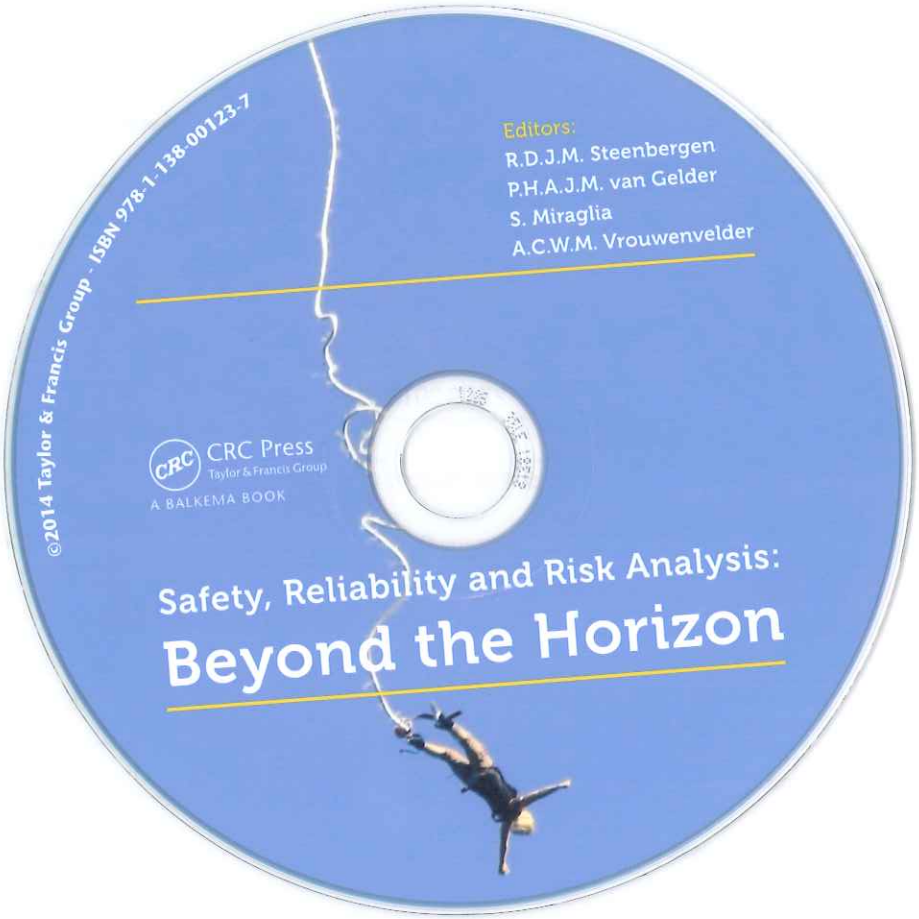
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Weighting Table: A broader view for the ergonomic intervention

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ABSTRACT: The use of the Ergonomics Tridimensional Analysis (ETdA) methodology to perform the assessment of risk situations on areas commonly used by workers and clients allows a broader understanding of a system ergonomic approach. The final task of the ETdA is the establishment of a Weighting Table to support the analyst on the ergonomic intervention decisions. The decision-making process is based on a 3-point colored scale, identifying the situations requiring a short-term intervention, a medium-term intervention or non-critical situations. In order to study the influence of the weights in decision making process a comparative study on results obtained from the Weighting Tables was done. The Ergonomic factors affected by the clients' weight were assessed and each type of changes separately studied. Obtained results showed that increasing weights given to clients dimension can lead to different decision-makings regarding the ergonomic intervention.

1 INTRODUCTION

Acording to Norros & Savioja (2007) the development of new technologies in the decade of 1980, contributed to the market segmentation were clients assume a different role. In modern society, the ergonomic contexts' differentiation is the result of a market customization where clients are becoming intrinsically linked to the organizations (Norros & Savioja, 2007). 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 (Loureiro, 2012). 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 & 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 and manufacturing process becomes more sustained. That is, sequential and rigid division of labor, characteristic from mass production, are gradually being replaced by a system approach. According to Carayon & 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. 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. One of the aspects that can contribute to improve the work organization in terms of performance and wellbeing is the use of a participatory approach. In order to achieve desirable goals, people are involved in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes (Kogi, 2006).

