that men tend to have more knowledge about ergonomic issues. Therefore, their estimate about the possibility of an accident occurrence is lower than with women.

Taking this into consideration, the Analyst's decision making, regarding the ergonomic intervention must consider the identification of risk behaviours that can have a negative impact on client.

5.4.3. Professionals' dimension

The Professionals' dimension characterization regarding socio demographic aspects is not possible to concretize, since the Professionals' analysis is done in an anonymous way. The Professionals' dimension profile is based on the information provided by the sector code (see section 5.1) presented in the evaluation form (Annex 2). Through an exploratory analysis, the distribution of the Professionals according to their working section is made.

The Professionals of the CAFCP 01 that were included in this study are distributed through five sections: Gaming section, SPC (Service Provided to Client), TV/Photo, Music and Books. The most representative group is related to SPC, representing nearly 37% (Figure 5.10). According to the division of the common area made by the Analyst (Table 5.2), this group of Professionals develops its activity on section 5. The other groups develop their activities on sections 1 and 2.

The distribution of Professionals on CAFCP 02 is presented in Figure 5.11. As shown, there is a wide diversity of activities. The most representative group (nearly 20%) corresponds to Professionals that develop their activities in the front office section.

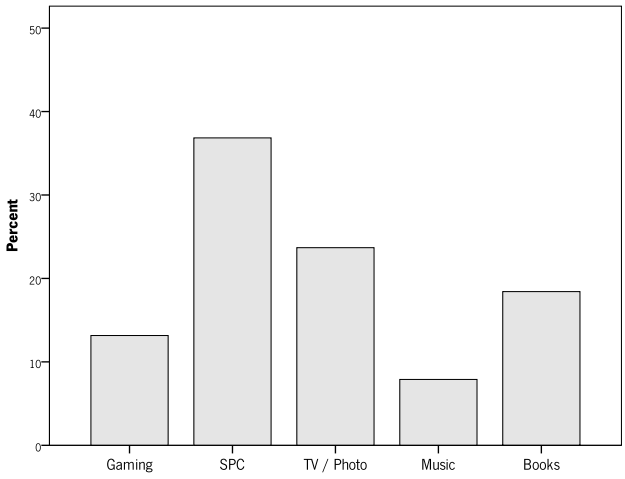

Figure 5.10. Distribution of the Professionals, by sections (CAFCP 01).

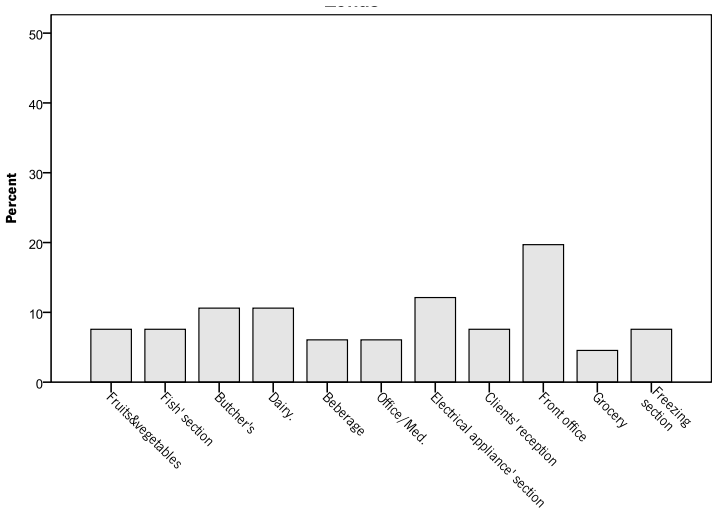

Figure 5.11. Distribution of the Professionals, by sections (CAFCP 02).

5.5.Ergonomic Variables (Ce, Pe and Ae)

In order to obtain ETdA variables that can be analyzed ensemble, an inter and intra dimension analysis of the ergonomic factors is made (Level 3). The variables are named the Ce, Pe and Ae variables as previously defined (see section 4.2.3, Chapter 4).

5.5.1. Clients' dimension

In order to develop a combined analysis of the temporary variables (Tv) to obtain a single ergonomic variable, Ce variable, an experimental study was conducted on two Qe questions, included in ETdA questionnaire, presented in Annex 3. Questions number 9 and number 20.7 were used to perform this study (questions used to evaluate the lighting quality EF). The starting point for this analysis was to understand which of those two questions (Tv questions) best reflects the Clients' perceptions regarding to lighting evaluation. Psychometric properties of the ETdA questionnaire (section 5.1) indicate that the instrument is able to differentiate the commercial

area as a usable common area, independently of the expectations of the Clients. Construct validity evaluated by means of a factorial analysis, revealed that items were loaded on two factors named “Clients’ wellbeing” and “Clients’ ergonomics perception”. The results show that the instrument has good internal consistency with a Cronbach’s alpha equal a 0.968 for the first factor and a satisfactory internal consistency for the second factor equal to 0.603. The Qe9 measures the Clients’ well-being satisfaction and Qe20.7 measure the Clients’ ergonomics perception. For this reason, it is considered that the question Qe20.7 better characterizes Clients’ ergonomics perception about this specific ergonomic factor. Therefore, question Qe20.7 is preferred to define the Ce variable related to the evaluation of lighting quality regarding Clients’ dimension.

The ETdA questionnaire psychometric proprieties must be taken into consideration on the decision of which temporary variables will be representative of the Clients’ evaluation.

The pre-processing of data regarding Qe questions (ETdA questionnaire) is presented in Table 5.12. The main purpose of this procedure is to allow a pooled analysis of the ETdA variables. In order to achieve this, standardization and recoding of the scales is required. Standardization is related to the re-scale from a negative evaluation towards a positive evaluation. Recoding is made in accordance with what was presented on subsection 4.4.1 of Chapter 4.

Table 5.12. Data pre-processing, procedures for each EF.

Ergonomic factor	Pre-processing
Noise	Scale standardization and recode
Lighting	Scale recode
Accident risk	Scale standardization and recode
Thermal environment	Scale standardization and recode
Common areas	Scale recode
Postures	Scale recode
Lifting	Scale recode
Restrictiveness	Scale recode
Decision making	Scale recode
Physical activity	Scale
Communication /interrelation	Scale recode

A comparison of the Clients’ ergonomic evaluation by CAFCP was done. The obtained values represent the mean of the EFs evaluation (3-point scale) corresponding to Ce results (Table 5.13).

Considering that the Clients’ evaluation is done through a 3-point scale, it can be said that Clients from CAFCP 01 rated positively (>2.0) the following EFs: noise, lighting, thermal environment, common area appearance and lifting. A satisfactory evaluation was obtained for the remaining EFs. Clients from CAFCP 02 rated positively noise, lighting, common area general appearance and lifting while the remaining EFs had only a satisfactory evaluation (>1 and <2).

Table 5.13. Comparison of Clients' ergonomic evaluations (Ce results) (mean), by CAFCP.

Ergonomic Factor	Ce results	
	CAFCP 01	CAFCP 02
Noise	2.62	2.77
Lighting	2.97	2.70
Risk accident	2.05	1.89
Thermal environment	2.55	2.45
Common area	2.98	2.65
Postures and movements	n.a.	1.94
Lifting	2.71	2.53
Restrictiveness	1.82	2.21
Physical activity	1.62	2.05
Communication/Interrelation	1.83	1.88

(n.a. not applicable)

A deeper study was conducted in order to test the differences between the two Clients' dimensions evaluations, regarding both CAFCP results. Results of this study are presented in Table 5.14.

Table 5.14. Comparison of both CAFCP Clients' ergonomic evaluations (Ce results).

Ergonomic Factor	Mann-Whitney Test [U, significance level; effect size]
Noise	U=14.685, z= 2.512; p <0.05, r = 0.00
Lighting	U=9.687, z= -6.548; p <0.001, r =-0.36
Risk of accident	U=10.696, z=-3.363; p <0.05, r = 0.18
Thermal environment	U=11.478, z=-2.097; p <0.05, r =-0.12
Workspace	U=11.663, z= -2.184; p <0.05, r =-0.19
Lifting*	U=11.891, z= -1.415; p> 0.05, r = -0.08
Restrictiveness	U=15.755, z= 3.923; p <0.001, r = 0.22
Decision making	U=1.993, z=-15.145; p <0.001, r = -0.90
Physical activity	U=14.906, z= 3.927; p <0.05, r = 0.22
Communication interrelation	U=10.511, z= -3.250; p <0.05, r = -0.18

The differences between the obtained mean ranks are statistically significant. The only exception observed is the lifting ergonomic factor, marked with an asterisk in Table 5.16 and as highlighted with a bold dark line in Figure 5.12.

The results of the Clients' ergonomic evaluation by CAFCP are statistically different (exception for lighting). Indeed, differences in the profiles were observed (see section 5.4.1) and, as expected from results presented in Table 5.9 and Table 5.10, these differences may, in some way, have influence on the ergonomic evaluation. As previously discussed (see section 5.4.2), the supplementary variables can have influence on the EFs evaluation. Therefore, it is expected that, for instance, Clients' age could have influence on lifting EF evaluation, i.e., oldest Clients rated with lower scores this EF (Loureiro et al., 2012).

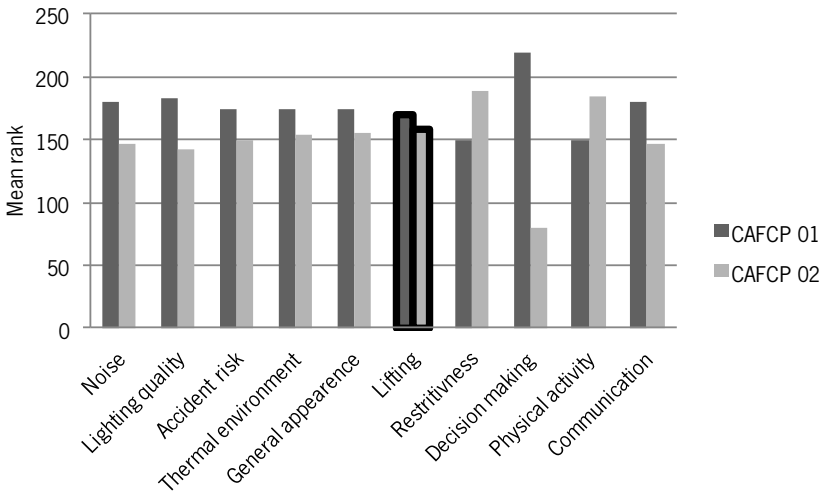

Figure 5.12. EFs Mean ranks, by CAFCP

5.5.2. Professionals' dimension

Results of the evaluation forms are based on the average computed for each assessed EF. The obtained values represent the Pe results.

Results of Professionals' evaluation from CAFCP 01 are presented in Table 5.15.

Table 5.15. Professionals' ergonomic evaluation, Pe results (CAFCP 01).

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting
Gaming	1,20	2,00	2,40	2,00	2,20	1,40	1,20
SPC	1,79	2,00	2,43	1,71	2,21	1,64	1,86
TV/Photo	1,89	2,11	2,22	1,89	2,44	2,11	2,33
Music	2,00	1,67	1,67	1,67	2,00	2,00	2,00
Books	1,71	1,86	2,43	1,57	1,86	1,29	1,29

Sections	Restritiveness	Decision making	Job content	Attentiveness	Physical act.	Comunication
Gaming	1,60	2,20	2,20	1,80	1,80	2,40
SPC	2,00	2,29	2,14	2,14	2,00	2,71
TV/Photo	1,89	2,33	2,11	1,89	2,00	2,56
Music	2,00	2,00	1,67	1,67	2,00	2,00
Books	1,71	1,71	1,43	1,43	1,29	2,00

In general, Professionals' evaluation was also satisfactory. However, two sections were negatively rated: gaming and books sections. In each of them, the EFs rated negatively were identified as follows:

- Gaming section: noise, postures and movements, lifting.
- Books section: postures and movements, lifting, attentiveness and physical activity.

Results of Professionals' evaluation from CAFCP 02 are presented in Table 5.16.

In general, the evaluation was also satisfactory. However, as negative evaluations can highlight risk situations that otherwise could not be detected, a deeper study on this subject was performed. Professionals from all sections rated negatively thermal environment.

Table 5.16. Professionals' ergonomic evaluation, Pe results (CAFCP 02).

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting
1	2,00	2,20	1,80	1,20	2,00	1,40	1,60
2	1,60	2,20	1,80	1,40	2,00	2,00	1,60
3	1,71	2,00	1,86	1,00	2,29	1,86	1,43
4	1,86	2,14	1,57	1,57	2,14	2,00	1,86
5	2,00	2,25	1,75	1,25	2,00	1,25	1,25
6	1,75	1,75	2,00	1,00	1,50	1,50	1,25
7	1,88	2,00	1,63	1,75	1,88	1,63	1,38
8	1,80	2,20	2,00	1,00	1,60	1,40	2,00
9	1,80	2,20	2,00	1,00	1,60	1,40	2,00
10	1,46	1,85	1,50	1,00	1,62	1,33	1,23
11	1,60	2,20	1,80	1,40	2,00	2,00	1,60

Sections	Restritiveness	Decision making	Job content	Attentiveness	Physical act.	Comunication
1	1,80	1,50	2,20	1,80	2,00	1,80
2	1,60	1,60	2,00	1,75	2,20	2,00
3	1,57	1,86	1,86	1,57	1,29	1,71
4	1,86	1,71	2,00	2,00	1,86	2,00
5	2,00	2,00	1,75	2,00	2,25	2,25
6	1,25	1,25	1,75	2,00	2,00	2,00
7	1,50	1,25	2,00	2,00	1,75	2,00
8	1,80	2,20	1,80	2,00	1,80	2,40
9	1,80	2,20	1,80	2,00	1,80	2,40
10	1,58	1,69	1,85	2,00	1,69	1,92
11	1,60	1,60	2,00	1,75	2,20	2,00

A different behavior was observed on Professionals working on the electrical appliances section. This result is expected, as this section does not represent a critical situation in terms of thermal environment evaluation (see section 2, Annex 7). Professionals from the front office section rated negatively the EFs related to postures and movements and lifting. Professionals from sections 1, 3, 4, 6, 7, 8, 9, also negatively evaluated these EFs. Only Professionals from the butcher's section rated negatively the physical activity EF. Decision-making and restrictiveness were negatively rated by Professionals from both office media and electrical appliances sections. This restrictiveness evaluation is probably due to the size of the displayed products.

Regarding the ergonomic factors that are concerned with physical environment, results show evidence that Professionals are, in some way, affected by thermal environment conditions.

Professionals from both CAFCP rated negatively the posture and movements and lifting EFs. This suggests that the evaluation is independent of the type of the activity. With this regard, it is important to notice that tasks that are more demanding for human body if not properly executed can be responsible for musculoskeletal injuries.

5.5.3. Analyst dimension

This section represents the results of the ETdA ergonomic analysis made by the Analyst dimension. This analysis was based on direct (directly in real work conditions with particular attention to the interrelation Professional/Client) and indirect (video recordings or photographic material) observations, interviews with supervisors, Professionals and safety staff. Simple measure devices were used in supplementary analysis of noise, thermal environmental, lighting and anthropometric study. The Analyst's results are presented on the Annex 7.

A summary of the Analyst ergonomic evaluation is presented in Table 5.17 (CAFCP 01) and Table 5.18 (CAFCP 02). The obtained values are the Ae results.

Table 5.17. Analyst ergonomic evaluation, Ae results (CAFCP 01).

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting
1	2	1	3	3	1	2	1
2	2	3	3	3	0	2	1
3	2	1	3	3	0	2	3
4	2	3	3	3	0	3	3
5	2	2	3	3	1	3	3

Sections	Restritiveness	Decision making	Job content	Attentiveness	Physical act.	Comunication
1	1	3	3	3	3	3
2	1	3	3	3	3	3
3	3	3	3	3	3	3
4	3	3	3	3	3	3
5	1	3	3	3	3	3

Table 5.18. Analyst ergonomic evaluation, Ae evaluation (CAFCP 02).

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting
1	2,00	2,20	1,80	1,20	2,00	1,40	1,60
2	1,60	2,20	1,80	1,40	2,00	2,00	1,60
3	1,71	2,00	1,86	1,00	2,29	1,86	1,43
4	1,86	2,14	1,57	1,57	2,14	2,00	1,86
5	2,00	2,25	1,75	1,25	2,00	1,25	1,25
6	1,75	1,75	2,00	1,00	1,50	1,50	1,25
7	1,88	2,00	1,63	1,75	1,88	1,63	1,38
8	1,80	2,20	2,00	1,00	1,60	1,40	2,00
9	1,80	2,20	2,00	1,00	1,60	1,40	2,00
10	1,46	1,85	1,50	1,00	1,62	1,33	1,23
11	1,60	2,20	1,80	1,40	2,00	2,00	1,60

Sections	Restritiveness	Decision making	Job content	Attentiveness	Physical act.	Comunication
1	1,80	1,50	2,20	1,80	2,00	1,80
2	1,60	1,60	2,00	1,75	2,20	2,00
3	1,57	1,86	1,86	1,57	1,29	1,71
4	1,86	1,71	2,00	2,00	1,86	2,00
5	2,00	2,00	1,75	2,00	2,25	2,25
6	1,25	1,25	1,75	2,00	2,00	2,00
7	1,50	1,25	2,00	2,00	1,75	2,00
8	1,80	2,20	1,80	2,00	1,80	2,40
9	1,80	2,20	1,80	2,00	1,80	2,40
10	1,58	1,69	1,85	2,00	1,69	1,92
11	1,60	1,60	2,00	1,75	2,20	2,00

The most problematic situations concerning CAFCP 01 are related to noise, lighting conditions, workspace, postures and movements, lifting and restrictiveness. Regarding CAFCP 02 results, it is possible to identify as most problematic situations accident risk, thermal environment conditions, postures and movements and attentiveness.

The analysis of the results was also conducted in terms of identifying the situations that lead to negative evaluations as well as the ETdA dimensions that were engaged on those situations. Results are presented in Table 5.19 (CAFCP 01) and Table 5.20 (CAFCP 02).

Table 5.19. Identification of the critical situations and the involved ETdA dimensions (CAFCP 01).

Ergonomic Factor	Critical situation	ETdA dimension
Workspace	Legs space in subsection 1 and 5	Professionals
Lifting	Shelves high and conference of products in the checkout	Clients and Professionals
Restrictivness	Conference of orders in the same place where Clients require information Existence of a common line for payment and products return Existence of products left in the corridors for restitution	Clients and Professionals
Postures and Movements	Conference activities made in subsection 1, Clients postures in subsection 3	Clients and Professionals
Lighting conditions	Glare	Clients
Acoustic environment	Alarms and advertising and warnings that pass through the intercom	Professionals and Clients

Table 5.20. Identification of the critical situations and the involved ETdA dimensions (CAFCP 02).

Ergonomic Factors	Critical situation	ETdA dimension
Postures and Movements	Clients' difficulties on operate the shopping trolleys Back pain related to products replacement tasks Conference of products in the checkout	Clients and Professionals
Accident Risk	Special attention to products replacement in the shelves	Clients and Professionals
Restrictiveness	Existence of products left in the corridors for restitution	Clients and Professionals
Attentiveness	Special attention to: Products replacement on grocery, office media and electrical appliance shelves Sale registration and payment in front office section	Professionals
Thermal environment	Special attention to the percentage of dissatisfied Professionals and Clients.	Clients and Professionals

5.6.Weighting Table Development

The development of the weighting tables is based on the ETdA variables results (Ce, Pe and Ae). For each dimension, a weighting is assigned and the values corresponding to Ae, Ce and Pe variables are added. The decision making is based upon the obtained weighted value.

In the current study, several considerations were taken into consideration in order to develop the weighting tables. Namely, the ergonomic analysis of the Analyst that was done by section, the distribution of the evaluation forms that was done by activity and the existence of two sections, 3 and 4, on CAFCP 01 designed exclusively for Clients' attendance.

Taking this into consideration, a careful data scan was required in order to ensure uniformity and coherence in the joint analysis. Regarding the last remark, it was considered that Professionals dimension weight related to sections 3 and 4 on CAFCP 01 must be zero. Through question number16 (ETdA questionnaire 1, in Annex 6) it was possible to infer about Clients that usually

attended those sections. Only those Clients' evaluations were considered on the weighting table development, regarding sections 3 and 4 of CAFCP 01.

The decision making process is based on a 3-point coloured scale. Red colour is used to highlight situations that require a short-term intervention. Yellow identifies the situations that required a medium-term intervention and green represents non-critical situations. Regarding these weighting table results, the Analyst identifies the red colours within the table. Sections and corresponding EF are also identified. The two weighting tables designed for CAFCP 01 and CAFCP 02 are provided below, Table 5.21 and Table 5.22, respectively. As an example each ETdA dimension was assigned with a 33% weight.

To perform the Weighting Table of CAFCP 01, the sections were organized taken into consideration the division suggest by the Analyst (see Table 5.4). Results within the table are presented as follows: section 1 includes Gaming 1, Music 1, TV/ photo 1 and Books 1; section 2 includes Gaming 2, Music 2, TV/ photo 2 and Books 2. These two sections, as well as section 5 (SPC), are weighted by the three dimensions. Results of Gaming 3 and Kids' areas are weighted by Clients' and Analyst's dimensions. Postures and movements, job content and attentiveness are assessed by Professionals' and Analyst's dimensions. In order to allow a joint analysis of the ETdA variables, and taking into consideration what was mentioned above, a new division of the CAFCP 01 was made by the Analyst, and presented in Table 5.19. The results obtained on the weighting tables regarding kids' and gaming 3 sections are represented in grey, as these sections are exclusive for Clients' attendance, being evaluated by the Analyst's and Clients' dimensions. It should be highlighted that this analysis is focused on the study of Clients' dimension influence on the decision. Taking this into consideration, job content and attentiveness will not be considered in this study, as they were only assessed by Analyst and Professionals dimensions. The grey colour was used to identify the two columns related to these EFs as well as to identify the gaming 3 and kid's sections.

Table 5.21. CAFCP 01 Weighting table (33% of weight).

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restrictiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	1,94	1,99	2,48	2,52	2,06	1,70	1,64	1,47	2,71	2,60	2,40	2,57	2,41
Gaming 2	1,94	2,66	2,48	2,52	2,06	1,70	1,64	1,47	2,71	2,60	2,40	2,57	2,41
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,21	1,88	2,24	2,41	1,99	2,00	1,90	1,61	2,64	2,34	2,34	2,64	2,28
Music 2	2,21	2,55	2,24	2,41	1,99	2,00	1,90	1,61	2,71	2,34	2,34	2,50	2,41
TV/Photo 1	2,17	2,03	2,42	2,48	2,14	2,06	2,01	1,57	2,75	2,60	2,56	2,64	2,46
TV/Photo 2	2,17	2,69	2,42	2,48	2,14	2,06	2,01	1,57	2,75	2,56	2,45	2,64	2,46
Books 1	2,11	2,03	2,42	2,48	2,14	1,65	2,01	1,57	2,75	2,22	2,22	2,64	2,46
Books 2	2,11	2,61	2,49	2,37	2,14	1,65	1,67	1,51	2,54	2,22	2,22	2,40	2,28
SPC	2,14	2,32	2,49	2,42	2,06	2,32	2,52	1,61	2,74	2,60	2,40	2,64	2,51
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Results show evidence that the yellow colour is the most prevalent. Restrictiveness is the most critical ergonomic factor (red cells). Regarding this issue, a short-term intervention is required in gaming 1 and 2. It is possible to notice a value of 1.51 in the section Books 2, which is close to the boundary between the yellow and red borderline.

The Weighting value for each situation is obtained according to equation (5.1) and (5.2):

$$\text{Weighting Restrictiveness (Books 2)} = \frac{1}{3}Ce+\frac{1}{3}Pe+\frac{1}{3}Ae=\frac{1}{3}1.82+\frac{1}{3}1.70+\frac{1}{3}1=1.51 \quad \text{Eq. (5.1)}$$

$$\text{Weighting Restrictiveness (Gaming 1, 2)} = \frac{1}{3}Ce+\frac{1}{3}Pe+\frac{1}{3}Ae=\frac{1}{3}1.82+\frac{1}{3}1.60+\frac{1}{3}1=1.47 \quad \text{Eq. (5.2)}$$

Regarding the weighted results obtained for Gaming 1 section and taking into account what was presented in Table 5.19 (identification of situations that might cause restrictiveness), a further study was done on this subject. Results of an exploratory analysis made on restrictiveness EF show that 100% of Professionals rated satisfactory this EF while 42% of Clients who usually attend to this section gave a negative evaluation. Clients' evaluation (Mdn= 121.54) about restrictiveness did not differ significantly from Professionals evaluation (Mdn= 127.39), [U= 5.344, Z= - 0.600, $p>0.05$, r= -0.04]. The exploratory analysis presented in section 5.4.1 helped in these results' interpretation. Restrictiveness is assessed through question number 18 in ETdA questionnaire 1 (Annex 6). This question evaluates the existing software in terms of its capability on helping Professionals access the information requested by Clients regarding, for example, the products on stock. Results show that 77% of Clients who usually attend this section are satisfied with Professionals' training. This suggests that restrictiveness may be related to software performance instead of Professional skills. Indeed, restrictiveness' evaluation is highly associated to software performance evaluation [$\chi^2(12)= 30.371$, $p<0.001$]. This result is expected because in these workstations, the conference of orders is done using the same computer where Professionals do products consulting by Clients demand. This example clearly demonstrates Clients' importance on the evaluation of the restrictiveness.

Restrictiveness' results regarding section 2 (book and gaming) can be explained by the existence of stocks left in the passage, near the shelves. Throughout the day, Professionals place them in the shelves. This can be restrictive as it can prevent or hinder the passage of Clients or Professionals.

In this CAFCP nearly 50% of the Clients are male and according to the results presented on Table 5.9, men are more demanding with regard to situations that may cause some restrictiveness. Therefore, the holistic approach of the problem allowed the identification of situations that might cause restrictiveness.

The weighting table for CAFCP 02 is presented in Table 5.22.

The two ergonomic factors that will be considered to the analysis are signed with an asterisk (*) in Table 5.22, representing a short-term and priority intervention (red colour).

The Weighting value for each item was obtained as indicated in equations 5.3 and 5.4:

$$\text{Weighting Accident risk} = \frac{1}{3}Ce+\frac{1}{3}Pe+\frac{1}{3}Ae=\frac{1}{3}1.89+\frac{1}{3}1.50+\frac{1}{3}1=1.46 \quad \text{Eq. (5.3)}$$

$$\text{Weighting Thermal environmental} = \frac{1}{3}Ce+\frac{1}{3}Pe+\frac{1}{3}Ae=\frac{1}{3}2.45+\frac{1}{3}1+\frac{1}{3}1=1.48 \quad \text{Eq. (5.4)}$$

Table 5.22. CAFCP 02 Weighting table (33% of weight).

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restrictiveness	Decision making	Job content	Attentiveness	Physical act.	Communication
1	2,59	2,63	1,90	2,22	2,55	1,78	2,04	2,00	2,18	2,60	2,40	2,29	2,10
2	2,46	2,63	1,90	2,28	2,55	1,98	2,38	1,94	2,22	2,50	2,27	2,36	2,17
3	2,50	2,57	1,91	1,48 *	2,65	1,93	1,99	1,93	2,30	2,43	2,21	2,05	2,07
4	2,54	2,61	1,82	1,67	2,60	1,65	2,13	2,02	2,25	2,50	2,35	2,24	2,17
5	2,59	2,65	1,88	2,23	2,55	1,40	1,93	2,07	2,35	2,38	2,35	2,38	2,25
6	2,51	2,48	1,63	2,15	2,38	1,48	1,93	1,82	2,10	2,38	1,68	2,29	2,17
7	2,55	2,57	1,50	2,40	2,51	1,52	1,97	1,90	2,10	2,50	1,68	2,21	2,17
8	2,52	2,63	2,30	1,82	2,08	1,78	2,51	2,34	2,42	2,40	2,35	2,23	2,30
9	2,52	2,63	2,30	1,82	2,08	1,45	2,51	2,00	2,42	2,40	2,02	2,23	2,30
10	2,41	2,51	1,46*	2,15	2,42	1,43	1,92	1,93	2,25	2,42	1,68	2,19	2,14
11	2,46	2,63	1,90	1,62	2,55	1,98	2,04	1,94	2,22	2,50	2,27	2,36	2,17

The first obtained value is related to the front office section and the second one corresponds to butcher' section. Taking into consideration information provided on Table 5.20, both Clients and Professionals dimensions can be involved in the identified situations. According to the Analyst evaluation (see section 3, in Annex 7), accident risk on the front office section is related to awkward postures during the conference of products on the payment process. Regarding thermal environment evaluation, results showed that 69% of the Professionals and 36% of the Clients rated negatively this EF. The hypothesis that tests if both dimensions have the same sensation is rejected [U= 274.50, Z= -13.716, p< 0.001, r= -0.9]. In fact, they are not statistically significantly related [$\chi^2(2)$= 0.801, p>.05]. On average Professionals' dimension reported lower classification (Mdn= 68.29) than Clients' dimension (Mdn= 154.46). It is interesting to observe that the highest standardizing residual' value within the contingency table, is related to a positive evaluation on Clients' dimension and a negative evaluation on Professionals' dimension (Loureiro, Leão and Arezes, 2011). This suggests that, when Clients think that temperature level is "good", more Professionals than expected consider the temperature as an ergonomic risk factor. Indeed, thermal environmental conditions and the fact that Professionals do not want to use appropriate clothes to face low temperatures may be the reason for Professionals' negative evaluation. According to results presented on Table 5.10 (see section 5.4.2), supplementary variables did have influence on thermal environment evaluation in opposition to accident risk. In fact, results showed that regular visitors, older Clients and women rated consistently more negatively thermal environment EF. Despite the positive evaluation on this EF from the Clients, these issues should be taken into consideration on the decision-making process, as Clients are integrated on the whole system, and organizations are focused on their wellbeing.

Regarding the medium-term interventions, related to yellow colours presented in Tables 5.21 and 5.22, a priority list of ergonomic intervention is proposed. This list is based upon the following procedure: situations corresponding to weighted values closer to 1.50 are considered to have priority in relation to those presenting weighted values around 2.50.

5.7. Decision-making

A study on the influence of the weights in decision making is also required as different weights might lead to different decision-making. The novelty brought by the ETdA model is the addition of the Clients' dimension to the ergonomic analysis and decision-making. This is the reason why in this study, different weights are studied regarding Clients dimension. The weights that will be studied were presented in Table 4.9 (see section 4.4.2). The study is based on the number of

red, yellow and green cells and observed type of changes: red to yellow (in both directions), yellow to green (both directions) and green to red (both directions). It should be highlighted that the Weighting tables 1, 2 and 3 represent an occupational ergonomic analysis, as Clients dimension was not weighted.

To ensure that the study will be focused on Clients' influence, equal weights are assigned to Professionals and Analyst dimensions. Taking this into account, several weighting tables were obtained for the CAFCP 01 and CAFCP 02, as presented on Annexes 8 and 9.

A further study on this subject is presented in the following paragraphs.

CAFCP 01

A summary of the weighted results regarding the identification of the number of decisions is presented in Table 5.23.

Results show that increasing weights given to Clients dimension are related to changes from red to yellow and green to yellow (both directions).

In fact, by comparing the results from tables 1 and 4 (Annex 8), it is possible to observe that the difference between the red cells (19-10) does not imply an increase, on the same proportion, in green cells (22-28). It is also important to remark that no green changes to red or red to green were observed.

Table 5.23. Number of decisions, by different weighting table (CAFCP 01).

	Weight percentage			Decision Making		
Weighting table	**Client**	**Analyst**	**Professional**	**R**	**Y**	**G**
1	0	50	50	19	58	22
2	0	25	75	8	80	11
3	0	75	25	27	23	49
4	5	47,5	47,5	10	61	28
5	10	45	45	10	59	30
6	25	37,5	37,5	5	66	28
7	1/3	1/3	1/3	2	70	27
8	40	30	30	0	75	24
9	50	25	25	0	74	25
10	70	15	15	0	58	41
11	80	10	10	0	55	44
12	90	5	5	0	36	63
13	100	0	0	1	28	70
14	0	0	100	6	89	4
15	0	100	0	23	10	66

Regarding Clients' dimension, weights above 33% do not yield any effect on the number of red cells. Results also show evidence that the number of green cells increases substantially with a 70% weight given to this dimension. This situation is expected as Clients' dimension presents the greatest number of green cells (Weighting table 13, in Annex 8). It is also possible to observe that

the number of green cells is approximately the same on the weighting tables 13 (100% Clients) and 15 (100% Analyst) (Annex 8). The main difference lies on the number of red and yellow cells.

In order to understand the influence of Clients on the decision making process, a further study on this subject was made. This study was based on the observation of the type of changes that occurs with different weights. Ergonomic factors and sections affected by the weight were also assessed. Each type of changes is studied separately. Additional information related to the changes on the values corresponding to the decision-making are also provided.

Results presented in Table 5.24 show that red to yellow changes (R/Y) were identified in the following ergonomic factors: lighting, lifting, restrictiveness and workspace. These changes were observed in all analyzed sections.

Table 5.24. Study of the red to yellow changes, by weight

Clients' weight	Ergonomic factor	Sections	Additional information
0%→5%	Lighting	Gaming 1	1.50→1.57
	Workspace	Music1,2	1.50→1.57
		Books 2	1.43→1.51
	Restrictiveness	SPC	1.50→1.52
	Lifting	Music 1,2	1.50→1.56
10%→25%	Lifting	Books 2	1.30*→1.57
	Restrictiveness	TV1,2 and Book 1	1.48→1.54
25%→33%	Lifting	Gaming 1,2	1.50→1.64
	Restrictiveness	Books 2	1.47→1.51

It is possible to observe that values related to R/Y changes, are in the boundaries of the decision limit (1.50). Nevertheless, an outsider value corresponding to 1.30 is identified and marked with an asterisk (*) within the table. The weighted equation on this EF (equation 5.5) suggests that the highly rated Clients' evaluation might be responsible for this weighed value. Due to this fact, a small weight in the Clients dimension produces a change in the decision result.

$$\text{Weighting Thermal environmental} = \frac{1}{4}Ce+\frac{3}{8}Pe+\frac{3}{8}Ae=\frac{1}{4}2.91+\frac{3}{8}1.29+\frac{3}{8}1=1.30 \qquad \text{Eq.(5.5)}$$

Results presented in Table 5.25 show green to yellow changes (G/Y).

Results show that changes from green to yellow (G/Y) are related to accident risk and communication/interrelation. The weighted values related to this type of change are in the boundaries of the decision limit corresponding to 2.50. Observed changes occur in the interval [10 - 40] % weight regarding Clients dimension.

Table 5.25. Study of the green to yellow changes, by weight.

Clients' weight	Ergonomic factor	Sections	Additional information
10%→25%	Communication	Gaming 1, 2	2.61→2.48
	Accident risk	Music 2	2.54→2.46
25%→33%	Accident risk	Gaming 1, 2	2.54→2.48
		Books 2, SPC	2.55→2.48
33%→40%	Communication	Tv/photo 1, 2	2.54→2.46
		Books 1, 2	2.54→2.46

Finally, Table 5.26 shows the number of observed changes from yellow to green (Y/G).

Table 5.26. Study of the yellow to green changes.

Clients' weight	Ergonomic factor	Sections	Additional information
0%→5%	Lighting	Gaming 2	2.50→2.52
	Decision	Music 1	2.50→2.52
	Physical activity	Music 1; Photo1,2;	2.50→2.52
		SPC	2.50→2.52
5%→10%	Thermal env.	Gaming 1, 2	2.50→2.51
10%→25%	Lighting	Books 2	2.48→2.57
	Accident risk	TV/photo1,2;Books 1	2.45→2.57
	Physical activity	Gaming 1, 2	2.45→2.53
25%→33%	Lighting	Music 2	2.49→2.55
	Decision	Books 2	2.50→2.54
	Lifting	SPC	2.50→2.52
50%→70%	Lighting	TV/photo1;Books 1	2.26→2.55
		SPC	2.49→2.68
	Thermal	TV/photo1,2;Books 1	2.50→2.52
			2.29→2.57
			2.24→2.54
	Workspace	All sections	2.35→2.60
			2.21→2.52
			2.29→2.57
70%→80%	Lighting	Music 1	2.48→2.64
	Thermal	Music 1,2; SPC	2.49→2.51
80%→90%			2.42→2.52
			2.50→2.52
	Noise	All sections	2.49→2.56
			2.47→2.54
			2.48→2.55
	Thermal env.	Books 2	2.50→2.52
			2.39→2.55
	Lifting	All sections	2.47→2.59
			2.50→2.61
			2.40→2.55

As expected from results analysis from Table 5.23, Y/G changes were the most significant ones. From a Clients' weight of 5% it is possible to observe the influence of Clients on decision making.

The weighted values responsible for changes on the decision making are close to the boundary limit corresponding to 2.50. However, a group of values corresponding to workspace evaluation, ranged from 2.20 to 2.30, lead to Y/G changes. These values are related to a 50% weight attributable to Clients' dimension.

CAFCP 02

A summarization of the results regarding the identification of the number of decisions is presented in Table 5.27. Results show that increasing weights given to Clients dimension are related to changes from red to yellow and green to yellow (both directions). No green changes to red or red to green were observed. Weights above 40% do not yield a significant effect, meaning that also no occurrence from red to yellow has been identified.

Table 5.27. Number of decisions, CAFCP 02.

	Weight percentage			Decision Making		
Weighting table	**Client**	**Analyst**	**Professional**	**R**	**Y**	**G**
1	0	50	50	14	89	18
2	0	25	75	19	102	0
3	0	75	25	12	35	74
4	5	47,5	47,5	10	82	29
5	10	45	45	10	86	25
6	25	37,5	37,5	8	92	21
7	1/3	1/3	1/3	7	90	24
8	40	30	30	4	91	26
9	50	25	25	0	91	30
10	70	15	15	0	91	33
11	80	10	10	0	88	33
12	90	5	5	0	88	35
13	100	0	0	10	86	44
14	0	0	100	24	67	30
15	0	100	0	12	97	12

The same procedure as presented to CAFCP 01, was done. The type of change that occurs with different weights was observed, so as to identify the ergonomic factors and sections that are implicated. Each type of change is studied separately.

Results presented in Table 5.28 show red to yellow changes (R/Y). These changes were identified in the following ergonomic factors: accident risk, thermal environment and postures and movements. Sections 4, 6, 7 and 11 were the most reported.

Table 5.28. Study of the red to yellow changes, by weight.

Weighting table	**Ergonomic factor**	**Sections**	**Additional information**
0%→25%	Thermal environment	4	1.46→1.58
		11	1.32*→1.51
25%→33%	Accident risk	7	1.46→1.50
	Postures and movements	7	1.47→1.52
33%→40%	Accident risk	10	1.46→1.50
	Thermal environment	3	1.48→1.58
	Postures and movements	6	1.46→1.53

Results also allow the identification of the weighted values close to the boundaries of the decision limit, corresponding to 1.50. These values are in the interval [1.46, 1.48]. The value corresponding to 1.32 (marked with an asterisk in the table) is considered an outlier. Regarding the weighting equation for this weight value (equation 5.6) it is possible to say that a weight of 25% on Clients dimension is enough to produce a change on the decision making. This is an expected result, as a highly value for Ce was obtained.

$$\text{Weighting Thermal environmental} = \frac{1}{4}Ce+\frac{3}{8}Pe+\frac{3}{8}Ae=\frac{1}{4}2.45+\frac{3}{8}1.40+\frac{3}{8}1=1.32 \qquad \text{Eq. (5.6)}$$

Results presented in Table 5.29 show changes from green to yellow (G/Y). Results show that changes from green to yellow (G/Y) are related to the following EFs: decision making, physical activity and communication/interrelation.

Table 5.29. Study of the changes green to yellow, by weight.

Clients' weight	Ergonomic factor	Sections	Additional information
0%→5%	Accident risk	8	2.50→2.47
	Decision Making	9	2.54→2.46
		2	2.53→2.42
	Physical activity	5	2.55→2.44
10%→25%		11	2.53→2.42
		5	2.51→2.34
	Communication	8	2.58→2.40
		9	2.58→2.40

Both communication/interrelation and decision-making are included in the group of organizational EFs. The weighted values related to the identified changes are closed to the boundary of the decision limit (2.50). The sections involved are 2, 5 8, 9 and 11. Most of the changes occur with a 25% weight, regarding Clients' dimension.

Results presented in Table 5.30 show Yellow changes to Green (Y/G).

Table 5.30. Study of the from yellow to green, changes.

Weighting table	Ergonomic factor	Sections	Additional information
25%→33%	Noise	8, 9	2.49→2.52
	Lighting	10	2.49→2.51
	Workspace	7	2.41→2.51
50%→70%	Noise	2	2.49→2.51
		11	2.49→2.54
70%→80%	Noise	10	2.50→2.66
80%→90%	Workspace	8, 9	2.48→2.57

Results shows that Y/G changes were observed on noise, workspace and lighting EFs. These changes are related to sections 2, 7, 9, 10 and 11. Once more, the values that determine the changes are positioned in the boundary limit, corresponding to 2.50.

5.8. A Comparative Study by CAFCP

A comparative study on results obtained from the weighting tables by CAFCP, was done. This study comprises two different analyses. The first one is focused on the weightings and the other one on the EFs sensitivity. The results of these analyses are presented in the following paragraphs.

5.8.1. Analysis by Weight

Results show that increasing weights given to Clients dimension are related to changes from red to yellow and green to yellow (both directions). No green changing's to red or red to green where observed.

Regarding CAFCP 01, it is possible to observe the influence of Clients on the decision-making, R/Y and Y/G, from a weight of 5%, while in CAFCP 02 it is necessary a minimum of 25%. G/Y changes occur from a weight of 10% regarding CAFCP 01 and 5% on CAFCP 02. Some considerations about these values must be done:

- Changes produced with a 5% weight regarding Clients dimension, can have different meanings.
- The weighted values can be very close to the boundary of the decision limit (equations 5.1, 5.2 and 5.3).
- Ce value is very different from Ae and Pe values (equations 5.4, 5.5 and 5.6).

In both situations, a small weighting values assigned to Clients' dimension produces a change in decision making.

In this comparative analysis, it is also important to highlight the differences between the Professionals' evaluations from each CAFCP. These differences can be checked trough tables 5.15 and Table 5.16. In general, Professionals from CAFCP 02 gave lower scores than Professionals from CAFCP 01.

Another important remark is related to the analysis of the results from the weighting tables corresponding to 1/3 of weight for each dimension. Different decision making can be observed and therefore different list of priorities. Considering the example of what is a priority in CAFCP 01, restrictiveness regarding gamming section, and what is a priority in CAFCP 02, postures and movements on butcher's section. The differences observed on Clients profile from both CAFCP should also be considered on the decision-making process. As different profiles and weighting tables can be obtained according to the commercial area under, these considerations suggest that results should not be extensible to other companies of the same franchising.

5.8.2. Analysis by Ergonomic Factor (EF)

Differences on the evaluations between the pair AP and AC were also analyzed (Tables 5.31 and 5.32). This study was conducted by EF using the results from the weighting tables presented in Annexes 8 and 9. This procedure allows analyzing the different sensibilities to the EF under

study. Once more, the number of cells regarding the decision-making, were counted. Weighting tables 1 (AP evaluation) and 16 (AC evaluation) were considered to perform this study.

Regarding CAFCP 01, similar results are obtained on accident risk (positive evaluation), restrictiveness (negative evaluation), decision making (positive evaluation) and postures and movements (satisfactory evaluation) (Table 5.31). Regarding the study on restrictiveness presented above, these results are expected as Clients and Professionals' dimensions can be involved on situations that were identified as responsible for restrictiveness.

Table 5.31. Comparative study of the pair AP and AC, CAFCP 01.

Ergonomic factor	Red cells		Yellow cells		Green cells	
	AP	AC	AP	AC	AP	AC
Noise	0	0	9	0	0	9
Lighting	2	0	6	5	1	4
Accident risk	0	0	2	0	7	9
Thermal environment	0	0	9	0	0	9
Workspace	3	5	6	4	0	0
Postures/movements	0	0	9	9	0	0
Lifting	5	0	3	8	0	1
Restrictiveness	9	8	0	1	0	0
Decision making	0	0	0	0	11	11
Physical activity	0	0	9	2	0	7
Communication	0	0	2	9	7	0

Results of pair AP are lower than pair AC, on physical environmental EFs such as: noise, lighting and thermal environmental. These results were already expected regarding the number of working hours (in average, 8 hours per day, 6 days per week). Physical activity' evaluation is in the same situation. Results of pair AC are lowest regarding communication/interrelation EF.

Regarding CAFCP 02, results are similar on noise and lighting EFs (positive evaluation), postures and movements (negative and satisfactory evaluations) and lifting and restrictiveness (satisfactory evaluation) (Table 5.32).

Table 5.32. Comparative study of the pair AP and AC, CAFCP 02.

Ergonomic factor	Red cells		Yellow cells		Green cells	
	AP	AC	AP	AC	AP	AC
Noise	0	0	0	0	11	11
Lighting	0	0	0	0	11	11
Accident risk	3	0	8	8	0	3
Thermal environment	5	0	6	5	0	6
Workspace	0	0	9	3	3	9
Postures/movements	5	5	6	6	0	0
Lifting	0	0	11	8	0	3
Restrictiveness	0	0	11	10	0	1
Phisical activity	0	0	8	11	0	3
Decision making	0	0	11	0	0	11
Communication	0	0	0	11	0	0

The obtained results for noise and lighting conditions were expected regarding the Analyst evaluation of physical environment conditions. The pair AP rated more negatively the thermal

environment EF, risk accident and general appearance of the store. Results concerning the thermal environment conditions are already expected due to thermal conditions that this area presents and regarding the number of working hours (in average, 8 hours per day, 6 days per week). Even though the pair AP is rated more negatively than accident risk, the number of yellow cells is equal. This suggests that Clients might also be aware about the hazards. The pair AC rated more negatively communication/interrelation and physical activity EFs.

5.9.ETdA: New Applications

In order to test the use of ETdA methodology in a different context from the one developed in the commercial areas, a study case in the health sector was also performed in the framework of a Master thesis (Fernandes, 2011). This study case was conducted on four physical therapy clinics. The ergonomic contexts defined in these clinics are a clear example of the interrelationship between patients and Professionals. Physical therapists undergo an intense physical and emotional workload. It is known that most of the complaints reported by these Professionals are related to mismatch furniture, lack of space in the workplace and use of unsuitable equipment (Fernandes et al., 2011). These factors are related to several identified situations such as: handling of patients, static postures and flexion and rotation of the spine. The main purpose of physical therapists is to promote the health and well-being of patients helping them to achieve the maximum functionality and quality of life.

General guidelines, as presented on Chapter 4, were used in the implementation of the ETdA methodology. The first step of ETdA implementation was the contact between the Analyst and managers of the physical therapy clinics under study. This contact aimed to present and define the ETdA planning. The second step was related to the application of the ETdA observation tools. It is important to notice that, although ETdA questionnaires were developed in a commercial sector, their use can be generalized to other sectors. In this case, it was suitably adapted to be used in the considered health care systems. Regarding the original version of the ETdA questionnaires, the adjustments that were made were related to terminology. A pre-test was performed using the adapted ETdA questionnaire to check if the questions were correctly interpreted by this type of Clients (patients). Evaluation forms and direct and indirect observation remained similar to those presented on Annexes 1 and 2. Finally, the last step was related to data collection provided by the observation tools. The obtained information was then used to develop the weighting tables, one for each clinic. These tables were used to support the Analyst on the decision making process.

Briefly, it is possible to highlight that the obtained results showed differences on the evaluations given by the pair Patient/Analyst and Professional/Analyst. Analysis of the supplementary variables allowed the identification of patients' characteristics that might have influence on the decision-making to ergonomic intervention. Indeed, patients' evaluation highlighted the existence of critical situations that otherwise would not be identified.

ETdA model initially designed to perform an ergonomic analysis on commercial areas was also validated to be used in areas where people freely circulated independently of the economic sector.

5.10. ETdAnalyser Development

The final stage of the ETdA development was related to the establishment of a computational system that can helps the Analyst to implement this ergonomic model in common areas. Folmer and Bosch (2004) stated that "Software is developed with a particular purpose, to provide specific functionality to allow a stakeholder to support a task in a specific context". Taking this into consideration, a model framework, ETdAnalyser, was proposed to provide the Analyst with a fast and simple way of collecting and analyzing data. Ultimately, the application domain of the ETdAnalyser is the ergonomics field, providing a supporting tool to the ergonomic decision.

Considering the Ergonomic Tridimensional Analysis, ETdA, designed specifically for common areas with free circulation of people, it was considered that stakeholders, such as users of the ETdAnalyser, were the Analysts who provided the ergonomic analysis and proposed the correspondent ergonomic intervention. At this point of development, the major concern of the ETdAnalyser was to architect a software that presents a level of functionality that allowed the Analyst to collect data and analyze jointly the three ETdA dimensions results (Clients, Professionals and Analyst). In the future, specific attributes, such as performance and usability, which contribute to the quality of software, must be studied. A first step in further research could be the study of the ETdAnalyser usability. Closer investigation is required to examine the relationship between usability patterns, usability properties' and usability attributes of the ETdAnalyser.

As it was previously mentioned (see Chapter 1), this software development was the outcome of a project undertaken in the framework of this PhD thesis, together with a group of students of Computer Engineering (Teixeira, Costa, Loureiro, Leão and Arezes, 2012). Initially, two objectives related to ETdAnalyser development were proposed: learnability and functionality. That is, the product was meant to be user-friendly, and the system meant to efficiently complete the proposed tasks.

Several steps were identified in the ETdAnalyser development and presented in Figure 5.13.

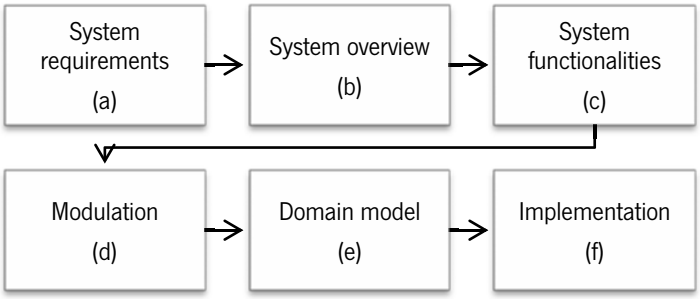

Figure 5.13 Main steps of ETdAnalyser development.

Considering the ETdAnalyser development, system requirements ((a) in Figure 5.13) were related to the analysis of the main tasks that the Analyst performs and the time required to execution. Three main tasks were identified:

(1) Design of the analysis (including the setup of the items),
(2) Definition of data input
(3) Generation of the report.

The tasks that could be automated were related to the data input and report generation. Also, to simplify even further the process of data input, it was decided to create a web based platform. This platform allowed Clients and Professionals, to submit the forms (web forms). Since some data could already be in a digital format, it was first necessary, to develop a way to import them into the system (file import). In this case the analyzer could input the data, through a user-friendly interface (direct submission).

Regarding the analysis creation allowing the forms to be available and for the report generation, a standard application with access to centralized data (data must be always updated) was developed.

In this system two types of users had to be taking into account: one type included the Analysts and the second, the Clients and Professionals. They play very different roles, and the system had to be designed to assemble both of their needs. Regarding the web based platform, it had to be simple, intuitive, and provide a quick operation. This was a very important issue since Professionals would fill the forms during working time and Clients would not agree to participate if it takes much of their time. Considering that the application is for Analysts' restrictive application, it is important that the language used was concise with accurate technical terminology, leaving no place for misunderstandings or ambiguity.

The major concern regarding the presentation of results in form of report, was related to text and graphical presentation of the results. At this stage, the definition of a colour scale representing the decision-making to ergonomic intervention and, the possibility of graphic drawing to present the results of supplementary variables analysis, were considered.

A Website was the option made to insert the ETdA observation tools into the system. Another important issue that has contributed to the website option was related to the possibility of the Analyst to process information related to more than one establishment. Regarding this issue it was considered that Web was an easy way to collect data.

Regarding the domain model, the Analyst defined the procedure for analysis according to the work organization. At this point of time, Analyst did also define which ergonomic factors should be studied and the weighing of the results.

The submission of the data forms into the database could be made by three different ways. The first one was related to hand copy an existing paper form to the application. The other was related to import a file onto the application. The last one was by submitting the form directly through the website.

When the Analyst verified that data collected is adequate to reproduce reliable information, a report of the results could be generated by the application. This report consists of statistical data and graphical representation, considering the analysis made by Professional activity, zone or common place (in a defined scale). Depending on the result, the Analyst defined the ergonomic intervention.

The application was multi-user, meaning that, several Analysts may take advantage of the application simultaneously.

In order to help the Analyst planning, a "concept-projects" was created, that is a project stands for a work/commercial space. In this way, a registered Analyst may have several projects, an each of them several analyses. The diagram of the domain model in illustrated in Figure 5.14.

Regarding the use cases, as well as their participants, two sub-systems, the website, and the application were defined. In the applications, the more basic operations were management (add, edit, delete) of the projects, analyses and Analysts. As it was mentioned before, the edition of the analysis was a pre-procedure; therefore it was not included in this section of the application. It was given the possibility to generate the web forms, insert data manually or generate the report during the edition of an analysis. In the first case, it was possible to generate a new web form or open an existent one. Then for each type of form it could be added/edited questions, the type of answer to be used and made a proper association of the questions to the items. The checklist was automatically generated, due to its nature. The manual data input was done directly on the application, but once the website allowed the forms input, it was decided to integrate it, into the application. In this way, the Analyst did not have to leave his/her working environment (application) to perform another task.

After the creation of a project analysis and insertion of data, by any of the given options, it was possible to generate the report. Several situations were considered in this task. The first one was related to the existence of an option that allowed the introduction of the results according the activities, sections or common areas. The other one was the possibility for the Analyst to insert comments about the result, and/or insert statistical data about the Clients' profile. The comments may be actions (ergonomic decision-making) to be taken regarding a specific item, tips to improve the result, among others. Taking this into account, it was possible to generate a report based on the given options. The application automatically created a document with the result, the comments added, and the statistics. The graphic generation was part of the document handling program, therefore was not necessary to create a specific sub-system to perform this task.

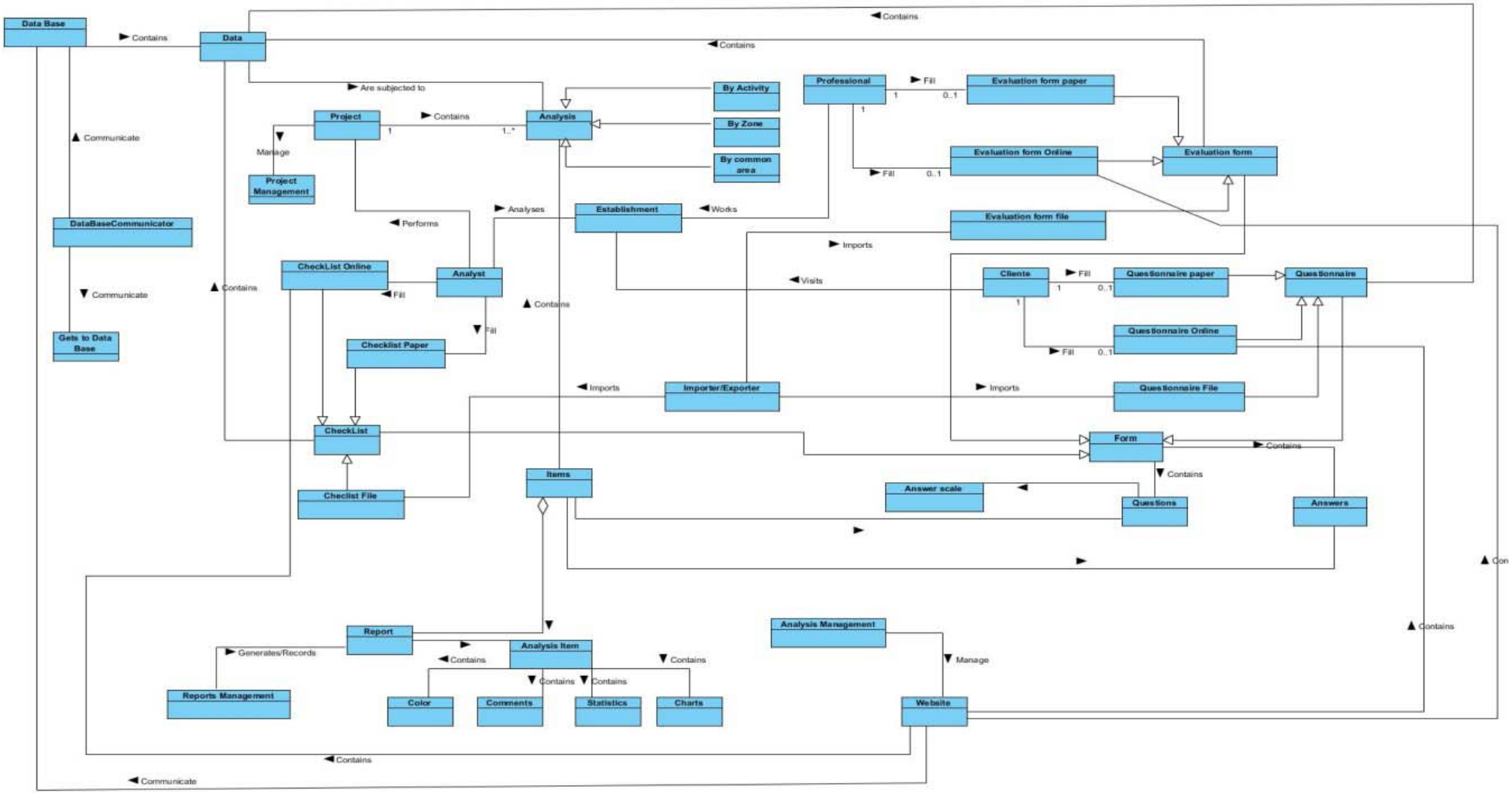

Figure 5.14 Domain model diagram

In order to coloured the ETdAnalyser software application, running examples will be presented in Figure 5.15. The data collected from the application of ETdA in CAFCP 02 was used to test the ETdAnalyser functionality. A part of the report Management is presented in Figure 5.16. As it is possible to see, a scale using a gradient of colours is used. The obtained colour will determinate the Analyst decision for the ergonomic intervention.

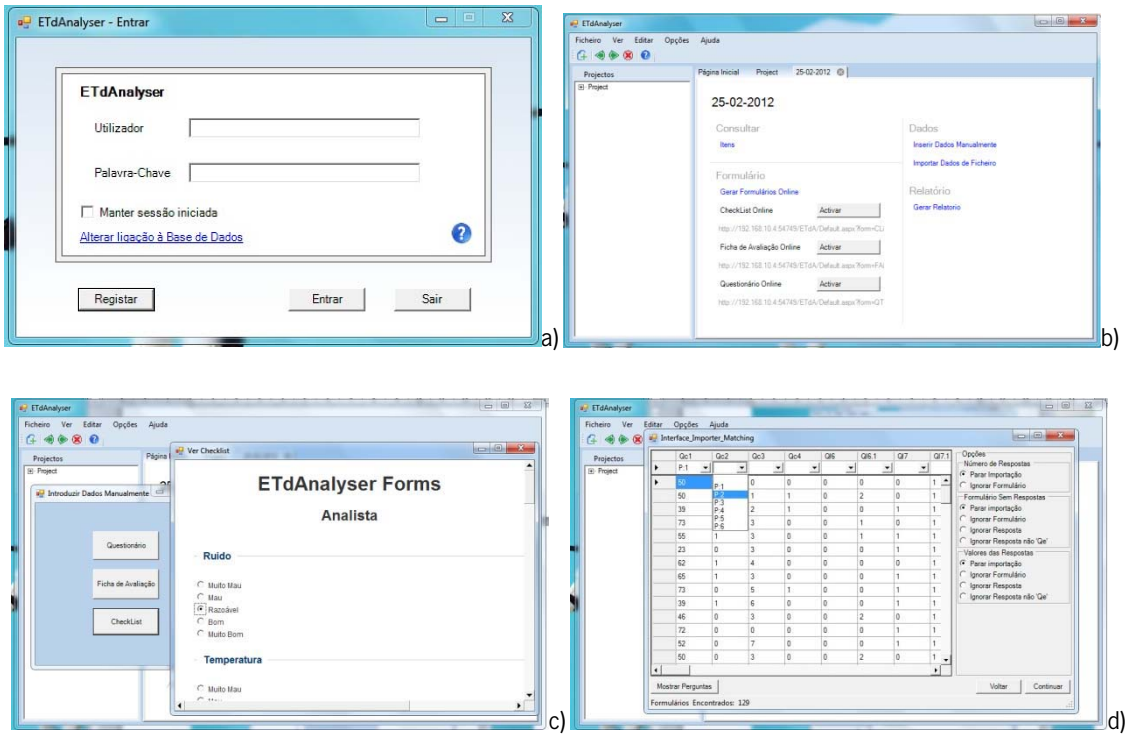

Figure 5.15. ETdAnlyser running examples: a) Login application, b) Management analysis application, c) Manually data Insertion, d) File importation.

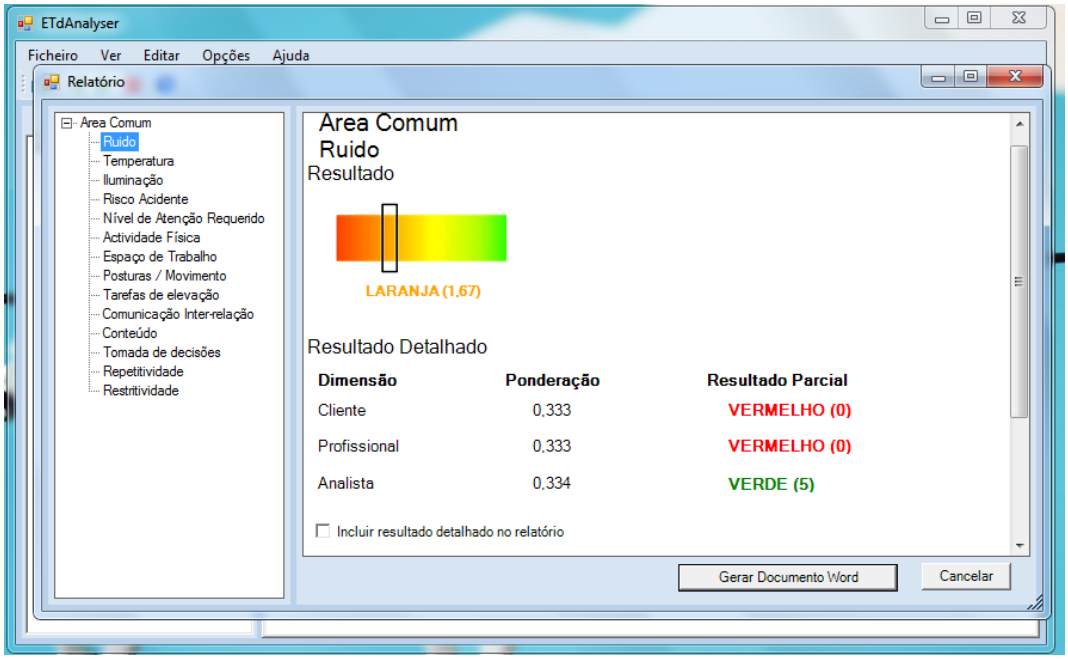

Figure 5.16. Report Management

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PART III

Conclusions

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Chapter 6. Conclusions and Future Work

This final chapter presents an overview of the major findings of this thesis. A discussion on the research questions presented on chapter 3 is also provided. The chapter also addresses the contributions of this work and outlines opportunities for future research and developments.

The main purpose of this thesis was to study and characterize, from an ergonomics point of view, the common areas with free circulation of people considering the perspective of Clients, as well as Professionals of these areas. It was proposed that these common areas with free circulation of people should be analyzed not only in an occupational perspective, but also from an usability point of view. This is, the common area must be analyzed as an integrated part of a complex and dynamic socio-technical system where all the participants should be well identified, as well as the interrelations of which they are a part of. Indeed, one of the Ergonomics challenges is related to the understanding of interactions among humans and other elements of a system.

The fact that organizations are seen as social-technical systems requires from ergonomics a holistic vision of the problems in terms of a proper identification of the participants on the ergonomic context that is going to be analysed. Effectively, Clients and Professionals that circulate freely and interrelate on these areas may equally be exposed to the same ergonomic risk factors. Therefore, in this case the "human wellbeing" should be concerned to all system participants, that is, both Clients and professionals.

The ETdA conceptualization was built under a theoretical framework supported by literature review. The development of a case study, comprised by two different common areas, allowed the development of a methodology for analysis in a real-life context. The fact that the ETdA methodology was developed in a research context and was able to be used in a real-life context, showed its operability.

Overview of the key-findings

This study has shown that it is possible to have a broader understanding of a system ergonomic approach when Clients are participants on the ergonomic context under analysis.

This study allowed the identification of the system participants that should be considered on ergonomic analysis of common areas with free circulation of people. They were named ETdA dimensions. The development of the correspondent ETdA observation tools was also achieved. Results of psychometric proprieties of the ETdA questionnaire showed differences between Clients' wellbeing and ergonomic perceptions, indicating that the ETdA questionnaire allowed Clients in the differentiation between issues that are relevant to the ergonomic analysis and those related to the characterization of their wellbeing. In fact, the ETdA questionnaire is now available to be used accurately by the Analyst, to collect information about the Clients dimension as well as an observation tool to perform an ergonomic analysis under the ETdA methodology.

The identification and definition of the variables, ETdA variables and the supplementary variables, that are defined by the ETdA model, proved to be important not only on the characterization of the Clients dimension but also to make a systematically and pooled analysis of the ETdA three dimensions results, as supported from the results.

This study shows that, in practice, the definition of general guidelines to ETdA use, proved to be useful on the ETdA implementation on the two commercial areas. However, some adjustments were made on the data collection stage. These adjustments were related to the ETdA questionnaire. This study also shows that the ETdA questionnaire is an observation tool for general use that is independent of the economic sector in which it is applied. The original structure of the questionnaire in terms of supplementary and ergonomic variables was maintained regarding the following contexts: commercial areas and the health care system. The adjustments were related to the terminology regarding the context of application. The possibility of adding relevant questions into the questionnaire, mainly questions related to Clients' complaints, found to be important to the engagement of the managers on the successful implementation of the ETdA model. Evidence showed that this engagement was related to the fact that managers want to know more about their Clients' expectations.

The study of the influence of the supplementary variables on the ergonomic evaluation highlighted some critical situations that should be taken into consideration during the decision-making process. Gender and age differences regarding the ergonomic issues are often reported in research studies, but the reasons why these differences occur and their implication on ergonomic intervention are rarely analyzed. A study on this subject together with a tridimensional ergonomic analysis of areas with free circulation of people can also be helpful for the decision-making process.

This study also revealed the importance of the analysis of work organization and lay-out of the areas under the use of the ETdA methodology. Indeed, the process of characterization of the common area under a perspective of usability (Professionals and Clients attendance in the area) allowed the identification of sections designed for Clients' exclusive use. If an occupational approach focused on workspace analysis was used to perform the ergonomic analysis, probably these sections will not be considered.

The proposed three level analyses of the data allowed a systematical analysis of the results from the ETdA observation tools. This step proved to be important in the definition of the ETdA variables that were used in the weighting tables' development. The algorithm used to perform data analysis involving exploratory data analysis; inference and decision-making. The proposed methodology for data analysis simplified the complexity of the obtained results regarding the three dimensions.

When comparing the obtained weighting tables among the common areas, for the considered case study, different decisions-making were achieved. As a consequence, different proposals to be presented to mangers, regarding the priority list of situations that required an intervention, were also defined. This seems to indicate that results obtained from the ETdA application on a given real-life context should not be extensible to another. In fact, the same methodology was used but different results were obtained according to the specific area under study. This indicates

that the work organization and lay-out, the Clients' profile, and the interactions between Clients and Professionals might also have influenced on the results.

This study also highlighted the Clients' importance on the ergonomic analysis, by the comparison of the results obtained through the weighting tables, with and without considering the Clients' dimension. The use of the ETdA methodology allows studying the influence of each of the ETdA dimensions on the decision-making. This study can be conducted to analyse the perception of each dimension regarding a given ergonomic factor or simply, to identify which are the critical situations that need a short-term intervention.

ETdA methodology reveals to be a potential societal instructive model, considering that the inclusion of Clients' dimension in the ergonomic analysis can contribute to focus the Clients' attention to ergonomics issues. The development model seems to increase the population awareness for ergonomics. The inclusion of all the participants of the common areas on the analysis creates a co-production responsibility in the changes to be implemented.

ETdA can be seen as a continuous model. Considering the managements point of view, it seems easier to make organisational changes when the main intervenient, the Clients, has the same opinion of the Analyst and/or the Professionals. The results of this work indicate that the agreement between the results of the Clients and Professionals results has more impact on the top management acceptance of the ergonomic intervention proposals.

The software ETdAnalyser developed, showed to be a useful tool in the ETdA implementation, mainly with regard to the web functionality. ETdAnalyser option for mapping the observation tools results, in order to assembling the ETdA variables in a suitable way, facilitates the weighting tables development. This process performed manually proved to be quite time consuming. The software' versatility in terms of results analysis found to be an added value. Analyst can decide if the results are weighted regarding the type of analysis or by ergonomic factor. This option is useful on the study of the ergonomic factors in terms of perceptions (comfort and wellbeing). The fact that the software automatically generates a report comprising all the decisions facilitates the task of the analyst establishing priorities for the ergonomic intervention.

Opportunities for future research

Many of the results explored with ETdA were closely linked to the real-life context in which organizations operated. The definition of the guidelines for the general use of the ETdA provides a ready model for the adoption in similar studies but in other real-life contexts. Interesting and future research may also arise from the use of these guidelines in different contexts. By collecting more data it might be possible to perform a further study about the perceptions of people in terms of wellbeing and comfort. This study may also contribute to the stimulation of further avenues of enquiry related to the need to develop a statistical thinking to the ergonomics research.

Considering the cost of workplace accidents, the organizations should evaluate all the possible options for accident prevention. The risk assessments must include not only the occupational accidents probability, but also the hypothesis of the clients' involvement on situations that can lead to an accident. ETdA as a new ergonomic approach that presents a realistic (in occupational and usability terms) overview of the common areas can be used for data collection to provide the necessary information to perform a study on this subject.

One of the major concerns of the ETdAanalyser was to architect a software that presents a level of functionality that allowed the analyst to collect data and jointly analyze the results of the three ETdA dimensions. The supplementary variables analysis was done in a separate file. The integration of the Clients' profiles in decision-making is a challenge for future work. Specific attributes of this software, such as performance and usability, which contribute to the quality of software, must be studied in future work. A first step in further research could be the study of the ETdAnalyser usability. Closer investigation is required to examine the relationship between usability patterns, usability properties and usability attributes of the ETdAnalyser.

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Annexes

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Annex 1

Analyst checklist

Scale				CAFCP		Data
1	2	3	4			
N	A	P	!			
EF				**Section**	**Code**	**Comments**
Noise						
Thermal environment						
Lighting						
Accident Risk						
Attentiveness						
Physical Activity						
Workspace						
Lifting						
Communication/interrelation						
Job content						
Decision-making						
Repetitiveness						
Restrictriveness						

Annex 2

Evaluation form

Universidade do Minho

FICHA DE AVALIAÇÃO

2011

A ficha de avaliação foi elaborada no âmbito do desenvolvimento de um Modelo de Análise Ergonómica Tridimensional. Um dos objectivos é definir o perfil do seu posto de trabalho, inserido numa área de livre circulação de pessoas. Reflicta por favor, na organização das tarefas que desempenha, no espaço de trabalho e sua envolvência e classifique, segundo a escala de avaliação, todos os itens que constituem a Análise Ergonómica. A sua opinião é importante e pode contribuir para melhorar a sua actividade.

A SUA OPINIÃO É IMPORTANTE.

Escala para avaliação

Muito mau	Mau	Bom	Muito bom
- -	-	+	+ +

	RUÍDO - Analise se o ruído existente interfere com a comunicação ou com a sua concentração no trabalho e, avalie.
	ILUMINAÇÃO - Observe se a iluminação existente é suficiente (zonas de encandeamento e/ou ofuscamento, zonas escuras e/ou demasiado iluminadas) e, avalie.
	RISCO DE ACIDENTE - Considere para a análise a probabilidade de ocorrência de um acidente e a gravidade do mesmo caso ocorra e, avalie.
	TEMPERATURA AMBIENTE- Considere como referência uma situação de conforto térmico e por comparação, avalie.
	ESPAÇO DE TRABALHO- Observe se o espaço de trabalho é suficiente para adoptar posturas adequadas e realizar os movimentos livremente e se permite ajustar sempre que possível os equipamentos e materiais. Avalie.
	POSTURAS E MOVIMENTOS – Reflicta sobre a posição do pescoço e ombros, braços (cotovelo e pulso), tronco, ancas e pernas durante a sua actividade profissional e, avalie.
	TAREFAS DE ELEVAÇÃO - Considere o peso que tem levantar, a postura adoptada e o nº de elevações efectuadas e, avalie.
	RESTRITIVIDADE - Verifique se as condições de desempenho das suas tarefas (equipamentos disponíveis, método de trabalho, tempo para realizar a tarefa) dificultam o seu desempenho e, avalie.
	REPETITIVIDADE - Considere a duração e a forma de como são repetidas do mesmo modo as tarefas que desempenha e, avalie
	TOMADA DE DECISÕES- Considere se a informação disponível é suficiente e de qualidade, quando necessita de tomar uma decisão e**,** avalie.
	CONTEÚDO DO TRABALHO - Considere para a análise, o número e qualidade de tarefas individuais que tem que executar e, avalie.
	NÍVEL DE ATENÇÃO REQUERIDO - Considere para a análise a % de tempo que tem que estar atento e o grau de exigência da tarefa e, avalie.
	ACTIVIDADE FÍSICA GERAL- Considere as tarefas, métodos de trabalho e os equipamentos disponíveis para determinar o grau de exigência da sua actividade profissional e, avalie.
	COMUNICAÇÃO E INTER-RELAÇÃO - Reflicta sobre o seu relacionamento com colegas e superiores, e disponibilidade dos mesmos e, avalie.

Utilize este espaço para dar a sua opinião / sugestão

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Annex 3

ETdA questionnaire, version1

Universidade do Minho

QUESTIONÁRIO PARA ANÁLISE ERGONÓMICA 2008

Este Questionário foi elaborado no âmbito do desenvolvimento de um Modelo de Estudo de Avaliação Ergonómica em Para Farmácias.A sua resposta é de vital importância, leia atentamente todas as questões e responda conforme o solicitado.

A SUA OPINIÃO É IMPORTANTE

01-03-2008

19. Se alguma vez usufruiu dos tratamentos de Beleza e Bem-estar, por favor consulte a grelha de respostas de forma a avaliar os diferentes aspectos relacionados com esta área de serviços, caso contrário passe à pergunta seguinte

Muito má	Má	Razoável	Boa	Muito boa
1	2	3	4	5

	(1 a 5)
Acolhimento	
Simpatia	
Relação preço/qualidade	
Limpeza	
Temperatura ambiente	
Luz ambiente	
Ruído	

SUGESTÕES

20. Para melhorar os processos de trabalho e o aspecto geral da Para-Farmácia, que melhorias gostaria de ver implementadas? (utilize o espaço seguinte para escrever)

CARACTERIZAÇÃO DO CONSUMIDOR

1. Quantos anos tem? (Escreva): ___anos
2. Qual é o seu sexo? (Marque com x)

   Feminino ☐ Masculino ☐
3. Indique qual é a sua profissão:_____.
4. Qual a importância que dá às considerações ergonómicas na concepção de espaços de trabalho? (marque com x)

Muito pouca	Pouca	Alguma	Muita	Bastante

5. É cliente habitual desta Para farmácia? (Marque com x)

   Sim ☐ Não ☐
6. Indique qual o motivo da preferência desta Para Farmácia? (Pode assinalar mais do que uma opção)

Proximidade da área de residência	
Proximidade da área de trabalho	
Por motivos ocasionais	
Por confiança nos produtos e serviços prestados	
Recomendado por alguém	
Outros	

ANÁLISE ERGONÓMICA PELO CONSUMIDOR

7. Alguma vez sentiu dificuldade em alcançar a algum produto exposto nas prateleiras? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

8. Considera que as dimensões do balcão de atendimentos estão ajustadas à população utilizadora? (Marque com x)

Sim ☐ Não ☐ Não sei ☐

9. Na sua opinião, como classifica a iluminação da Para Farmácia?

Muito má	Má	Razoável	Boa	Muito boa

10. Já alguma vez, nesta Para farmácia, se sentiu incomodado por alguma fonte de ruído? (Marque com x)

Sim ☐ Não ☐

11. Se respondeu que sim à pergunta anterior, por favor escreva qual a fonte de ruído, caso contrário passe às perguntas seguintes:

_____

12. Na sua opinião, como considera o aspecto geral da Para farmácia? (Marque com x)

Muito mau	Mau	Razoável	Bom	Muito bom

13. A "actividade física geral" é determinada de acordo com o nível de actividade física exigido pelo trabalhador, pelos métodos e pelos equipamentos utilizados. Segundo esta definição, como classifica esta actividade profissional relativamente à componente física?

Fraca	Média	Intensa

14. É habitual requisitar informação mais detalhada acerca de algum produto ou serviço desta para farmácia? (Marque com x)

Sim ☐ Não ☐

15.Em que medida está satisfeito ou insatisfeito com o grau de formação dos funcionários desta Para farmácia? (Marque com x)

Muito insatisfeito	Insatisfeito	Indiferente	Satisfeito	Muito satisfeito

16. Dos produtos e serviços a seguir mencionados, indique quais os que habitualmente solicita. (Pode assinalar mais do que uma opção)

Medicamentos não sujeitos a receita médica	
Puericultura	
Nutrição	
Cosmética	
Higiene capilar	
Higiene oral	
Estética	
Consultas médicas	
Outras terapias	

17. Como avalia o risco de ocorrer algum acidente nesta Para Farmácia? (Marque com x)

Impossível	Pouco provável	Provável	Muito provável	Certo

18. Na sua opinião, o trabalho executado com recurso a suporte informático, limita o tempo de atendimento? (Marque com x)

Sim ☐ Não ☐

Annex 4

Three level analysis

Published paper

Loureiro, I. F, Leão, C. P., Arezes, P. (2011). Clients, Professional and Analyst Dimensions: Intra and Inter Relationships Analysis in the Decision-making. Proceedings from ENBIS-11: European Network for Business and Industrial Statistics. Coimbra, Portugal.

Clients, Professional and Analyst dimensions: intra and inter relationships analysis in the decision-making

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Abstract
Considering the Clients, Professional and Analyst dimensions, the ETdA (Ergonomic Tri dimensional Analysis) matrix assembling leads to the weighting table helping the Analyst in the ergonomic intervention' decision. A three level methodology is proposed: (1) descriptive analysis to allow the characterization and study of the different answers profile in Clients and Professional dimensions; (2) correlation between the different answer categories and the level 1 results; (3) ergonomic factors' multivariate analysis. In the level 3, an inter and intra dimension analysis will be done. The main issue of the intra dimensions analysis is the ergonomic factors relevance and intensity study, that is, to understand how the different ETdA dimensions feel the ergonomic factors and, to measure the intensity of the ergonomic perception in each ETdA dimension. The inter dimension analysis, allows the understanding of the ETdA dimensions' relationships importance helping the results weighting. The mechanisms that regulate the interaction between the ETdA dimensions will have a positive impact in the professional workplace (commercial areas with free circulation of people) and consequently in clients' general opinion on those areas contributing for the success of management strategies.
Keywords: Clients and Professional Profile, Decision-making, Ergonomic analysis, Multivariate Statistics, Weighting Table

1. INTRODUCTION

In human work activities, different ergonomic methodologies can be used to evaluate intrinsic and extrinsic ergonomic factors (EF), helping the activity characterization and identification of critical situations that need ergonomic intervention (MacLeod, 2003). The available literature in the field of ergonomics provides an identification and description of several ergonomic contexts that comprise the professional workplace. According to the complexity of the task and its level of automation and to the professionals' interrelation with management and clients, a dynamic environment can be defined (Cellier, Eyrolle & Marine, 1997). In these environments, the total quality management philosophy is focused not only in workforce satisfaction, but also in clients' satisfaction, since in modern social-technical systems they are intrinsically linked to the organizations. Therefore, processes of improvements are often multidimensional (considering all the organizational participants), cross and serially correlated (Jarrett & Pan, 2007). Ergonomic Tri-dimensional Analysis (ETdA) is a new approaching developed specifically to areas where professionals' activities are related with a clients or consumers' service provide or products sales (common areas). This situation provides a human interaction. In these areas, different professionals activities' can be identified leading to different ergonomic contexts (Loureiro, Leão & Arezes, 2010a; Stuhlmacher & Cellar, 2001). Observation tools were assembling to each one of three dimensions considered: a questionnaire, an evaluation sheet and direct and indirect observation (checklist) for the clients, professionals and analyst dimensions, respectively. The variables analysed with this model are named the Ergonomic Factors (EF) and allow the ETdA operability. They can be divided into two major groups: intrinsically (individual: work postures, general physical activity, communication/inter-relation and attentiveness) and extrinsically (environmental: noise, illumination, thermal environment and risk accident or occupational: professional training quality, job content, decision making, restrictiveness) (Loureiro, Leão & Arezes, 2010b). The ergonomic factors' set is flexible, and they can be chosen according to the area under analysis. Considering the ETdA dimensions, they can be submitted to different processing's, reproducing variables that can be analysed ensemble, the ETdA variables. It is proposed a model framework to measure the intensity of the ergonomics perception in each ETdA dimension and to study the ETdA dimensions' relationships magnitude. This procedure is important to a tridimensional assembling matrix, helping the analyst in the results' weighting and decision make to the ergonomic intervention. The development of a concept map allowed the representations of the relationships among ETdA dimensions simplifying the massiveness of variables (EF) in a three dimension model (Kettenring, 2009). A inter and intra analysis was used in different levels of action.

2. MATERIALS AND METHOD

The first step of ETdA model application is the contact between the analyst and the manager of the organization under study. It is when the *modus operandi* of the multidimensional process is defined. This is a very important issue in the ETdA application since it encourages the participation of the entire organization in the process success.

The second step of this ergonomic approach is the application of the ETdA observation tools: questionnaire in clients' dimension, evaluation sheet in the professionals dimension and direct and indirect observation (checklist) in the analyst dimension.
The third step is related to data collection and to the tri-dimensional results' analysis. ETdA datasets analysis can be complex since there are at least 14 EFs to be analyzed by the three dimensions and particularly in clients' dimension. Through the ETdA observation tool of the clients' dimension, the questionnaire, it is also possible to have knowledge of the socio demographic characterization of the population, in particular of the clients' population characterization. A preprocessing of the obtained data must be done to avoid inappropriate conclusions. This procedure will simplify and summarize the dimensions results, leading to the three dimensions matrix assembling (Kettenring, 2009). This matrix is the starting point to the weighting table construction which represents the ergonomic intervention proposals. The need to develop these tables, support the analyst final task: real perception of the ergonomic situation and elaboration of the priority list of changes to be implemented according to the gravity of the identified situations. The process involves exploratory data analysis; inference and decision-making.

2.1. Ergonomic factors: ETdA variables

In order to define the ETdA weight matrix, firstly it is necessary to categorize the results obtained through the observation tools. Several variables can be defined according to their relevance in the ergonomic analysis: supplementary, temporary and ETdA variables (Figure 1). A proper study of the identified variables and their applicability in the data analysis is required.

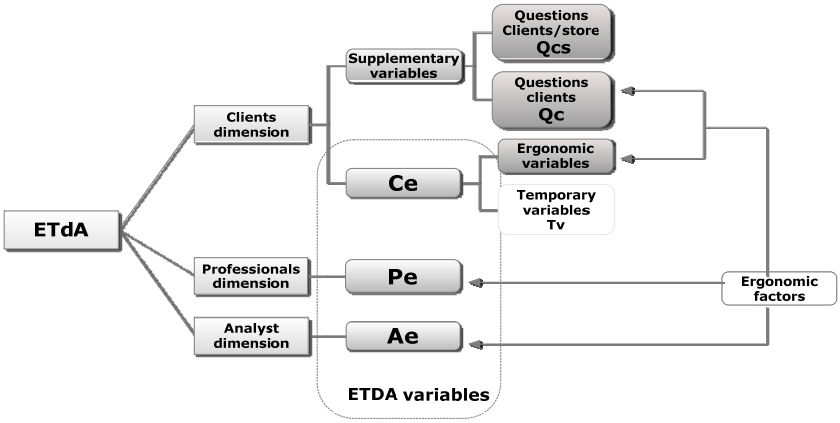

Figure 1 – ETdA variables

ETdA data gathering is obtained throw the dimensions' observation tools. The obtained results are related with the ergonomic evaluation of the common area under study. A socio characterization of the population in clients' dimension is also defined. Therefore, it is important to understand the differences between the ETdA dimensions data collected.
The observation tools used by professionals and analyst dimensions allowed the ergonomic factors evaluation using a four level opinion scale ("very bad", "bad", "good" and "very good"). The existence of categories showing the severity on a particular situation ("very bad" and "bad"), is considered relevant in the ETdA analysis, since it can be used as an indicator for the urgent need of ergonomic intervention. This answer tendency could be used as an advice-guide, highlighting some risky situations that otherwise could not be detected, and they also can be useful, to support the decision when the analyst and clients are in agreement. Helping the decision of an ergonomic intervention the four level opinion scale can be rescaled to a two level one. With this procedure, a positive ("very good" and "good" answer categories') and negative ("very bad" and "bad" answer categories') classifications are obtained. The ETdA variables are Ae, in the analyst dimension, and Pe, in the professional dimension (Figure 1).
ETdA questionnaire, the clients' observation tool, was validated in previous study (Loureiro, Leão & Arezes, 2010b). Briefly, it comprises three major parts; client's characterization, clients' ergonomic evaluation and an open question. In the first part, two groups of questions can be identified. The first one is related with the clients' socio demographic characteristics (Questions clients, Qc, Figure 1). The other one indicates the clients/store relationship (Qcs, Figure 1). Even though authors recognise the importance of the Qc and Qcs variables in the concept maps developing, they are considered as supplementary (Field, 2009) as they do not have a principal role in the ETdA dimensions matrix assembling. The ergonomic

factors evaluation (Ergonomic questions, Qe) is done using a three or four level scale (frequency, probability or opinion scales). The results of the ergonomic questions can reproduce two different types of variables: ETdA (Ce) and temporary (Tv) variables. When the ergonomic factors are analysed by one question then Ce variables are obtained (see Anthropometric limitations; Postures and movements in Table 1). If there is more than one question used to analyse an ergonomic factor (see Lightning quality in Table 1), temporary variables (Tv) are obtained. In this specific case, a combined analysis must be done, in order to obtain a single classification of the EF. The obtained classification will be used in the tri-dimensional matrix leading to the results' weighting. This step will help the analyst decision making for ergonomic intervention. Table 1 represents the definition of Ergonomic variables in Clients' observation tool and identifies which question is related with the EF that is, identifies the different ETdA variables.

Table 1 – Ergonomic variables in Clients' observation tool

Ergonomic variables	Characterization and Ergonomic factors	Question number	ETdA Variables
Clients characterization (Qc)	Age	Qc1	
	Gender	Qc2	
	Profession	Qc3	
	Qualifications	Qc4	
	Regular client?	Qce5	
Clients/store (Qce)	Visit frequency reason	Qce6	
	Shopping preferences	Qce16	
	Quality/price relation	Qce20.3	
Clients' ergonomic evaluation(Qe)	Anthropometric limitations (Postures and movements)	Qe8	Ce
	Lightning quality	Qe9; Qe20.7	Tv
	Noise problem	Qe10; Qe20.8	Tv
	General physical activity	Qe12	Ce
	Shopping Trolley	Qe13; Qe20.10; Qe21	Tv
	Professionals' qualifications	Qe14; Qe20.5; Qe20.2	Tv
	General opinion about the store & Cleaning of the store (Work Site)	Qe11; QE20.4	Tv
	Risk accident	Qe17	Ce
	Thermal evaluation	Qe19; Qe20.6	Tv
	Restritiveness	Qe18; Qe20.9; Qe21	Tv
	Work communication and personal contact	Qe14	Ce

2.2. Ergonomic factors: ETdA levels

According to Lindsay (Lindsay, 2004), data collection planning is a very important issue for the collection, exploration and analysis of data sets. As a consequence of a deeper study made with the obtained variables and their relationships, identified by the concept maps (Figure 1), a three level analysis of the ETdA results is proposed (Figure 2).

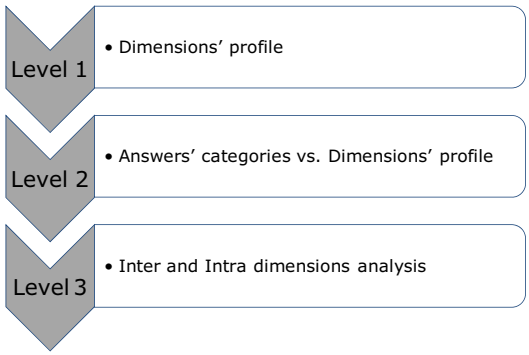

Figure 2 – Three level analysis of the ETdA results

The three dimensions are characterized throw an exploratory analysis, using a set of graphs or frequencies table, allowing the dimensions' profile definition. In clients' dimension the supplementary variables (Questions clients, Qc, and questions clients/store, Qcs) help to create the clients' dimension profile. With the defined profiles and the different answer categories, several correlations can be studied. For instance,

it is possible to verified that the gender' influence in the ergonomic perception is significant. To increase the meaningful of the results, it may be necessary to do a categories' recoding, using the standard residuals procedure (Loureiro, Leão, Arezes & Eufrasio, 2011). Finally, using an inter and intra dimension analysis an ergonomic factors' multivariate analysis is then made. The main issue of the intra dimensions analysis is the ergonomic factors relevance and intensity study, that is, to understand how the different ETdA dimensions feel the ergonomic factors and, to measure the intensity of the ergonomic perception in each ETdA dimension. The inter dimension analysis, allows the understanding of the ETdA dimensions' relationships importance helping the results' weighting.

3. EXPERIMENTAL STUDY

A study case based on the ETdA development in a Wholesale retail store was performed. This category of business is characterized by large open spaces, with common circulation areas designed for workers and clients. ETdA planning was defined with the store management, and observation tools were applied. This commercial area comprises a large open space where a wide variety of products are displayed; identifying different ergonomic contexts with specific professionals' activities. This situation was crucial to the ergonomic analysis procedure: it was necessary firstly to divide the common area in sectors according to the professional activity identified. The observation tool for the professional dimension, was delivered by sector thus, making it possible to obtain a global and per professional activity profile. An initial results' experimental study was conducted to analyze the proposed three level analysis (see section 2.2) within the user population of these common areas using two ergonomic variables: lightning quality and risk accident. Note that the first one is considered as a supplementary variable characterized by two questions Qe9 and Qe20.7 (see Table 1), and the other, is a fixed ergonomic variable (Ce in Figure 1).

3.1. ETdA: Level 1 results

From the total delivered questionnaires in clients' dimension, the results reveal that 129 clients participated in the study-case, yielding a 43% response rate. Clients' age ranged between 17 to 76 years old, with a mean age of 49. About 66.1% of the respondents were male. It is interest to observe that in a five points scale' (in an increasing order level of opinion), clients have considerable knowledge regarding to ergonomic issues and being regular clients (85%) (Loureiro, Leão & Arezes, 2010b).

In professionals' dimension, and based on a total of 183 professionals, 58% reported a positive answer classification. The temperature evaluation was the only ergonomic factor that reveals substantial differences. In each common areas section, risk ergonomic factors were identified according to negatives professionals' evaluation. For instance, considering the noise factor, 20.9% of the professionals considered the existence of a problem noise in the section related with the "front office" or "checkout". In present work, a descriptive analysis was done to characterize the lightning quality and risk accident ergonomic factors (Table 2).

Table 2 – Lightning quality and risk accident ergonomic factors descriptive statistics (mean; standard deviation; sample size)

Ergonomic factor	Clients dimension		Professional dimension
Risk accident	(2.39; 0.532; 127)		(2.74; 0.538; 105)
Lightning quality	Qe9	Qe20	
	(2.69; 0.51; 128)	(3.77; 0.655; 128)	(2.04; 0.515; 106)

Since lightning evaluation in clients' dimension, is a temporary variable (Tv), a preprocessing must be done in order to obtain an ergonomic variable (Ce), transporting the analysis to level 3. The starting point is, witch question, Qe9 or Qe20 that best reflects the clients' opinion related to lightning evaluation? Which Tv variable must be transformed in Ce, in order to go into the ETdA matrix? In previous work, the psychometric properties evaluation of the Clients' ETdA questionnaire indicates that the instrument is capable of differentiating the commercial area as a usable common area independently of clients' expectations. Construct validity was evaluated by means of a factorial analysis, which revealed that items were loaded on two factors named "clients' well-being satisfaction" and "clients' ergonomics perception". The results showed that the instrument has good internal consistency with a Cronbach's alpha equal a 0.968 for the first factor and 0.603 for the second factor. The Qe9 measures the clients' well-being satisfaction and Qe 20.7 measure the clients' ergonomics perception (Loureiro, Leão & Arezes, 2010b). Since the purpose of the ETdA matrix assembling is a combined analysis of the ETdA questionnaire and the others ETdA dimensions tools, it is authors believes that question Qe 20.7 better characterize clients' ergonomics perception about this ergonomic factor. Therefore question 20.7 is the selected to define the Ce variable.

2.2. Level 2 results

In level 2, correlations between the different answer categories and level 1 result are studied. For example, results shows that lightning quality and risk accident evaluation as well as the ergonomic concern about workplace design are independent of the clients' gender (p>.05).

2.3. Level 3 results

A clients and professionals dimensions' intra analysis seems to indicate a similar risk perception of accident: 22.9% of the clients consider likely the possibility of an accident occurs versus 28.6% of the professionals. The inter analysis results shows that the risk of accident average is the same across clients and professionals' dimensions (p=0.29, α=0.05). Professionals' risk evaluation is highly associated with the Clients´ perception of a risk accident $\chi^2(1) = 100.157, \text{continuos correction}, p \leq .001$. However, the biggest standardizing residual value is associated with clients' positive and professionals' negative answers tendency. It is possible to do an inference of this tendency in distributions related with Figure 3. This suggests that when clients think that it is unlikely a risk situation in the commercial area under study, more professionals' than excepted considerer the existence of a risk situation in that commercial area.

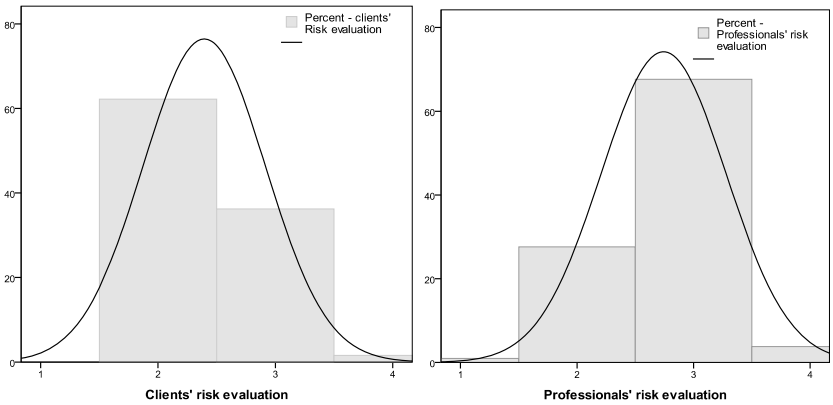

Figure 3 (a) Clients' risk evaluation distribution (b) Professional' risk evaluation distribution

A similar study was done with the lightning quality variable. Results shows that 2.4% of the clients versus 5.1% of the professionals consider "bad" this EF and 25.8% of the clients reported acceptable lightning quality. The hypothesis that tests if the distribution of the professionals and clients' lightning quality evaluation is the same across the dimensions' is rejected (p<.001), and they are not significantly related ($\chi^2(4) = 1.735,\ p > .05$). In this particularly case, the biggest standardizing residual value is associated with the answer category "very good lightning" quality in clients dimension and satisfactory lightning quality in professionals' dimension. This suggests that clients and professionals expectations about the ergonomic factor lignin quality are similar.

The ETdA variables accomplish by this three level analysis are showed in Table 3.

Table 3 – ETdA matrix for Risk accident and lightning quality

Ergonomic variable	Pe	Ce	Ae
Risk accident	2	3	2
Lightning quality	3	3	3

The obtained weighting table matrix will help the Analyst in the ergonomic intervention decision.

4. GENERAL DISCUSSION

The ETdA (Ergonomic Tri dimensional Analysis) development follows the ergonomics future tendency since it allows the participation of the entire organization in critical situations' identification and proposals of intervention. Observation tools' were developed to allow data collection in each dimension. A preprocessing of the obtained results must be done allowing the three dimensions matrix assembling. This matrix is the starting point to the weighting table construction. This procedure helps the Analyst in the ergonomic intervention' decision make. A three level analysis is proposed to study the defined ergonomic variables: supplementary, temporary and ETDA variables. In present work, the ETdA questionnaire psychometric proprieties were considered in the decision of which intermediary variable will represent the ergonomic factor in the matrix assembling table. Even though, the main issue of the supplementary variables is to contribute to the dimension profile definition, it is authors' believes that the obtained dimensions profile can also be relevant in the results' weighting.

In order to test the proposed three level analyses viability, an experimental study was done in a Wholesale retail store. In each dimension, observation tools were applied. After data collection and analysis, first results showed that it is possible to obtain a weighting table matrix with the three dimensions' evaluation results. This matrix can be defined as the simplification and summarization of the ETdA dimensions results helping the Analyst in the decision making for ergonomic intervention.

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Annex 5

Data normalization: the chi-square contribution

1. Introduction

This study aimed to analyse the process of data rescaling. Questions that presented a low number of answers in a given category were analysed. Based on the chi-square test, a proper analysis of the rescaling was done. Several contingency tables were analysed, in terms of the estimation of the standardize residuals contribution on the chi-square statistic. The study was conducted on database obtained through the ETdA application in common areas during the framework of my Mater Thesis (Loureiro, 2008).

2. Research problem

The use of descriptive statistics and exploratory data analysis, regarding the accident risk evaluation, showed that clients accident risk perception had 95% of positive answers (unlike || and impossible ||categories) and 5% of negative answer tendency (likely|| and very likely categories) (Figure A51).

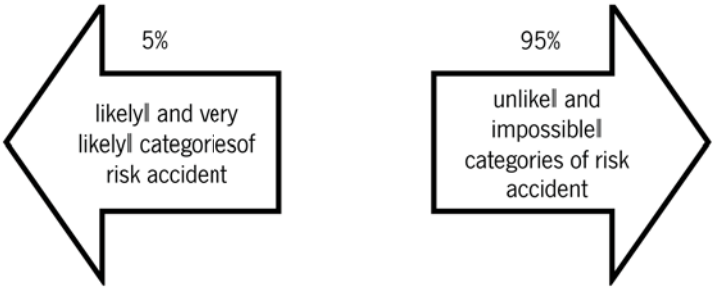

Figure A5.1. Answer tendency regarding accident risk evaluation

The existence of categories showing the severity on a particular situation was considered relevant in the ergonomic analysis using the ETdA model, because it could represent an indicator for the need of a supplementary ergonomic study. This answer tendency could be used as an advice-guide, highlighting some risky situations that otherwise could not be detected, and can be useful to support the decision when the analyst and client were in agreement. In order to establish a correlation between the outcome variables (extrinsic and intrinsic ergonomics' factors) and the clients' perception of a risky situation, testing its independency, a deeper analysis was done.

The Pearson chi-square test statistic tests whether the two variables are independent (Hypothesis H0). Conventionally significance value must be less than 0.05 (Field, 2009). In this case, the hypothesis is rejected, gaining confidence that they are related in some way.

Table A5.1 show the results of the significance level (Chi-Square Test) obtained from the study of the association between the extrinsic and intrinsic ergonomics' factors and the clients' perception of a risky situation.

Table A5.1. Significance level

	Occupation	**Age**	**Gender**	**Shelf dimension**	**Noise**	**Lighting**	**Trading desk dimension**	**Physical effort**
Accident risk	0,917	0.92	0.32	0.4	0,029	0,029	0.000	0,383

Results show that the client's age, gender and professional activity are unrelated to client's perception of risk. The environments ergonomic factors like noise and quality illumination were found to be significantly related to the same issue (clients risk perception). The evaluation of professional physical effort in his activity was unrelated to risk accident perception (Chi-square, $p<0.05$) as well as the shelf dimension. The majority of the respondents (77%), when asked if the trade balcony was adjusted to the user population reported that it was adjusted to professionals and clients dimensions. This factor was highly associated with the variable accident of risk ($p< 0.001$).

In order to understand the real validity of the significant obtained results, a deeper analysis was made.

According to Field (2009), there are two important assumptions to be considered in the chi-square test. To this test be sensitivity, every person, item or entry must contribute to one cell of the contingency table, and the expected frequencies should be greater than five. Is this case, the sampling distribution is probably close enough to a perfect chi-square distribution, making significance tests. In larger contingency table, although the results obtained could be inaccurate, it is acceptable to have 20% of the excepted frequencies bellow five (FE<5). In this case, the percentage of cells that had less than five excepted frequencies were counted and the results presented in Table A5.2.

Table A5.2 Percentage of cells with expected frequencies bellow 5, by contingency table

Crosstabs Risk situation*Anthropometric dimensions (trading desk)	**Crosstabs Risk situation*Lightning quality**	**Crosstabs Risk situation*Noise problem**
58.3% (7 Cells)	62.5% (10 Cells)	50% (4 Cells)

Results shows that despite the sample size was adequate to perform the chi-square test, a large amount of cells with excepted frequencies bellow five were identified. This fact could reproduce not very reliable information. The numbers of the cells with excepted frequencies bellow five was weighted using the standard residuals. The residual it is the error (difference) between the excepted and the observed frequencies (A5.1) and it can be standardized dividing this difference by the square root of the excepted frequency (A5.2).

$$\text{residulalij}=\text{observedij}-\text{modelij} \quad \text{(A5.1)}$$

$$\text{standardized residual}=(\text{observedij}-\text{modelij})/(\text{modelij}) \quad \text{(A5.2)}$$

Given that the chi-square statistic is the sum of these standardized residuals, it seems reasonable that looking for the individual standardized residuals can give an idea of each one contribution to the chi-square statistic. A comparative analysis was done, using the χ^2 value for the cells with excepted frequencies bellow five and the value of the same test considering all cells. The values of the cells that transgress de chi-square presuppose, can be obtained by the formula (A5.3), using the χ^2 value of the standard residuals (A5.3).

$$X^2 = \sum std\ Residuals^2 \quad \text{(A5.3)}$$

Table A5.3 Chi square value *versus* chi-square (standard residuals), by contingency table

	Risk situation×Anthropometric dimensions	**Risk situation×Lightning quality**	**Risk situation×Noise problem**
$\chi 2$ (...)=⋯.,p≤.005	37.396	18,825	9,018
$X^2 = \sum std\ Residuals^2$	9,02	4.71	8.38

In fact, the contribution of the cells with excepted frequencies bellow five in the Risk situation×Anthropometric dimensions and Risk situation×Lightning quality was lowest than in Risk situation×Noise problem. In this case, the contribution was considered significant therefore it was not possible to exclude the answers categories related with the identified cells with frequencies bellow five. A first approaching of the problem could lead to an elimination of the answer categories where the biggest percentage of those cells was identified, since the weight of the cells with FE<5 were not significant. However, the existence of categories showing the severity on a particular situation should be considered relevant as it could represent an indicator for a supplementary ergonomic study. Considering the ETdA conceptualization it was no possible to eliminate those answer categories. Another important issue was the dispersion in the contingency table, of the cells with frequencies above five. That is, the identification of the cells with frequencies below five, not always corresponded to the same category, they were distributed over more than one category. This observed situation impaired the elimination of a given category from data analysis. In consequence, a deeper analysis was done weighing the value of the chi-square statistic calculated for each category.

A compared analysis was done between:

a) the results from the chi-square test calculated from the standard residuals values, regarding the categories that presented expected frequencies bellow five and,
b) the value of the same test, considering all the cells related with that category.

3. Compared analysis

The results related to the crosstabulation Risk situation×Anthropometric dimensions are presented in Table A5.4.

Table A5.4. Compared analysis on crosstabulation Risk situation×Anthropometric dimensions

	Categories	**Anthropometric dimensions**			**Chi square**	
		Do not know	Yes	No	**(a)**	**(b)**
Risk Situation	Impossible				1.60	1.69
	Unlikely					1.64
	Likely	5.6 **(d)**			2.69	34.05 **(c)**
	Very Likely				0.22	0.22
Chi square	**(a)**	0,25	2.53	1.69		
	(b)	33.05 **(c)**	2.57	1.98		

The results indicate that cells wit excepted frequencies bellow five had a little contribution to the overall association that the chi-square statistic measures ((a) column and row in Table A5.4). As expected the biggest result ((c) in Table A5.4), was related to the cells with the biggest standardize residual (Z=5.6, p<.00, (d) in Table A5.4). These values were associated with "likely" Risk situation and "Do not know if the anthropometric dimensions of the trading desk..."categories. This means that when clients had a likely perception of a risk accident the standardizing residual was significant regarding the "do not know" category, which in turn signified that when clients had a likely perception of a risk situation, significantly more than expected did not know if the trading desk was adjusted to the population.. The "Yes" and "No" categories obtained similar results; therefore no associate was identified in terms of this ergonomic factor. The categories related to the question used to assess the risk situation showed a clearly positive and negative answer tendency. Therefore, it was proposed the cells redistribution in two major groups: unlikely and likely client's perception of a risk situation. The clients who did referred that a risk situation was impossible or unlikely to happen, were including on the first group.

Table A5.5 represents the results related to the Chi-square statistics (group of cells with expected frequencies bellows five vs. chi-square statistics regarding all categories

Table A5.5 Compared analysis on crosstabulation Risk situation×lightning quality

	Categories	**Lightning quality**				**Chi square**	
		Bad	**Acceptable**	**Good**	**Very good**	**(a)**	**(b)**
Risk Situation	Impossible					0.13	13.35 **(c)**
	Unlikely					0.04	1.08
	Likely					3.69	3.85 **(d)**
	Very Likely					0.6	0.6
Chi square	**(a)**	0.18	1.82	0.5	2.21		
	(b)	0.18	1.86	4.38	10.5		

$\chi 2$ (9)=18.825.,p≤.05)

The results indicate a small contribution of each cell presenting FE<5 (see (a), rows and columns Table A5.5). The biggest contribution was related to the "likely" category and "very good" category. It can be observed that the major contribution to the chi-square statistic was related to the "Impossible" ((c) in Table A5.5) and Likely ((d) in Table A5.5). The results suggested a division of the categories related to the accident risk question that in two major groups: unlikely and likely. The clients who have an impossible and unlikely perception of risk were included on the first group. The Likely group was related to likely and very likely categories. The lightning quality ergonomic factor was divided in three groups: Bad (very bad and bad categories), acceptable and good (good and very good categories) lighting quality. The acceptable category should be considered as one because the ETdA model emphasis's the most critical answer categories and "acceptable" doesn't necessary means a good opinion.

Table A5.6 represents the results related to the Chi-square statistics (group of cells with expected frequencies bellows five vs. chi-square statistics regarding all categories.

Table A5.6. Compared analysis on crosstabulation Risk situation× problem noise

	Categories	Problem Noise		Chi square	
		No	Yes	(a)	(b)
Accident risk	Impossible			0.01	0.01
	Unlikely			0.49 **(f)**	0.5
	Likely		2.8 **(e)**	7.84 (c)	8.2
	Very Likely			0.04	0.04
Chi square	**(a)**	0.0	8.38 **(d)**		
	(b)	0.74	8.38		

The results showed that the biggest contribution of each cell with expected frequencies bellow five (see (e), rows and columns) in the chi-square result (χ^2 (3) = 9.018., p< 0.05), was related to "Likely" perception of a risk situation ((c) in Table A5.6) and the existence of a problem noise source ((d) in Table A5.6). If all the cells related to that category were considered ((b) in Table A5.6), it seemed reasonable to assume that the same remarks could be made. In fact, the largest standardizing residual value was associated with both categories of answer (z=2.8, p< 0.05, (e) in Table A5.6). This suggested that, when clients thought that an accident was likely to occur in the commercial area under study, more clients than expected considered that this accident was due to the existence of a noise problem in that commercial area.

Results from this study, suggested that the analysis of the chi-square statistic, cell by cell or category by category, can help to understand witch categories contribute to the overall association that chi-squares statistic measures. In this case, it was observed that the major cells' contribution to the overall chi-square statistic was related to the "likely" category ((c) in Table A5.6). The second big contribution was related to the "unlikely" category .That suggested that the data related to the accident risk evaluation, should be rescaling in two new variables: Unlikely and Likely. Regarding the question related to the accident risk evaluation, it was proposed that "impossible" and "unlikely" categories were including on the first group. The Likely group was related to "likely" and "very likely" categories.

Regarding the contingency tables presented above, new analysis was run (analysis 2). It was expected that the percentage of cells with expected frequencies bellow five was lower than the results obtained from the first analysis (analysis 1). Comparative results are presented in Table A5.7

Table A5.7. Percentage of cells with expected frequencies above five, by analysis

	% of cells with expected frequencies above five		
Analysis	**Risk situation*Anthropometric dimensions**	**Risk situation*Lightning quality**	**Risk situation*Noise problem**
1	58.3%	62.5%	50%
2	33%	50%	25%

Results showed a decrease on the percentage of cells with expected frequencies bellow five. A nw The new significance value was obtained (Table A5.8)

Table A5.8. Significance value, by analysis

Analysis	Risk situation× Anthropometric dimensions	Risk situation× Lightning quality	Risk situation× Noise problem
1	0.000	0.029	0.029
2	0.000	0.69	0.013

Regarding the Risk situation*Anthropometric dimensions and Risk situation*Noise problem results, it was possible to observe that with this scale recoding, the accuracy of the result was maintained, as the significance level remained the same. Regarding the Risk situation*Lightning quality it was interesting to observe that the rescaling, previously made, reproduced changes in the chi-square statistic significance. In this case, the Hypothesis that tests the variables' independence was not rejected. Therefore the variables analysed were independent (p**>**.05). The chi-square statistic' significance related with Risk situation*Noise problem remained lower than 0.05, indicating an association between this two ergonomic factors.

The significance value related with Risk situation*Anthropometric dimensions (trading desk) was highly significance (p**<.001)** This indicated that the client's perception of a risk situation had a significant effect on whether the clients' opinion on the anthropometric dimensions was appropriated. The association between theses ergonomic factors indicated that the pattern of responses in the Anthropometric dimensions (trading desk) categories was significantly different.

Considering that the proposed rescaling produced changes in the chi-square results, a new analysis was conducted on clients' perception of a risk situation and the others ergonomic factors indicated in the Table A5.6. This analysis considered the division of the scale used to evaluate the accident risk EF in two groups unlikely and likely as presented before.

Results of this study are presented in Table A5.9

Table A5.9. Significance value, by analysis

Analysis	Professional activity	Age	Gender	General physical activity
1	0.917	0.92	0.32	0,383
2	0.183	0.668	0.183	0.612

Results show that the clients' perception of a risk situation was not significantly related to the age.

Table A5.10 presents the results related to the contingency table risk situation* anthropometric limitations, considering the group of cells with expected frequencies bellows five and the chi-square statistics regarding all categories

Table A5.10. Compared analysis on crosstabulation Risk situation×Anthropometric limitations

		Anthropometric limitations			Chi-square	
	Categories	**Never**	**Rarely**	**Occasional**	**(a)**	**(b)**
Risk Situation	Unlikely					0.17
	Likely					5.1
Chi-square	(a)		1©	0.81©		
	(b)	0.53	1.09	0.85		

χ^2 (2)=2.437, p**<005**

The categories related with the ergonomic factor Anthropometric limitations (clients' postures and movements) shows a tendency to associate the "rarely" and "occasional categories" ((c) in Table A5.10).

By doing this procedure a new chi-square statistic value was obtained and the number of cells with EF bellows five decreased (33% to 25%).

The same analysis was conducted on the occupational ergonomic factors professional skills and Trust Requiring information. The environments ergonomic factors such as; trust in attendance, information demand and professionals' skill training were found to be significantly related to the clients' perception of the risk accident. Even thought the significance value related with risk situation* professional skill training is highly significance ($p<.001$), indicating that the client's Professional skill training clients' opinion has a significant effect on perception of a risk situation; the large percentage of cells with EF<5 ((a) in table A5.11) suggested a new rescaling.

Table A5.11. Significance value, by analysis

	Professional skill training	**Trust in attendance**
Significance value	0.000	0.018
Number of cells EF**<5**	60% (a)	25%.

The categories redistribution was based in the $\chi 2$ (std Residuals) value, by category just considering the FE <5 ((a) in Table A5.11) and the value of the same test considering all cells related to that category (b). The obtained results are presented in Table A5.12.

Table A5.12. Compared analysis on crosstabulation Risk situation× Professional skill training

		Professional skill training						
		Very dissatisfied	**Dissatisfied**	**Indifferent**	**Satisfied**	**Very satisfied**	**(a)**	**(b)**
Risk Situation	**Unlikely**						7.26	7.35
	Likely						57.94	59.67
Chi-square	**(a)**	0.1	0.1	61.37	0.04	1.68		
	(b)				0.04	1.78		

The results indicate a small contribution of each cell with excepted frequencies bellow five (see (a), rows) in the chi-square result related with Risk situation* Professional skill training The biggest contribution is related with the indifferent professional skill training category and Likely risk situation categories. Although the results could suggest an exclusion of the categories with $\chi 2$ (std Residuals) values near zero, it was authors believe that it was better to associate the categories in order to obtain new variables, such as: dissatisfied (very dissatisfied, dissatisfied categories), indifferent and satisfied (satisfied and very satisfied categories). The significance of the statistic test is maintained but the number of cells with EF<5 is lower than the value obtained from the first analysis.

To two ergonomic factors restrictiveness and clients' perception of a risk accident were independent ($p < 0.05$), meaning that the pattern of responses in the restrictiveness categories was significantly different.

Table A5.13 presents the final results related with the clients' perception of a risk situation and the ergonomic factors studied namely noise, quality lightning, general physical activity.

Results show that there was a significant association between the clients' perception of accident risk and the environment ergonomic factor (Noise), $p < 0.05$. The occupational ergonomic factor "Trust in attendance" was significantly associated with client perception of accident risk. Professionals' skills and Anthropometric Dimensions were highly associated with the clients´ perception of accident risk ($p < 0.001$).

Table A5.13 Chi- square statistic: significance values, by EFs

	Professional activity	**Age**	**Gender**	**General physical activity**	**Problem Noise**	**Lightning quality**	**Professionals skills**	**Trust in attendance**	**Restrictiveness**	**Anthropometric Dimensions**	**Anthropometric Limitations**
accident risk	0.969	0.668	0.183	0.612	0.013	0.69	0.000	0.0018	0.747	0.000	0.119

Annex 6

ETdA questionnaire 1 and ETdA questionnaire 2

24. Para melhorar os processos de trabalho e o aspecto geral do estabelecimento, que melhorias gostaria de ver implementadas? (utilize o espaço seguinte para escrever)

QUESTIONÁRIO PARA ANÁLISE ERGONÓMICA: dimensão cliente

2011

Este Questionário foi elaborado no âmbito do desenvolvimento de um Modelo de Estudo de Avaliação Ergonómica. A sua resposta é de vital importância, leia atentamente todas as questões e responda conforme o solicitado.

A SUA OPINIÃO É IMPORTANTE

Universidade do Minho

1. Idade (Escreva)_____ anos
2. Género (Marque com x): Feminino ☐ Masculino ☐
3. Profissão: _____

4. Habilitações literárias

Até 12ºano		Doutoramento	
Licenciatura		Curso tecnológico/profissional	
Mestrado		Outro	

5. Qual a importância que dá às considerações ergonómicas na concepção de espaços de trabalho?

Muito pouca	Pouca	Alguma	Muita	Bastante

6. É cliente habitual deste estabelecimento? Sim ☐ Não ☐

6.1 Se sim, com que frequência visita o estabelecimento? (Marque com x)
- vezes ☐ 1 x por semana ☐ 2 a 3 x por semana ☐ + vezes ☐

7. Indique qual o motivo da preferência? (Pode assinalar mais do que uma opção)

Proximidade da área de residência	
Proximidade da área de trabalho	
Por motivos ocasionais	
Por confiança nos produtos e serviços prestados	
Recomendado por alguém	
Outros	

8. Alguma vez sentiu dificuldade em alcançar algum produto exposto nas prateleiras?

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

9. Na sua opinião, como classifica a iluminação do estabelecimento?

Muito má	Má	Razoável	Boa	Muito boa

10. Já alguma vez, neste estabelecimento, se sentiu incomodado por alguma fonte de ruído? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

Indique por favor o local _____ a fonte de ruído _____

11. Na sua opinião, como considera o aspecto geral do estabelecimento? (Marque com x)

Muito mau	Mau	Razoável	Bom	Muito bom

12. A "actividade física geral" é determinada de acordo com o nível de actividade física exigido pelo trabalhador, pelos métodos e pelos equipamentos utilizados. Segundo esta definição, como classifica esta actividade profissional relativamente à componente física?

Fraca	Média	Intensa

13. Na sua opinião, a música ambiente contribui para uma atmosfera de bem-estar? (Marque com x)

Nunca	Às vezes	Muitas vezes	Sempre

14. É habitual requisitar informação mais detalhada acerca de algum produto ou serviço deste estabelecimento? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

15.Em que medida está satisfeito ou insatisfeito com o grau de formação dos funcionários deste estabelecimento? (Marque com x)

Muito insatisfeito	Insatisfeito	Indiferente	Satisfeito	Muito satisfeito

16. Dos produtos e serviços a seguir mencionados, indique quais os que habitualmente solicita. (Pode assinalar mais do que uma opção)

Livros	
Música	
Filmes	
Música	
Informática	
Imagem e som	
Foto e vídeo	
Telecomunicações	
Artigos infantis	

17. Como avalia o risco de ocorrer algum acidente neste estabelecimento? (Marque com x)

Impossível	Pouco provável	Provável	Muito provável	Certo

18. Na sua opinião, o trabalho executado com recurso a suporte informático, limita o tempo de atendimento? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

19. Já alguma vez, em alguma área se sentiu incomodado pela temperatura ambiente?

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

20. De acordo com a grelha de respostas de 1 a 5:

Muito má	Má	Razoável	Boa	Muito boa
1	2	3	4	5

Classifique o estabelecimento em relação a todos os aspectos indicados

Acolhimento	
Simpatia	
Relação preço/qualidade	
Limpeza	
Grau de formação dos funcionários	
Temperatura ambiente	
Iluminação	
Ruído	
Tempo de espera na caixa	

21. Já alguma vez o volume da música ambiente perturbou a comunicação oral? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

22.Este estabelecimento coloca à disposição do cliente um saco para transporte das suas compras. Já alguma vez utilizou este saco de compras?

Nunca	Às vezes	Muitas vezes	Sempre

23. Já alguma vez procedeu à troca ou devolução de um artigo adquirido neste estabelecimento?
Sim ☐ Não ☐

Indique o tipo de artigo:_____

Indique o motivo da troca/devolução:_____

22. Para melhorar os processos de trabalho e o aspecto geral do estabelecimento, que melhorias gostaria de ver implementadas? (utilize o espaço seguinte para escrever)

QUESTIONÁRIO PARA ANÁLISE ERGONÓMICA: dimensão cliente

2010

Este Questionário foi elaborado no âmbito do desenvolvimento de um Modelo de Estudo de Avaliação Ergonómica. A sua resposta é de vital importância, leia atentamente todas as questões e responda conforme o solicitado.

A SUA OPINIÃO É IMPORTANTE

Universidade do Minho

1. Idade (Escreva): ____ anos
2. Género (Marque com x): Feminino ☐ Masculino ☐
3. Profissão: _____
4. Habilitações literárias

Até 12ºano		Doutoramento	
Licenciatura		Curso tecnológico/profissional	
Mestrado		Outro	

5. Qual a importância que dá às considerações ergonómicas na concepção de espaços de trabalho? (marque com x)

Muito pouca	Pouca	Alguma	Muita	Bastante

6. É cliente habitual deste estabelecimento? Sim ☐ Não ☐

6.1 Se sim, com que frequência visita o estabelecimento? (Marque com x)

- vezes ☐ 1 x por semana ☐ 2 a 3 x por semana ☐ + vezes ☐

7. Indique qual o motivo da preferência? (Pode assinalar mais do que uma opção)

Proximidade da área de residência	
Proximidade da área de trabalho	
Por motivos ocasionais	
Por confiança nos produtos e serviços prestados	
Recomendado por alguém	
Outros	

8. Alguma vez sentiu dificuldade em alcançar algum produto exposto nas prateleiras?

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

9. Na sua opinião, como classifica a iluminação do estabelecimento?

Muito má	Má	Razoável	Boa	Muito boa

10. Já alguma vez, neste estabelecimento, se sentiu incomodado por alguma fonte de ruído? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

Indique por favor o local _____ a fonte de ruído _____

11. Na sua opinião, como considera o aspecto geral do estabelecimento? (Marque com x)

Muito mau	Mau	Razoável	Bom	Muito bom

12. A "actividade física geral" é determinada de acordo com o nível de actividade física exigido pelo trabalhador, pelos métodos e pelos equipamentos utilizados. Segundo esta definição, como classifica esta actividade profissional relativamente à componente física?

Fraca	Média	Intensa

13. Alguma vez sentiu dificuldade em manobrar o carrinho de transporte de compras? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

14. É habitual requisitar informação mais detalhada acerca de algum produto ou serviço deste estabelecimento? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

15.Em que medida está satisfeito ou insatisfeito com o grau de formação dos funcionários deste estabelecimento? (Marque com x)

Muito insatisfeito	Insatisfeito	Indiferente	Satisfeito	Muito satisfeito

16. Dos produtos e serviços a seguir mencionados, indique quais os que habitualmente solicita. (Pode assinalar mais do que uma opção)

Frutas e legumes	
Peixaria	
Talho	
Charcutaria e lacticínios	
Congelados	
Adega	
Bebidas	
Mercearia	
Detergentes	
Área não alimentar	

17. Como avalia o risco de ocorrer algum acidente neste estabelecimento? (Marque com x)

Impossível	Pouco provável	Provável	Muito provável	Certo

18. Na sua opinião, o trabalho executado com recurso a suporte informático, limita o tempo de atendimento? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

19. Já alguma vez, em alguma área se sentiu incomodado pela temperatura ambiente? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

Indique por favor o local _____

20. De acordo com a grelha de respostas de 1 a 5:

Muito má	Má	Razoável	Boa	Muito boa
1	2	3	4	5

Classifique o estabelecimento em relação a todos os aspectos indicados

Acolhimento	
Simpatia	
Relação preço/qualidade	
Limpeza	
Grau de formação dos funcionários	
Temperatura ambiente	
Iluminação	
Ruído	
Tempo de espera na caixa	
Carrinho para transporte de compras	

21. Alguma vez encontrou algum obstáculo que dificultasse a manobra do carrinho de transporte de compras? (Marque com x)

Nunca	Raramente	Às vezes	Muitas vezes	Sempre

Indique por favor em que situação _____

Annex 7

Analyst evaluation

Results of the analyst assessments, by CAFCP are presented in the following lines.

1. Lighting (Illuminance and glare)

According to Parsons (2000), light can affect human performance at general tasks and glare can cause a distraction effect. Therefore, lighting guidelines are necessary to provide the desired visual performance.

The measurements of lighting environment (illuminance and illuminance ratios) are present in Table A7.1 (CAFCP 01) and Table A7.2 (CAFCP 02).

Table A7.1 Iluminance and Iluminance ratios (CAFCP 01)

Section	Subsection	Measure value (Mv; lux)	Recommended value (Rv; lux)	100*MV/Rv	Glare
1	1	175	500	35	Glare
	2	222	200	111	
2	1	166	500	33,2	
	2	96.5	200	48,25	
3	1	350	500	70	Glare
	2	160	200	80	
4	1	166	500	33,2	No glare
	2	628	200	314	
	3	250	500	50	Glare
5	1	228	500	45,6	
6	1	567	500	113,4	Glare
	2	174	200	87	
7	4	254	500	50,8	
8	5	390	500	78	Glare
9	1	285	500	57	Glare
	2	610	500	122	

Regarding the lighting environment measurements in CAFCP 01, it is considered that visual performance of professionals can be compromised in the activities related to balconies identified in subsection 1 and 3 and 5 abovementioned. It is important to remark that light in subsection 3 is directly related to clients' discomfort.

Table A7.2 Iluminance and Iluminance ratios (CAFCP 02)

Section	Measure value (Mv; lux)	Recommended value (Rv; lux)	100*MV/Rv	Glare
1	529	500	211,6	Glare
2	820	200	328	
3	545	500	218	
4a	573	200	229,2	
4b	567	500	1488,4	Glare
5	172	500	68,8	Glare
6	244	200	97,6	
7	1063	500	425,2	No glare
8	212	200	44	
9				
10	[50.8- 656]	500	35,952	

Considering the function of the building, the user population and the professionals' activities, it considered that the lighting conditions in CAFCP 02 are satisfactory (Table A7.2). Due to an energy saving policy differences in lighting conditions were observed in the expositions area. This factor doesn't have influence in the professionals' performance.

2. Thermal environment

Six main factors (air velocity, air temperature, globe temperature, humidity, the activity of the occupants, and the clothing worn by the occupants) and two test conditions (weight and height in average) were quantified in order to assess human response to thermal environment. Predicted Heat Strain model (PHS) developed by Malchaire and Piette, (1999) integrates these values in a way that will provide the calculation of the PPV/PMV and WBGT index. This model also presents as an advantage rapid data handling. According to Miguel (2005), the American conference of Governmental Industrial Hygienists (ACGIH) suggest the use of the Wet bulb globe temperature index (WBGT) to assessing the effects of a heat stress on a worker. WBGT limits (ISO 7243, 1995); 34.5-(M/19.7), M=W/m2] are provided for a number of work rates for acclimatized and non-acclimatized persons.

The PMV and PPD express warm and cold discomfort for the body as a whole. The index Predicted Mean Vote (PMV), predicts the mean vote, on a seven-point thermal sensation scale, of a large group of occupants in the room. The PMV index has been adopted as the International Standard method for assessing thermal comfort (ISO 7730, 2005). It is used to check whether a given thermal environment complies with comfort criteria and to establish requirements for different levels of acceptability.

The scale ranges from 3 (corresponds to hot) through 0 (corresponds to neutral and is the value for comfort) to -3 (corresponds to cold). The Seven-point thermal sensation scale is presented in (TableA7.3)

Table A7.3. Seven-point thermal sensation scale

+3	Hot
+2	Warm
+1	Slightly warm
0	Neutral
-1	Slightly cool
-2	Cool
-3	Cool

PMV it is a practical approach developed by Fanger (1970) to assess thermal environments for occupants' comfort. Thermal comfort can be defined as that condition of mind which expresses satisfaction with the thermal environment (Parsons, 2000).

As a function of PMV values, Individual differences are measured by a method for predicting the percentage dissatisfied (PPD) with the environment.

ISO 7730, 2005 refers that due to individual differences, it is impossible to specify a thermal environment that will satisfy everybody. There will always be a percentage dissatisfied occupants. But it is possible to specify environments predicted to be acceptable by a certain percentage of the occupants.

CAFCP 01

No differences in the measured values were identified across the different sections of the CAFCP 01. Results of the different factors that characterize the thermal environment of the CAFCP 01 are represented in table A7.4.

Table A7.4 Characterization of the thermal environment, CAFCP 01

Air temperature (ºC)	**24**
Air velocity (m/s)	0.1
Globe temperature (°C)	23
Relative humidity	43%
Metabolic rate (W)	220 (moderate work)
Clothing isolation (cl0)	0.6
Weight (Kg)	60
Height (m)	170

Results of WBGT and PPV/PMV are summarizes in Table A7.5.

Table A7.5. WBGT and PPV/PMV, CAFCP 01

WBGT	**PPV**	**PMV**
14.6	0.01	5%

CAFCP 01 presents a comfort thermal environment with no heat risk, according to the PHS interpretation on the bases of ISO 7933, 1989.

CAFCP 02

In the CAFCP 02 the air temperature ranges from 2.5°C in the butcher section to 16°C in the clients' reception. In cold areas (freezing area, butcher's area, fish area, grocery, dairy, and charcuterie section) the temperature drops considerably. This factor can have influence in the air temperature of the sections allocated to those areas. The area of exposure of the products that require special temperature conditions (0°C- 8°C) is an open space similar to large refrigerators where clients must go inside to make their purchases. It is important to notice that professionals that work is those sections have appropriate clothing for the cold but the decision to use or not is theirs. Usually, as they are uncomfortable, professionals choose not to use them. An influence due to cold adaptation must also be considered. Apart from clothing, other forms of adaptation, such as body posture and decreased activity, which are difficult to quantify, can result in the acceptance of cold temperatures (see ISO 7730, 2005). A jacket for cold protection it is also available to clients. According to the manager, clients have little experience of using jackets. Since air temperatures are above 0°C, professionals and clients' health are not compromised. Nevertheless, the effects of cold on human performance must not be ignored in the analysis. Studies of Parsons, 2000 refers cold discomfort is related to mean skin temperature and that Predicted Mean Vote (PMV) provides information to comfort related to cold environments.

The measured values of the different factors that characterize the thermal environment of the CAFCP 02 are represented in Table A7.6.

In sections were the air temperature is less than 10° C (see gray cells in Table A7.6), tables to PMV calculation were used (Annex E of the ISO 7730, 2005).

Table A7.6. Characterization of the thermal environment, CAFCP 02

	Sections											
	1	**2**	**3**	**4a**	**4b**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Air temperature (°C)	12	12	2.5	4	7	14	15	14	16		[14-17]	9
Air velocity (m/s)	0.29	0.18	0.30	0.2	0.39	0.00	0.00	0.00	0.01		0.00	0.00
Globe temperature (°C)	11.5	11	2	5	7	14	14	12	15		[14-17]	10.5
Metabolic rate (W)	220	220	220	220	220	220	220	220	140	140	220	220
Clothing isolation (cl0)	1	1	1	1	1	1	0.6	0.6	0.6	0.6	1	1
Weight (Kg)						1.60	1.60	1.60	1.60	1.60	1.60	
Height (m)						60	60	60	60	60	60	

PMV was calculated considering the air temperature equal to 10°C, relative air humidity of 50 %, the difference between air and mean radiant temperature less than 5 °C, metabolic rate equal to 2 metabolic unit (1 metabolic unit = 1 met = 58,2 W/m2) and a clothing insulation (Icl) equal to 1Clo. With this test conditions and depending on the air velocity, different PMV values are obtained (Table A7.6).

Table A7.7. Air velocity and PMV results, CAFCP 02

	Charcuterie/dalRY	butcher's section	Dairy
Air velocity (m/s)	0.20	0.30	0.40
PMV	-0.84	-0.84	-1.07

According to the seven-point thermal sensation scale the thermal environment evaluation of these sections is cold. People are discomfort with this environment without health risk.

It is important to report that the existence of a door in the dairy section that opens directly to the butcher' section, contributes to increase the air velocity. Meaning that, under the presented conditions (see Table A7.8) the percentage dissatisfied (PPD) is 49%. If the air velocity lowered to 0.1 m/s, quantitative prediction of the percentage of thermally dissatisfied people who feel too cool decreases to 23%.

PMV/PPD and PHS indexes results related to the sections presenting air temperature above 10°C are presented in Table A7.8

Table A7.8. PMV/PPD and PHS indexes (sections with air temperature above 10°C)

	Sections							
	1	**2**	**5**	**6**	**7**	**8**	**9**	**11**
PMV	-0.47	-0.50	0.4	0,07	-0.16	-095 (cold)	-1.46	0,07
PPD	10%	10%	5%	5%	6%	24%	49%	5%
PHS	Comfort	Comfort	Comfort	Comfort	Comfort	Discomfort without health risk	Discomfort without health risk	Comfort

The PHS results for clients' reception and front office sections are related to the considered professionals' activity metabolism (140 versus 220 W/m^2).

It is important to consider that the thermal environment characterization must also consider the clients attendance in the commercial area. Therefore, a simulation was done, considering the same environment conditions, a metabolism of standing, light activity (shopping, laboratory, light industry) and a thermal insulation equal to 0.6 Clo. In all sections, PHS results on the bases of the ISO 7933 reveal a discomfort without health risk in a cold thermal environment.

3. Risk analysis

According to Health and Safety Executive leaflet (HSE, 2011 accessed on 02 -03-2012), a risk assessment is simply a careful examination of what, in work context, could cause harm to people, so that it can be considered whether enough precautions are be taken into consideration, to prevent harm. Workers and others have a right to be protected from harm caused by a failure to take reasonable control measures. Considering the CAFCP context, risk assessment must considerer workers (professionals) and clients' attendance in the area.

The risk assessment process was performed according to the scheme presented in Figure A7.1. This procedure was developed to be used for similar areas in previous work (Loureiro, 2008)

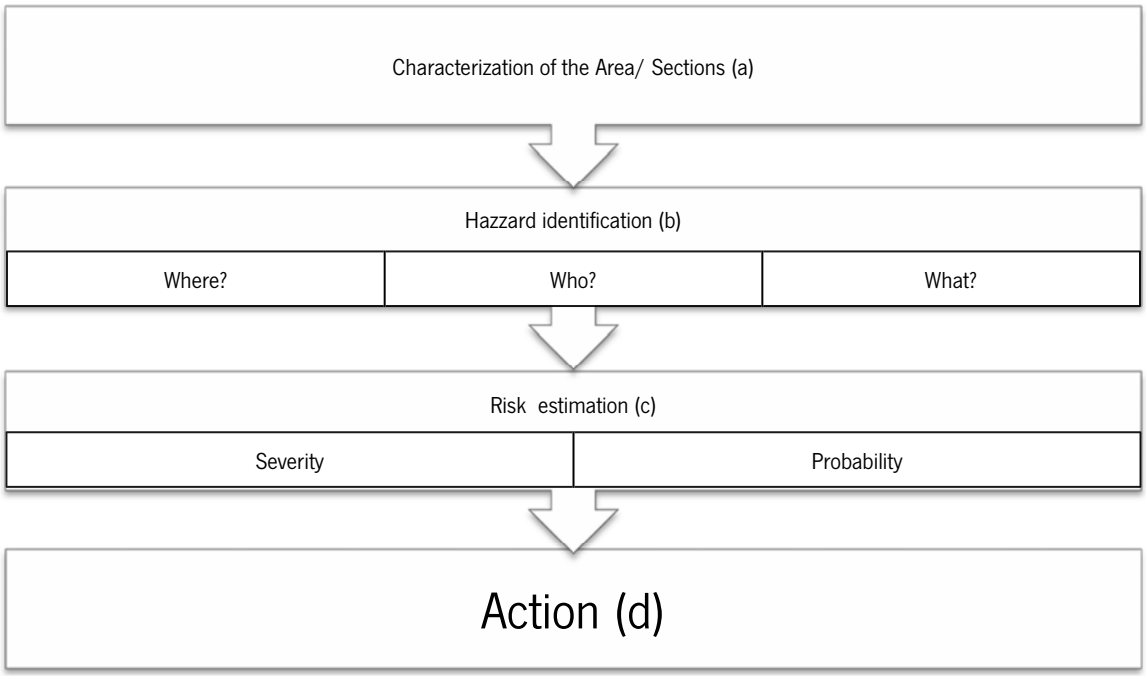

Figure A7.1. Risk assessment process

Through direct and indirect observations, characterization of the CAFCP was carefully done. It was taking into consideration, what could reasonably be expected to cause harm, manager and occupational safety personnel of CAFCP 02 were asked about theirs accident perceptions. Accident and ill-health records were consulted to help the identification of the less obvious hazards. EWA guidelines and by consulting the HSE practical guidance on hazards identifications, namely the shop risk assessment, hazards identification was done.

For each identified hazard ("what" in Figure A7.1), an identification of "who" might be harmed and where, was done. Two groups of people were considered on this step: (1) clients dimension or passers-by, (2) professionals dimension (people working in the CAFCP).

Having spotted the hazards risk estimation (c) was done by analyzing the chance, high or low, that somebody could be harmed by the identified hazards, together with an indication of how serious the harm could be. A risk matrix was used to help the analyst identify the level of risk associated with a particular issue (Table A7.9). This matrix category the likelihood of harm occurs and the potential severity of the harm. The risk level determines which risks should be tackled first.

Table A7.9. Matrix for Risk levels (HSE, assessed on 10-05-2012)

		Potential severity of harm		
		Slightly Harmful 1	Harmful 2	Extremely Harmful 3
Likelihood of harm occurring	Highly unlikely 1	Trivial 1	Tolerable 2	Moderate 3
	Unlikely 2	Tolerable 2	Moderate 4	Substantial 6
	Likely 3	Moderate 3	Substantial 6	Intolerable 9

According to the identified level of risk, an action (d) is required (Table A7.10).

Table A7.10. Action/arrangements according to risk levels

Risk evaluation	**Action /Arrangements**
Trivial	No need to improve preventive action. Continuous supervision
Tolerable	No need to improve preventive action. Check for most profits solutions or improvements. Continuous supervision
Moderate	Join efforts to reduce risk. Participatory intervention. Continuous supervision
Substantial	Do not begin work without the risk has decreased
Intolerable	Same, but if risk cannot be eliminated immediately, work should be forbid or area closed

Risk assessment' results for CAFCP 01 are presented in Table A7.11.

Table A7.11. Risk assessments, CAFCP 01

Risk	**Where?**	**What?**	**Who?**	**Severity**	**Probability**	**Risk level**
Cuts						
Falls from the same level						
Falls of different levels	Subsections 2	X	1	Small	Rather serious	Acceptablet
Falls tools, parts of a machine, equipments or products						
Movements or awkward postures	Subsections 4.3, 2	X	1 and 2			
	Subsections 1, 2,3, 5	X	1	Considerable	Slight	Acceptable
Stairs						
Lighting	Subsections1, 4.3	X		Small	Slight	Acceptablet
Noise						
Thermal environemet						
Workspace inappropriate	Subsections 1, 4, 5	X				

In CAFCP 01, the identified situations presented an acceptable risk. Movements or awkward postures of clients and professionals are related to:

- postures and movements adopted by professionals in tasks related to book replacements and,
- postures and movements adopted by clients‟ in the gaming area.

In the gaming section, there is a column were the available software is placed and can be tested by clients. By direct analyst observation and professionals interviews the analyst find out that the user population in this section is mainly composed by teenagers and the average time period of use of the software is 3 to 4 hours. An anthropometric study of this column was made and it was possible to understand that there was a misfit in the columns‟ dimensions. This can be a topic of a subsequent research, which can result in the proposition of another sizing of the structures according to contort and clients "wellbeing".

Risk assessment' results for CAFCP 02 are presented in Table A7.12.

Table A7.12. Risk assessments, CAFCP 02

Risk	Where?	What?	Who?	Severity	Probability	Risk level
Cuts	Butcher's section, Fish section	X	1	Small	Minor	Acceptable
Fall from the same level						
Fall of different levels	Office media, Electrical appliance, Grocery	X	1	Great	Rather serious	Important
Fall of tools, parts of a machine, equipments or products	Grocery, Butcher's section, Fish section	X	1 and 2	Great	Rather serious	Important
Movements or awkward postures	Electrical appliance, Freezing section, Charcuterie, Dairy, Fishing section, Fruits and vegetables, Beverage section, Grocery	X	1 and 2	Considerable	Slight	Acceptable
Incorrect Assembly of machines or equipment	Grocery, Fishing section, Butcher's section		1	Small	Minor	
Dangerous energies		X	1 and 2	Small	Minor	Acceptable
Stairs						
Lighting						
Noise						
Thermal environemet	Freezing section, butcher's section, Dairy		1 and 2	Small	Minor	Acceptable
Workspace inappropriate						
Others		X				

In CAFCP 02 two situations deserved special attention:

(1) the possibility of a lift from different levels;

(2) the possibility of tools, parts of a machine, equipments or products to fall.

Situation (2) was identified through direct analyst observation. It was related with products replacement in the shelves. Professional executes this task with the help of a lift-truck. When this situation happens, access to the corridor is sealed by a chain and clients are not allowed to enter this section. The fact is that clients pass through the chain, ignoring the prohibition warnings. This behavior places them in a situation of serious risk of injury, because the goods being placed on the shelves can drop from the top on them. The analyst considers that this clients‟‟ behavior can compromise the professionals‟‟ attentiveness to his work and consequently put him under a likely risk situation

4. Job content

The main lines of work organization are determined by managers. Tasks and the operational sequences that workers have to perform are analyzed, checking if they are consistent with the physical, physiological, sensory and cognitive abilities of workers.

All workers perform all of their work tasks: planning, implementing, inspection and execution.

The clients' attendance requires some cognitive demands on the professionals' attention and concentration, essential to record the clients' requests and make the right decisions. It is considered that the time available for professionals' execute their activities is enough to the tasks 'execution.

In CAFCP 01 and 02 this is not a critical situation.

5. Job restrictiveness

In this item assessment, two critical situations were identified in CAFCP 01:

- Conference of orders in the same place where clients require information (subsection 1)

- Existence of a common line for payment and products return (subsection 5/6)

- Existence of material for shelves' replacement left in the corridors can prevent or hinder the passage of clients or professionals (subsection 2)

This last situation was also identified in CAFCP 02.

In both CAFCP, the existing computer system is not restrictive, allowing a correct execution of the tasks.

6. Decision making

The training in this activity appears to be a crucial point for a correct decision making that, from the standpoint of the professional autonomy may affect the quality of information provided to the client. In CAFCP 01 and 02 this is not a critical situation.

7. Attentiveness

In CAFCP 02, an important critical situation, identified by analyst direct observation, was related with the products replacement in the shelves in grocery, office media and electrical appliance

sections. Professional executes this task with the help of a lift-truck. When this situation happens, access to the corridor is sealed by a chain and clients are not allowed to enter this section. The fact is that clients pass through the chain, ignoring the prohibition warnings. This behavior places them in a situation of serious risk of injury, because the goods being placed on the shelves can drop from the top on them. The analyst considers that this clients‟‟ behavior can compromise the professionals‟‟ attentiveness to his work and consequently put him under a likely risk situation.

In both CAFCP tasks related to sale registration and payment required from the professionals a rather great attention demand. A mistake in his field can affects clients and the organization profits.

8. Worker communication and personnel contacts

Special attention was given to making communication and contacts possible between clients/professionals, clients/manager, professionals/professionals, professionals/supervisor or manager. No problem was identified.

9. Noise

Noise measurement, as part of this macroergonomic analysis, aims at obtaining data to make a diagnosis regarding the workers' occupational noise exposure situation. In doing so, it may be inferred, for example, that the values obtained can cause ear damage to exposed workers and/or deterioration of the working environment.

The entire work area with free movement of people (clients and professionals), where verbal communication, concentration and comfort of those involved must be preserved, is considered for this analysis.

The classification of this item was based on the portuguese Decreto-Lei n.º 182/2006, September 2006.In light of this document, the values obtained relatively to the daily exposure of workers in each CAFP are below the lower action threshold, i.e., Lex,8h <80 dB (A). Lex,8h

The measurement of levels that may affect the comfort level of clients and/or professionals was considered. In CAFCP 01 three situations that might compromise this status were identified:

- the vicinity of an air conditioning outlet in the photography section, where the measured sound level was 63.1 dB (A);
- in the "gaming" section, where the three speakers of the console and monitor were being used by clients, a noise level of 69.5 dB (A) was obtained;
- advertising and warnings that pass through the intercom, where two values were randomly measured: 72.1 dB (A) next to the box; 67.2 dB (A) in the computer section.

Additionally, a value of peak sound pressure of 137dB (C) was measured, next to the speakers.

The values of daily exposure to occupational noise obtained in this expeditious pre-assessment seem to indicate the absence of risk of hearing loss due to exposure to hazardous levels of noise. In fact, these values are below the lower action contemplated in Decreto-Lei n.º 182/2006, September 2006. Nevertheless, the value of peak sound pressure level obtained coincides with

the upper action limit established by Portuguese legislation for this parameter, already reflecting a concerning level in terms of noise exposure.

Moreover, the evaluators are aware that the measurements made were merely indicative, not following any strategy or sampling criteria for measuring noise.

It is advisable to deepen this issue, by resorting to a more methodical approach for assessing occupational noise exposure of workers concerned, so as to obtain robust results.

Finally, if values obtained in subsequent assessments indicate that these workers are not exposed to noise levels established by Portuguese legislation as hazardous to auditory function, one may question how exposure to lower noise levels affect the comfort of workers, their concentration in the execution of tasks and verbal communication essential to their jobs.

10. General physical activity

CAFCP 01 and CAFCP 02 Peak load work can occur to some extent, but they do not produce a risk of overstrain.

11. Repetitiveness of the work

Situations with repetitive tasks have not been identified in both CAFCP.

12. Lifting

The design and layout of the workstation and commercial area must allow the lifting tasks to carrying out with without difficulty and safety.

It is considered that the shelves' height will have influence in the correct way to a product achievement or to placement. According to EWA guidelines, a normal lifting height is made between the wrist and shoulder. In CAFCP 01, the high of the shelves ranged from 15 cm, to 209 cm from the ground. Stress caused by lifting can be accessed from the weight of the loads that is when the loads are made below the ankles or above shoulders. The identification of critical lifting's' is presented in Figure A7.2. It is considered that in those identified situations, professionals' performance and clients' well-being can be compromised.

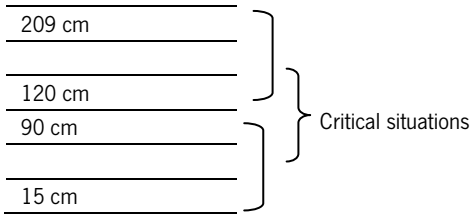

Figure A7.2. Identification of critical lifting's'

Similar situation was identified in CAFACP 02. It is also important to report that stress caused by lifting can be also accessed when clients place their purchases in the shopping trolleys. Lifting can be worsened by the height of the shelves as well as the weight of the product. Since this CAFCP is a retail store, in most cases, the products are sold in sets (not to unity), which makes the package weight greater than the weight of the unit package, making difficult the lifting height. Therefore, the products placements in the shelves must be take into consideration to avoid constraints related to clients and professionals' lifting tasks.

13. Postures and movements

Postures and movements evaluation was based on EWA guidelines. In Loureiro et al., 2008 anthropometric studies of the attendance balcony, common areas, and conference balcony were made and used to help the analyst evaluation. Postures and movements' evaluation are represented in Table A7.13 and Table A7.14.

Table A7.13. Postures and movements' evaluation (CAFCP 01)

Subsection	Dimension	Task	Neck-shoulders	Elbow-wrist	Back	Hips-legs
Subsection 1	Professionals	Attendance	3	3	3	3
		Conference	2	1	2	1
Subsection 2	Professionals/clients		2	2	2	2
Subsection 3	Clients		1	1	1	1
Subsection 4	Clients		3	3	3	3
Subsection 5	Professionals	Attendance	3	3	3	3

Table A 7.14. Postures and movements' evaluation (CAFCP 02)

Section	Dimension	Neck-shoulders	Elbow-wrist	Back	Hips-legs
1	Professionals	3	3	2	3
2	Professionals	3	3	2	3
3	Professionals	2	3	2	3
4a	Professionals	3	3	1	2
4b	Professionals	3	3	2	2
5	Professionals	3	3	1	2
6	Professionals	3	3	1	2
7	Professionals	3	3	1	2
8	Professionals/ clients	2	3	2	2
9	Professionals/ clients	2	3	1	3
10	Professionals/ clients	3	3	2	2
Others	Clients*	3	3	1	3

* Clients' difficulties in operate the shopping trolleys, especially when they are loaded, i.e., when the total weight can reach values of approximately 600 kg (1322 lbs).

14. Postures and movements

The evaluation was done by direct observation and as abovementioned, previous anthropometric studies were used (Loureiro et al., 2008) (Table A7.15)

Table A7.15. Postures and movements, CAFCP 01

Subsection	Horizontal area	Working height	Viewing	Legs space	Seat	Hand tools	Other equipment
Subsection 1	2	2	3	1	2	3	3
Subsection 2							
Subsection 3							
Subsection 4							
Subsection 5	2	2	3	1	2	3	3

Regarding the CAFCP 02, results for postures and movements evaluation are presented in Table A7.16.

Table A7.16. Postures and movements, CAFCP 01

Section	Dimension	Horizontal area	Working height	Viewing	Legs space	Seat	Hand tools	Other equipment
1	Professionals		3	3	3		3	
2	Professionals		3	3	3		3	
3	Professionals		3	3	3		3	
4a	Professionals		3	3	3		3	
4b	Professionals		3	3	3		3	
5	Professionals		3	3	3		3	
6	Professionals		3	3	3		3	
7	Professionals		3	3	3		3	
8	Professionals/ clients	2	3	3	3	2	3	
9	Professionals/ clients	2	3	3	3	2	3	
10	Professionals/ clients							
Others	Clients*		3	3	3		3	

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Annex 8

Weighting Tables, CAFCP 01

Weighting table 1

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	1,60	1,50	2,70	2,50	1,60	1,70	1,10	1,30	2,60	2,60	2,40	2,40	2,70
Gaming 2	1,60	2,50	2,70	2,50	1,60	1,70	1,10	1,30	2,60	2,60	2,40	2,40	2,70
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,00	1,34	2,34	2,34	1,50	2,00	1,50	1,50	2,50	2,34	2,34	2,50	2,50
Music 2	2,00	2,34	2,34	2,34	1,50	2,00	1,50	1,50	2,60	2,34	2,34	2,50	2,70
TV/Photo 1	1,95	1,56	2,61	2,45	1,72	2,06	1,67	1,45	2,67	2,60	2,56	2,50	2,78
TV/Photo 2	1,95	2,56	2,61	2,45	1,72	2,06	1,67	1,45	2,67	2,56	2,45	2,50	2,78
Books 1	1,86	1,56	2,61	2,45	1,72	1,65	1,67	1,45	2,67	2,22	2,22	2,50	2,78
Books 2	1,86	2,43	2,72	2,29	0,93	1,65	1,15	1,36	2,36	2,22	2,22	2,15	2,50
SPC	1,90	2,00	2,72	2,36	1,61	2,32	2,43	1,50	2,65	2,60	2,40	2,50	2,86
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 2

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	1,40	1,75	2,55	2,25	1,90	1,70	1,15	1,45	2,40	2,60	2,40	2,10	2,55
Gaming 2	1,40	2,25	2,55	2,25	1,90	1,70	1,15	1,45	2,40	2,60	2,40	2,10	2,55
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,00	1,50	2,00	2,00	1,75	2,00	1,75	1,75	2,25	2,34	2,34	2,25	2,25
Music 2	2,00	2,00	2,00	2,00	1,75	2,00	1,75	1,75	2,40	2,34	2,34	2,50	2,55
TV/Photo 1	1,92	1,83	2,42	2,17	2,08	2,06	2,00	1,67	2,50	2,60	2,56	2,25	2,67
TV/Photo 2	1,92	2,33	2,42	2,17	2,08	2,06	2,00	1,67	2,50	2,56	2,45	2,25	2,67
Books 1	1,78	1,83	2,42	2,17	2,08	1,65	2,00	1,67	2,50	2,22	2,22	2,25	2,67
Books 2	1,78	2,15	2,57	1,93	2,08	1,65	1,22	1,53	2,03	2,22	2,22	1,72	2,25
SPC	1,84	2,00	2,57	2,03	1,91	2,32	2,15	1,75	2,47	2,60	2,40	2,25	2,78
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 3

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	1,80	1,25	2,85	2,75	1,30	1,70	1,05	1,15	2,80	2,60	2,40	2,70	2,85
Gaming 2	1,80	2,75	2,85	2,75	1,30	1,70	1,05	1,15	2,80	2,60	2,40	2,70	2,85
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,00	1,17	2,67	2,67	1,25	2,00	1,25	1,25	2,75	2,34	2,34	2,75	2,75
Music 2	2,00	2,67	2,67	2,67	1,25	2,00	1,25	1,25	2,80	2,34	2,34	2,50	2,85
TV/Photo 1	1,97	1,28	2,81	2,72	1,36	2,06	1,33	1,22	2,83	2,60	2,56	2,75	2,89
TV/Photo 2	1,97	2,78	2,81	2,72	1,36	2,06	1,33	1,22	2,83	2,56	2,45	2,75	2,89
Books 1	1,93	1,28	2,81	2,72	1,36	1,65	1,33	1,22	2,83	2,22	2,22	2,75	2,89
Books 2	1,93	2,72	2,86	2,64	1,36	1,65	1,07	1,18	2,68	2,22	2,22	2,57	2,75
SPC	1,95	2,00	2,86	2,68	1,30	2,32	2,72	1,25	2,82	2,60	2,40	2,75	2,93
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 4

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	1,65	1,57	2,67	2,50	1,67	1,70	1,18	1,33	2,62	2,60	2,40	2,43	2,66
Gaming 2	1,65	2,52	2,67	2,50	1,67	1,70	1,18	1,33	2,62	2,60	2,40	2,43	2,66
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,03	1,42	2,32	2,35	1,57	2,00	1,56	1,52	2,52	2,34	2,34	2,52	2,47
Music 2	2,03	2,37	2,32	2,35	1,57	2,00	1,56	1,52	2,62	2,34	2,34	2,50	2,66
TV/Photo 1	1,98	1,63	2,58	2,45	1,78	2,06	1,72	1,46	2,68	2,60	2,56	2,52	2,73
TV/Photo 2	1,98	2,58	2,58	2,45	1,78	2,06	1,72	1,46	2,68	2,56	2,45	2,52	2,73
Books 1	1,89	1,63	2,58	2,45	1,78	1,65	1,72	1,46	2,68	2,22	2,22	2,52	2,73
Books 2	1,89	2,46	2,68	2,30	1,78	1,65	1,22	1,38	2,38	2,22	2,22	2,18	2,47
SPC	1,93	2,05	2,68	2,36	1,67	2,32	2,44	1,52	2,66	2,60	2,40	2,52	2,80
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 5

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	1,70	1,65	2,64	2,51	1,74	1,70	1,26	1,35	2,63	2,60	2,40	2,45	2,61
Gaming 2	1,70	2,55	2,64	2,51	1,74	1,70	1,26	1,35	2,63	2,60	2,40	2,45	2,61
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,06	1,50	2,31	2,36	1,65	2,00	1,62	1,53	2,54	2,34	2,34	2,54	2,43
Music 2	2,06	2,40	2,31	2,36	1,65	2,00	1,62	1,53	2,63	2,34	2,34	2,50	2,61
TV/Photo 1	2,01	1,70	2,55	2,46	1,85	2,06	1,77	1,48	2,69	2,60	2,56	2,54	2,69
TV/Photo 2	2,01	2,60	2,55	2,46	1,85	2,06	1,77	1,48	2,69	2,56	2,45	2,54	2,69
Books 1	1,93	1,70	2,55	2,46	1,85	1,65	1,77	1,48	2,69	2,22	2,22	2,54	2,69
Books 2	1,93	2,48	2,65	2,31	1,85	1,65	1,30	1,40	2,41	2,22	2,22	2,22	2,43
SPC	1,97	2,10	2,65	2,37	1,74	2,32	2,46	1,53	2,67	2,60	2,40	2,54	2,75
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 6

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	1,86	1,87	2,54	2,51	1,95	1,70	1,50	1,43	2,68	2,60	2,40	2,53	2,48
Gaming 2	1,86	2,62	2,54	2,51	1,95	1,70	1,50	1,43	2,68	2,60	2,40	2,53	2,48
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,16	1,74	2,26	2,39	1,87	2,00	1,80	1,58	2,61	2,34	2,34	2,61	2,33
Music 2	2,16	2,49	2,26	2,39	1,87	2,00	1,80	1,58	2,68	2,34	2,34	2,50	2,48
TV/Photo 1	2,11	1,91	2,47	2,47	2,04	2,06	1,93	1,54	2,73	2,60	2,56	2,61	2,54
TV/Photo 2	2,11	2,66	2,47	2,47	2,04	2,06	1,93	1,54	2,73	2,56	2,45	2,61	2,54
Books 1	2,05	1,91	2,47	2,47	2,04	1,65	1,93	1,54	2,73	2,22	2,22	2,61	2,54
Books 2	2,05	2,57	2,55	2,35	2,04	1,65	1,54	1,47	2,50	2,22	2,22	2,34	2,33
SPC	2,08	2,24	2,55	2,40	1,95	2,32	2,50	1,58	2,71	2,60	2,40	2,61	2,60
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 7

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Communication
Gaming 1	1,94	1,99	2,48	2,52	2,06	1,70	1,64	1,47	2,71	2,60	2,40	2,57	2,41
Gaming 2	1,94	2,66	2,48	2,52	2,06	1,70	1,64	1,47	2,71	2,60	2,40	2,57	2,41
Gaming 3	2,24	2,00	2,52	2,75	1,00	2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,21	1,88	2,24	2,41	1,99	2,00	1,90	1,61	2,64	2,34	2,34	2,64	2,28
Music 2	2,21	2,55	2,24	2,41	1,99	2,00	1,90	1,61	2,71	2,34	2,34	2,50	2,41
TV/Photo 1	2,17	2,03	2,42	2,48	2,14	2,06	2,01	1,57	2,75	2,60	2,56	2,64	2,46
TV/Photo 2	2,17	2,69	2,42	2,48	2,14	2,06	2,01	1,57	2,75	2,56	2,45	2,64	2,46
Books 1	2,11	2,03	2,42	2,48	2,14	1,65	2,01	1,57	2,75	2,22	2,22	2,64	2,46
Books 2	2,11	2,61	2,49	2,37	1,95	1,65	1,67	1,51	2,54	2,22	2,22	2,40	2,28
SPC	2,14	2,32	2,49	2,42	2,06	2,32	2,52	1,61	2,74	2,60	2,40	2,64	2,51
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 8

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Communication
Gaming 1	2,01	2,09	2,44	2,52	2,15	1,70	1,74	1,51	2,73	2,60	2,40	2,61	2,35
Gaming 2	2,01	2,69	2,44	2,52	2,15	1,70	1,74	1,51	2,73	2,60	2,40	2,61	2,35
Gaming 3	2,24	2,00	2,52	2,75	1,00	2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,25	1,99	2,22	2,42	2,09	2,00	1,98	1,63	2,67	2,34	2,34	2,67	2,23
Music 2	2,25	2,59	2,22	2,42	2,09	2,00	1,98	1,63	2,73	2,34	2,34	2,50	2,35
TV/Photo 1	2,22	2,12	2,39	2,49	2,22	2,06	2,08	1,60	2,77	2,60	2,56	2,67	2,40
TV/Photo 2	2,22	2,72	2,39	2,49	2,22	2,06	2,08	1,60	2,77	2,56	2,45	2,67	2,40
Books 1	2,16	2,12	2,39	2,49	2,22	1,65	2,08	1,60	2,77	2,22	2,22	2,67	2,40
Books 2	2,16	2,65	2,45	2,39	2,05	1,65	1,77	1,54	2,58	2,22	2,22	2,46	2,23
SPC	2,19	2,39	2,45	2,43	2,16	2,32	2,54	1,63	2,76	2,60	2,40	2,67	2,45
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 9

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Communication
Gaming 1	2,11	2,24	2,38	2,53	2,29	1,70	1,91	1,56	2,76	2,60	2,40	2,66	2,27
Gaming 2	2,11	2,74	2,38	2,53	2,29	1,70	1,91	1,56	2,76	2,60	2,40	2,66	2,27
Gaming 3	2,24	2,00	2,52	2,75	1,00	2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,31	2,15	2,19	2,44	2,24	2,00	2,11	1,66	2,71	2,34	2,34	2,71	2,17
Music 2	2,31	2,65	2,19	2,44	2,24	2,00	2,11	1,66	2,76	2,34	2,34	2,50	2,27
TV/Photo 1	2,28	2,26	2,33	2,50	2,35	2,06	2,19	1,63	2,79	2,60	2,56	2,71	2,31
TV/Photo 2	2,28	2,76	2,33	2,50	2,35	2,06	2,19	1,63	2,79	2,56	2,45	2,71	2,31
Books 1	2,24	2,26	2,33	2,50	2,35	1,65	2,19	1,63	2,79	2,22	2,22	2,71	2,31
Books 2	2,24	2,70	2,38	2,42	2,21	1,65	1,93	1,59	2,64	2,22	2,22	2,53	2,17
SPC	2,26	2,49	2,38	2,45	2,29	2,32	2,57	1,66	2,78	2,60	2,40	2,71	2,34
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 10

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	2,31	2,53	2,25	2,54	2,57	1,70	2,23	1,66	2,82	2,60	2,40	2,76	2,09
Gaming 2	2,31	2,83	2,25	2,54	2,57	1,70	2,23	1,66	2,82	2,60	2,40	2,76	2,09
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,43	2,48	2,14	2,49	2,54	2,00	2,35	1,72	2,79	2,34	2,34	2,79	2,03
Music 2	2,43	2,78	2,14	2,49	2,54	2,00	2,35	1,72	2,82	2,34	2,34	2,50	2,09
TV/Photo 1	2,42	2,55	2,22	2,52	2,60	2,06	2,40	1,71	2,84	2,60	2,56	2,79	2,12
TV/Photo 2	2,42	2,85	2,22	2,52	2,60	2,06	2,40	1,71	2,84	2,56	2,45	2,79	2,12
Books 1	2,39	2,55	2,22	2,52	2,60	1,65	2,40	1,71	2,84	2,22	2,22	2,79	2,12
Books 2	2,39	2,81	2,25	2,47	2,60	1,65	2,24	1,68	2,75	2,22	2,22	2,69	2,03
SPC	2,40	2,68	2,25	2,49	2,57	2,32	2,63	1,72	2,84	2,60	2,40	2,79	2,14
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 11

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Communication
Gaming 1	2,42	2,68	2,18	2,54	2,70	1,70	2,39	1,72	2,86	2,60	2,40	2,82	2,00
Gaming 2	2,42	2,88	2,18	2,54	2,70	1,70	2,39	1,72	2,86	2,60	2,40	2,82	2,00
Gaming 3	2,24	2,00	2,52	2,75	1,00	2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,50	2,64	2,11	2,51	2,68	2,00	2,47	1,76	2,84	2,34	2,34	2,84	1,96
Music 2	2,50	2,84	2,11	2,51	2,68	2,00	2,47	1,76	2,86	2,34	2,34	2,50	2,00
TV/Photo 1	2,49	2,69	2,16	2,53	2,73	2,06	2,50	1,75	2,87	2,60	2,56	2,84	2,02
TV/Photo 2	2,49	2,89	2,16	2,53	2,73	2,06	2,50	1,75	2,87	2,56	2,45	2,84	2,02
Books 1	2,47	2,69	2,16	2,53	2,73	1,65	2,50	1,75	2,87	2,22	2,22	2,84	2,02
Books 2	2,47	2,86	2,18	2,50	2,67	1,65	2,40	1,73	2,81	2,22	2,22	2,77	1,96
SPC	2,48	2,78	2,18	2,51	2,71	2,32	2,65	1,76	2,87	2,60	2,40	2,84	2,04
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 12

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Communication
Gaming 1	2,52	2,82	2,12	2,55	2,84	1,70	2,55	1,77	2,89	2,60	2,40	2,87	1,92
Gaming 2	2,52	2,92	2,12	2,55	2,84	1,70	2,55	1,77	2,89	2,60	2,40	2,87	1,92
Gaming 3	2,24	2,00	2,52	2,75	1,00	2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,56	2,81	2,08	2,53	2,83	2,00	2,59	1,79	2,88	2,34	2,34	2,88	1,90
Music 2	2,56	2,91	2,08	2,53	2,83	2,00	2,59	1,79	2,89	2,34	2,34	2,50	1,92
TV/Photo 1	2,55	2,83	2,11	2,54	2,85	2,06	2,61	1,78	2,89	2,60	2,56	2,88	1,93
TV/Photo 2	2,55	2,93	2,11	2,54	2,85	2,06	2,61	1,78	2,89	2,56	2,45	2,88	1,93
Books 1	2,54	2,83	2,11	2,54	2,85	1,65	2,61	1,78	2,89	2,22	2,22	2,88	1,93
Books 2	2,54	2,92	2,12	2,52	2,83	1,65	2,55	1,77	2,86	2,22	2,22	2,84	1,90
SPC	2,55	2,87	2,12	2,53	2,84	2,32	2,68	1,79	2,89	2,60	2,40	2,88	1,93
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 13

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Communication
Gaming 1	2,62	2,97	2,05	2,55	2,98	1,70	2,71	1,82	2,92	2,60	2,40	2,92	1,83
Gaming 2	2,62	2,97	2,05	2,55	2,98	1,70	2,71	1,82	2,92	2,60	2,40	2,92	1,83
Gaming 3	2,47	2,99	2,04	2,50	2,00	2,00	2,73	1,78	2,91	3,00	3,00	1,56	1,79
Music 1	2,62	2,97	2,05	2,55	2,98	2,00	2,71	1,82	2,92	2,34	2,34	2,92	1,83
Music 2	2,62	2,97	2,05	2,55	2,98	2,00	2,71	1,82	2,92	2,34	2,34	2,50	1,83
TV/Photo 1	2,62	2,97	2,05	2,55	2,98	2,06	2,71	1,82	2,92	2,60	2,56	2,92	1,83
TV/Photo 2	2,62	2,97	2,05	2,55	2,98	2,06	2,71	1,82	2,92	2,56	2,45	2,92	1,83
Books 1	2,62	2,97	2,05	2,55	2,98	1,65	2,71	1,82	2,92	2,22	2,22	2,92	1,83
Books 2	2,62	2,97	2,05	2,55	2,98	1,65	2,71	1,82	2,92	2,22	2,22	2,92	1,83
SPC	2,62	2,97	2,05	2,55	2,98	2,32	2,71	1,82	2,92	2,60	2,40	2,92	1,83
Kids' area	2,36	2,91	2,00	2,45	2,91	3,00	2,91	1,45	3,00	3,00	3,00	1,55	1,82

Weighting table 14

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Comunication
Gaming 1	1,20	2,00	2,40	2,00	2,20	1,70	1,20	1,60	2,20	2,60	2,40	1,80	2,40
Gaming 2	1,20	2,00	2,40	2,00	2,20	1,70	1,20	1,60	2,20	2,60	2,40	1,80	2,40
Gaming 3	2,24	2,00	2,52	2,75		2,00	2,87	2,39	2,96	3,00	3,00	2,28	2,40
Music 1	2,00	1,67	1,67	1,67	2,00	2,00	2,00	2,00	2,00	2,34	2,34	2,00	2,00
Music 2	2,00	1,67	1,67	1,67	2,00	2,00	2,00	2,00	2,20	2,34	2,34	2,50	2,40
TV/Photo 1	1,89	2,11	2,22	1,89	2,44	2,06	2,33	1,89	2,33	2,60	2,56	2,00	2,56
TV/Photo 2	1,89	2,11	2,22	1,89	2,44	2,06	2,33	1,89	2,33	2,56	2,45	2,00	2,56
Books 1	1,71	2,11	2,22	1,89	2,44	1,65	2,33	1,89	2,33	2,22	2,22	2,00	2,56
Books 2	1,71	1,86	2,43	1,57	2,44	1,65	1,29	1,71	1,71	2,22	2,22	1,29	2,00
SPC	1,79	2,00	2,43	1,71	2,21	2,32	1,86	2,00	2,29	2,60	2,40	2,00	2,71
Kids' area	2,18	1,96	2,50	2,73		3,00	2,96	2,23	3,00	3,00	3,00	2,28	2,41

Weighting table 15

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision	Job content	Attentiveness	Physical act.	Communication
Gaming 1	2,00	1,00	3,00	3,00	1,00	2,00	1,00	1,00	3,00	3,00	3,00	3,00	3,00
Gaming 2	2,00	3,00	3,00	3,00	1,00	2,00	1,00	1,00	3,00	3,00	3,00	3,00	3,00
Gaming 3	2,00	1,00	3,00	3,00	.	2,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00
Music 1	2,00	1,00	3,00	3,00	1,00	2,00	1,00	1,00	3,00	3,00	3,00	3,00	3,00
Music 2	2,00	3,00	3,00	3,00	1,00	2,00	1,00	1,00	3,00	3,00	3,00	3,00	3,00
TV/Photo 1	2,00	1,00	3,00	3,00	1,00	2,00	1,00	1,00	3,00	3,00	3,00	3,00	3,00
TV/Photo 2	2,00	3,00	3,00	3,00	1,00	2,00	1,00	1,00	3,00	3,00	3,00	3,00	3,00
Books 1	2,00	1,00	3,00	3,00	1,00	2,00	1,00	1,00	3,00	3,00	3,00	3,00	3,00
Books 2	2,00	3,00	3,00	3,00	1,00	2,00	1,00	1,00	3,00	3,00	3,00	3,00	3,00
SPC	2,00	2,00	3,00	3,00	1,00	3,00	3,00	1,00	3,00	3,00	3,00	3,00	3,00
Kids' area	2,00	1,00	3,00	3,00	.	3,00	3,00	3,00	3,00	3,00	3,00	3,00	3,00

Annex 9

Weighting Tables, CAFCP 02

Weighting table 1

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,50	2,60	1,90	2,10	2,50	1,70	1,80	1,90	2,25	2,60	2,40	2,50	2,40
2	2,30	2,60	1,90	2,20	2,50	2,00	2,30	1,80	2,30	2,50	2,38	2,60	2,50
3	2,36	2,50	1,93	1,00	2,64	1,93	1,71	1,79	2,43	2,43	2,29	2,14	2,36
4	2,43	2,57	1,79	1,29	2,57	1,50	1,93	1,93	2,36	2,50	2,50	2,43	2,50
5	2,50	2,63	1,88	2,13	2,50	1,13	1,63	2,00	2,50	2,38	2,50	2,63	2,63
6	2,38	2,38	1,50	2,00	2,25	1,25	1,63	1,63	2,13	2,38	1,50	2,50	2,50
7	2,44	2,50	1,31	2,38	2,44	1,31	1,69	1,75	2,13	2,50	1,50	2,38	2,50
8	2,40	2,60	2,50	1,50	1,80	1,70	2,50	2,40	2,60	2,40	2,50	2,40	2,70
9	2,40	2,60	2,50	1,50	1,80	1,20	2,50	1,90	2,60	2,40	2,00	2,40	2,70
10	2,23	2,42	1,25	2,00	2,31	1,17	1,62	1,79	2,35	2,42	1,50	2,35	2,46
11	2,30	2,60	1,90	1,20	2,50	2,00	1,80	1,80	2,30	2,50	2,38	2,60	2,50

Weighting table 2

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,25	2,40	1,85	1,65	2,25	1,55	1,70	1,85	1,88	2,60	2,40	2,25	2,10
2	1,95	2,40	1,85	1,80	2,25	2,00	1,95	1,70	1,95	2,50	2,06	2,40	2,25
3	2,04	2,25	1,89	1,00	2,46	1,89	1,57	1,68	2,14	2,43	1,93	1,71	2,04
4	2,14	2,36	1,68	1,43	2,36	1,75	1,89	1,89	2,04	2,50	2,25	2,14	2,25
5	2,25	2,44	1,81	1,69	2,25	1,19	1,44	2,00	2,25	2,38	2,25	2,44	2,44
6	2,06	2,06	1,75	1,50	1,88	1,38	1,44	1,44	1,69	2,38	1,75	2,25	2,25
7	2,16	2,25	1,47	2,06	2,16	1,47	1,53	1,63	1,69	2,50	1,75	2,06	2,25
8	2,10	2,40	2,25	1,25	1,70	1,55	2,25	2,10	2,40	2,40	2,25	2,10	2,55
9	2,10	2,40	2,25	1,25	1,70	1,30	2,25	1,85	2,40	2,40	2,00	2,10	2,55
10	1,85	2,13	1,38	1,50	1,96	1,25	1,42	1,69	2,02	2,42	1,75	2,02	2,19
11	1,95	2,40	1,85	1,30	2,25	2,00	1,70	1,70	1,95	2,50	2,06	2,40	2,25

	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness			Attentiveness	Physical activity	Comunication

Weighting table 3

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,75	2,80	1,95	2,55	2,75	1,85	1,90	1,95	2,63	2,60	2,40	2,75	2,70
2	2,65	2,80	1,95	2,60	2,75	2,00	2,65	1,90	2,65	2,50	2,69	2,80	2,75
3	2,68	2,75	1,96	1,00	2,82	1,96	1,86	1,89	2,71	2,43	2,64	2,57	2,68
4	2,71	2,79	1,89	1,14	2,79	1,25	1,96	1,96	2,68	2,50	2,75	2,71	2,75
5	2,75	2,81	1,94	2,56	2,75	1,06	1,81	2,00	2,75	2,38	2,75	2,81	2,81
6	2,69	2,69	1,25	2,50	2,63	1,13	1,81	1,81	2,56	2,38	1,25	2,75	2,75
7	2,72	2,75	1,16	2,69	2,72	1,16	1,84	1,88	2,56	2,50	1,25	2,69	2,75
8	2,70	2,80	2,75	1,75	1,90	1,85	2,75	2,70	2,80	2,40	2,75	2,70	2,85
9	2,70	2,80	2,75	1,75	1,90	1,10	2,75	1,95	2,80	2,40	2,00	2,70	2,85
10	2,62	2,71	1,13	2,50	2,65	1,08	1,81	1,90	2,67	2,42	1,25	2,67	2,73
11	2,65	2,80	1,95	1,10	2,75	2,00	1,90	1,90	2,65	2,50	2,69	2,80	2,75

Weighting table 4

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,51	2,60	1,90	2,12	2,51	1,71	1,84	1,92	2,24	2,60	2,40	2,47	2,36
2	2,32	2,60	1,90	2,21	2,51	2,00	2,31	1,82	2,29	2,50	2,36	2,56	2,45
3	2,38	2,51	1,93	1,07	2,64	1,93	1,75	1,81	2,41	2,43	2,27	2,13	2,31
4	2,45	2,58	1,79	1,34	2,58	1,52	1,96	1,94	2,34	2,50	2,48	2,40	2,45
5	2,51	2,63	1,88	2,14	2,51	1,17	1,67	2,01	2,48	2,38	2,48	2,59	2,57
6	2,39	2,39	1,52	2,02	2,27	1,28	1,67	1,65	2,12	2,38	1,53	2,47	2,45
7	2,45	2,51	1,34	2,38	2,45	1,34	1,73	1,77	2,12	2,50	1,53	2,35	2,45
8	2,42	2,60	2,47	1,55	1,84	1,71	2,50	2,39	2,57	2,40	2,48	2,37	2,64
9	2,42	2,60	2,47	1,55	1,84	1,24	2,50	1,92	2,57	2,40	2,00	2,37	2,64
10	2,26	2,44	1,28	2,02	2,32	1,21	1,66	1,81	2,33	2,42	1,53	2,32	2,41
11	2,32	2,60	1,90	1,26	2,51	2,00	1,84	1,82	2,29	2,50	2,36	2,56	2,45

Weighting table 5

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,53	2,61	1,90	2,13	2,52	1,72	1,87	1,93	2,23	2,60	2,40	2,44	2,31
2	2,35	2,61	1,90	2,22	2,52	1,99	2,32	1,84	2,27	2,50	2,34	2,53	2,40
3	2,40	2,52	1,92	1,14	2,64	1,93	1,80	1,83	2,39	2,43	2,26	2,12	2,27
4	2,46	2,58	1,80	1,40	2,58	1,54	1,99	1,96	2,33	2,50	2,45	2,37	2,40
5	2,53	2,63	1,88	2,16	2,52	1,21	1,72	2,02	2,45	2,38	2,45	2,55	2,51
6	2,41	2,41	1,54	2,04	2,29	1,32	1,72	1,68	2,12	2,38	1,55	2,44	2,40
7	2,47	2,52	1,37	2,38	2,46	1,38	1,77	1,80	2,12	2,50	1,55	2,33	2,40
8	2,44	2,61	2,44	1,59	1,89	1,72	2,50	2,38	2,54	2,40	2,45	2,35	2,58
9	2,44	2,61	2,44	1,59	1,89	1,27	2,50	1,93	2,54	2,40	2,00	2,35	2,58
10	2,29	2,45	1,31	2,04	2,34	1,24	1,71	1,83	2,32	2,42	1,55	2,30	2,37
11	2,35	2,61	1,90	1,32	2,52	1,99	1,87	1,84	2,27	2,50	2,34	2,53	2,40

Weighting table 6

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,57	2,62	1,90	2,19	2,54	1,76	1,98	1,98	2,20	2,60	2,40	2,34	2,18
2	2,42	2,62	1,90	2,26	2,54	1,99	2,36	1,90	2,24	2,50	2,29	2,42	2,25
3	2,46	2,55	1,92	1,36	2,65	1,93	1,92	1,89	2,33	2,43	2,23	2,08	2,14
4	2,51	2,60	1,81	1,58	2,59	1,61	2,08	2,00	2,28	2,50	2,39	2,29	2,25
5	2,57	2,64	1,88	2,21	2,54	1,33	1,85	2,05	2,39	2,38	2,39	2,44	2,34
6	2,47	2,46	1,60	2,11	2,35	1,42	1,85	1,77	2,11	2,38	1,64	2,34	2,25
7	2,52	2,55	1,46	2,39	2,49	1,47	1,90	1,86	2,11	2,50	1,64	2,25	2,25
8	2,49	2,62	2,35	1,74	2,01	1,76	2,51	2,35	2,46	2,40	2,39	2,27	2,40
9	2,49	2,62	2,35	1,74	2,01	1,39	2,51	1,98	2,46	2,40	2,01	2,27	2,40
10	2,37	2,49	1,41	2,11	2,39	1,36	1,84	1,90	2,27	2,42	1,64	2,23	2,22
11	2,42	2,62	1,90	1,51	2,54	1,99	1,98	1,90	2,24	2,50	2,29	2,42	2,25

Weighting table 7

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,59	2,63	1,90	2,22	2,55	1,78	2,04	2,00	2,18	2,60	2,40	2,29	2,10
2	2,46	2,63	1,90	2,28	2,55	1,98	2,38	1,94	2,22	2,50	2,27	2,36	2,17
3	2,50	2,57	1,91	1,48	2,65	1,93	1,99	1,93	2,30	2,43	2,21	2,05	2,07
4	2,54	2,61	1,82	1,67	2,60	1,65	2,13	2,02	2,25	2,50	2,35	2,24	2,17
5	2,59	2,65	1,88	2,23	2,55	1,40	1,93	2,07	2,35	2,38	2,35	2,38	2,25
6	2,51	2,48	1,63	2,15	2,38	1,48	1,93	1,82	2,10	2,38	1,68	2,29	2,17
7	2,55	2,57	1,50	2,40	2,51	1,52	1,97	1,90	2,10	2,50	1,68	2,21	2,17
8	2,52	2,63	2,30	1,82	2,08	1,78	2,51	2,34	2,42	2,40	2,35	2,23	2,30
9	2,52	2,63	2,30	1,82	2,08	1,45	2,51	2,00	2,42	2,40	2,02	2,23	2,30
10	2,41	2,51	1,46	2,15	2,42	1,43	1,92	1,93	2,25	2,42	1,68	2,19	2,14
11	2,46	2,63	1,90	1,62	2,55	1,98	2,04	1,94	2,22	2,50	2,27	2,36	2,17

Weighting table 8

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,61	2,64	1,89	2,24	2,56	1,80	2,09	2,02	2,17	2,60	2,40	2,25	2,04
2	2,49	2,64	1,89	2,30	2,56	1,98	2,39	1,96	2,20	2,50	2,24	2,31	2,10
3	2,52	2,58	1,91	1,58	2,65	1,94	2,04	1,95	2,28	2,43	2,19	2,04	2,01
4	2,57	2,62	1,83	1,75	2,60	1,68	2,17	2,04	2,23	2,50	2,32	2,21	2,10
5	2,61	2,65	1,88	2,25	2,56	1,45	1,99	2,08	2,32	2,38	2,32	2,33	2,18
6	2,53	2,50	1,65	2,18	2,41	1,53	1,99	1,86	2,09	2,38	1,72	2,25	2,10
7	2,57	2,58	1,54	2,40	2,52	1,57	2,02	1,93	2,09	2,50	1,72	2,18	2,10
8	2,55	2,64	2,25	1,88	2,14	1,80	2,51	2,32	2,38	2,40	2,32	2,19	2,22
9	2,55	2,64	2,25	1,88	2,14	1,50	2,51	2,02	2,38	2,40	2,02	2,19	2,22
10	2,45	2,53	1,50	2,18	2,45	1,48	1,98	1,96	2,23	2,42	1,72	2,16	2,08
11	2,49	2,64	1,89	1,70	2,56	1,98	2,09	1,96	2,20	2,50	2,24	2,31	2,10

Weighting table 9

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,64	2,65	1,89	2,27	2,58	1,82	2,16	2,05	2,15	2,60	2,40	2,19	1,95
2	2,54	2,65	1,89	2,32	2,58	1,97	2,41	2,00	2,17	2,50	2,21	2,24	2,00
3	2,57	2,60	1,91	1,72	2,65	1,94	2,12	2,00	2,24	2,43	2,17	2,01	1,93
4	2,60	2,63	1,84	1,87	2,61	1,72	2,23	2,07	2,20	2,50	2,27	2,15	2,00
5	2,64	2,66	1,88	2,29	2,58	1,53	2,08	2,10	2,27	2,38	2,27	2,25	2,06
6	2,57	2,54	1,69	2,22	2,45	1,60	2,08	1,92	2,09	2,38	1,77	2,19	2,00
7	2,61	2,60	1,60	2,41	2,55	1,63	2,11	1,98	2,09	2,50	1,77	2,13	2,00
8	2,59	2,65	2,19	1,97	2,23	1,82	2,51	2,30	2,32	2,40	2,27	2,14	2,10
9	2,59	2,65	2,19	1,97	2,23	1,57	2,51	2,05	2,32	2,40	2,02	2,14	2,10
10	2,50	2,56	1,57	2,22	2,48	1,56	2,07	2,00	2,20	2,42	1,77	2,11	1,98
11	2,54	2,65	1,89	1,82	2,58	1,97	2,16	2,00	2,17	2,50	2,21	2,24	2,00

Weighting table 10

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,69	2,67	1,89	2,34	2,61	1,87	2,31	2,12	2,11	2,60	2,40	2,06	1,77
2	2,63	2,67	1,89	2,37	2,61	1,96	2,46	2,09	2,12	2,50	2,15	2,09	1,80
3	2,65	2,64	1,90	2,01	2,65	1,94	2,28	2,08	2,16	2,43	2,12	1,96	1,76
4	2,67	2,66	1,86	2,10	2,63	1,81	2,35	2,12	2,14	2,50	2,18	2,04	1,80
5	2,69	2,67	1,88	2,35	2,61	1,70	2,26	2,15	2,18	2,38	2,18	2,10	1,84
6	2,65	2,60	1,77	2,31	2,53	1,74	2,26	2,03	2,07	2,38	1,88	2,06	1,80
7	2,67	2,64	1,71	2,43	2,59	1,76	2,28	2,07	2,07	2,50	1,88	2,03	1,80
8	2,66	2,67	2,07	2,16	2,40	1,87	2,52	2,27	2,21	2,40	2,18	2,03	1,86
9	2,66	2,67	2,07	2,16	2,40	1,72	2,52	2,12	2,21	2,40	2,03	2,03	1,86
10	2,61	2,61	1,69	2,31	2,55	1,71	2,25	2,08	2,14	2,42	1,88	2,02	1,79
11	2,63	2,67	1,89	2,07	2,61	1,96	2,31	2,09	2,12	2,50	2,15	2,09	1,80

Weighting table 11

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,72	2,68	1,89	2,38	2,62	1,90	2,38	2,15	2,09	2,60	2,40	2,00	1,68
2	2,68	2,68	1,89	2,40	2,62	1,96	2,48	2,13	2,10	2,50	2,11	2,02	1,70
3	2,69	2,66	1,89	2,16	2,65	1,94	2,36	2,12	2,12	2,43	2,10	1,93	1,67
4	2,70	2,67	1,87	2,22	2,64	1,86	2,41	2,15	2,11	2,50	2,14	1,99	1,70
5	2,72	2,68	1,88	2,38	2,62	1,78	2,35	2,17	2,14	2,38	2,14	2,03	1,73
6	2,69	2,63	1,81	2,36	2,57	1,81	2,35	2,09	2,06	2,38	1,94	2,00	1,70
7	2,71	2,66	1,77	2,43	2,61	1,82	2,36	2,12	2,06	2,50	1,94	1,98	1,70
8	2,70	2,68	2,01	2,26	2,48	1,90	2,52	2,25	2,16	2,40	2,14	1,98	1,74
9	2,70	2,68	2,01	2,26	2,48	1,80	2,52	2,15	2,16	2,40	2,04	1,98	1,74
10	2,66	2,64	1,76	2,36	2,58	1,79	2,35	2,12	2,11	2,42	1,94	1,97	1,69
11	2,68	2,68	1,89	2,20	2,62	1,96	2,38	2,13	2,10	2,50	2,11	2,02	1,70

Weighting table 12

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,75	2,69	1,89	2,41	2,64	1,92	2,45	2,18	2,07	2,60	2,40	1,94	1,59
2	2,73	2,69	1,89	2,42	2,64	1,95	2,50	2,17	2,07	2,50	2,08	1,95	1,60
3	2,73	2,68	1,89	2,30	2,65	1,94	2,45	2,17	2,09	2,43	2,07	1,90	1,59
4	2,74	2,68	1,88	2,33	2,65	1,90	2,47	2,18	2,08	2,50	2,09	1,93	1,60
5	2,75	2,69	1,88	2,42	2,64	1,86	2,44	2,19	2,09	2,38	2,09	1,95	1,61
6	2,73	2,66	1,85	2,40	2,61	1,88	2,44	2,15	2,06	2,38	1,99	1,94	1,60
7	2,74	2,68	1,83	2,44	2,63	1,88	2,44	2,16	2,06	2,50	1,99	1,93	1,60
8	2,74	2,69	1,95	2,35	2,57	1,92	2,52	2,23	2,10	2,40	2,09	1,93	1,62
9	2,74	2,69	1,95	2,35	2,57	1,87	2,52	2,18	2,10	2,40	2,04	1,93	1,62
10	2,72	2,67	1,82	2,40	2,62	1,87	2,44	2,17	2,08	2,42	1,99	1,92	1,60
11	2,73	2,69	1,89	2,32	2,64	1,95	2,45	2,17	2,07	2,50	2,08	1,95	1,60

Weighting table 13

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,60	2,40	1,88	1,50
2	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,50	2,05	1,88	1,50
3	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,43	2,05	1,88	1,50
4	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,50	2,05	1,88	1,50
5	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,38	2,05	1,88	1,50
6	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,38	2,05	1,88	1,50
7	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,50	2,05	1,88	1,50
8	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,40	2,05	1,88	1,50
9	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,40	2,05	1,88	1,50
10	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,42	2,05	1,88	1,50
11	2,77	2,70	1,89	2,45	2,65	1,94	2,53	2,21	2,05	2,50	2,05	1,88	1,50

Weighting table 14

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	2,00	2,20	1,80	1,20	2,00	1,40	1,60	1,80	1,50	2,60	2,40	2,00	1,80
2	1,60	2,20	1,80	1,40	2,00	2,00	1,60	1,60	1,60	2,50	1,75	2,20	2,00
3	1,71	2,00	1,86	1,00	2,29	1,86	1,43	1,57	1,86	2,43	1,57	1,29	1,71
4	1,86	2,14	1,57	1,57	2,14	2,00	1,86	1,86	1,71	2,50	2,00	1,86	2,00
5	2,00	2,25	1,75	1,25	2,00	1,25	1,25	2,00	2,00	2,38	2,00	2,25	2,25
6	1,75	1,75	2,00	1,00	1,50	1,50	1,25	1,25	1,25	2,38	2,00	2,00	2,00
7	1,88	2,00	1,63	1,75	1,88	1,63	1,38	1,50	1,25	2,50	2,00	1,75	2,00
8	1,80	2,20	2,00	1,00	1,60	1,40	2,00	1,80	2,20	2,40	2,00	1,80	2,40
9	1,80	2,20	2,00	1,00	1,60	1,40	2,00	1,80	2,20	2,40	2,00	1,80	2,40
10	1,46	1,85	1,50	1,00	1,62	1,33	1,23	1,58	1,69	2,42	2,00	1,69	1,92
11	1,60	2,20	1,80	1,40	2,00	2,00	1,60	1,60	1,60	2,50	1,75	2,20	2,00

Weighting table 15

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace	Post/mov.	Lifting	Restritiveness	Decision making	Job content	Attentiveness	Physical activity	Communication
1	3,00	3,00	2,00	3,00	3,00	2,00	2,00	2,00	3,00	2,60	2,40	3,00	3,00
2	3,00	3,00	2,00	3,00	3,00	2,00	3,00	2,00	3,00	2,50	3,00	3,00	3,00
3	3,00	3,00	2,00	1,00	3,00	2,00	2,00	2,00	3,00	2,43	3,00	3,00	3,00
4	3,00	3,00	2,00	1,00	3,00	1,00	2,00	2,00	3,00	2,50	3,00	3,00	3,00
5	3,00	3,00	2,00	3,00	3,00	1,00	2,00	2,00	3,00	2,38	3,00	3,00	3,00
6	3,00	3,00	1,00	3,00	3,00	1,00	2,00	2,00	3,00	2,38	1,00	3,00	3,00
7	3,00	3,00	1,00	3,00	3,00	1,00	2,00	2,00	3,00	2,50	1,00	3,00	3,00
8	3,00	3,00	3,00	2,00	2,00	2,00	3,00	3,00	3,00	2,40	3,00	3,00	3,00
9	3,00	3,00	3,00	2,00	2,00	1,00	3,00	2,00	3,00	2,40	2,00	3,00	3,00
10	3,00	3,00	1,00	3,00	3,00	1,00	2,00	2,00	3,00	2,42	1,00	3,00	3,00
11	3,00	3,00	2,00	1,00	3,00	2,00	2,00	2,00	3,00	2,50	3,00	3,00	3,00