Dul & Neumann (2009) refer that ergonomics implies having both a social goal (wellbeing) and an economic goal (total system performance). Dul et al. (2012) refer that performance and wellbeing are outcomes of fitting the environment to human. Performance is related to productivity, efficiency, effectiveness, quality, innovativeness, flexibility, safety and security, reliability and sustainability.

Wellbeing is concerned with health and safety, satisfaction, pleasure, learning and personnel development. According to Hasle & Jensen (2012), wellbeing is an experience of the human being that reflects its expectations from the situation. These two outcomes may have influence on each other and must be understood as strongly connected. By taking this into consideration, organizations must have both social and economic goals to achieve the optimization of the performance of the overall system (Kogi, 2006). Young et al. (2012) emphasize the need of a balance in the relation design/optimization of a process or a system.

The participatory methods place a particular emphasis on creating initiative of people through participatory, solving workplace problems. The advance related to the participatory approaches in workplace is dated since the mid-1980s. Cotton et al. (1988) pointed out that both workers and managers in cooperation should develop ideas. Kogi (2006) supports that, in the process of improvement, modern ergonomics issues are related to the involvement of as many people as possible. Organizations may use different processes to implement a participatory approach, such as self-assessment of working conditions. Indeed, most of the improvements related to the work conditions are carried out by considering the individual units (Men/Work) rather than the system as a whole (Querelle et al., 2012).

Nowadays, a more contemporary vision of the organization problem-solving is used. The decision-making process to obtain improvements considers that any work activity as part of a supply chain in which each element is both a supplier and a customer. Follow this thinking, interactions and the total network, rather than the entities, should be considered into analysis. That is, 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 part. By studying and understanding the real work activities, it is possible to observe Clients influence on many aspects of the worker performance.

Considering a holistic approach, Clients interact directly with the individual/group subsystem. Thus, Clients have influence on the environment subsystem and, in a certain way control the organizational subsystem strategies. Effectively, clients and professionals that circulate freely and interrelate on these areas may equally be exposed to the same ergonomic risk factors already identified for professionals. Several examples may be named: 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 well-being perspective, as well as professionals attendance on the area (usability goal). In these situations, ergonomic approaching must also recognize that Clients are an active part of the ergonomic context (Loureiro, 2012).

The strategies defined by managers will certainly have influence on workers' activities. 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. Indeed, the recognition of the public engagement on the decision-making process becomes a challenge to modern managements, being compulsory to understand the importance and the role of this new dimension on a system approach.

This paper aims to study the influence of the Clients on the decision-making process to ergonomic intervention, based on the obtained results from the application of the ETdA methodology in a commercial area (Loureiro, 2012), by a comparative study based on the ETdA weighting tables (Loureiro et al., 2012). According to this ergonomic approach, three dimensions are considered to perform the ergonomic analysis: the Analyst, the Professionals and the Clients. Observation tools were assembling to each one of these dimensions: the ETdA ergonomic checklist, the ETdA evaluation form, and the ETdA questionnaire. The variables analyzed with this model, named Ergonomic Factors (EF), allow the ETdA operability (Work postures and movements, General physical activity, Communication and Attentiveness, Noise, Illumination, Thermal environment, Risk accident, Professional training quality, Job content, Decision-making and Restrictiveness (Hakkarainena et al., 2011).

This paper, in order to illustrate the influence of the weights given to Clients dimension on the ergonomic decision-making is divided into three sections. After the Introduction, a brief description on the ETdA methodology principles is made, as well as its implementation on commercial areas. It is also presented the main steps of the decision-making process and the criteria to study the influence of the Clients on the process. Finally, the conclusions are presented, showing the relevance and the applicability of this new methodology in the new dynamic workspaces.

2 METHODOLOGY

In order to study the influence of different weights given to the three ETdA dimensions on the decision making process, a study case on a commercial area, was developed. This commercial area worked under a franchise concept and that belongs to a Dutch cash-and-carry chain. Cash-and-carry is an important wholesale warehouse, very similar to a large supermarket. Different professional activities are identified, as well as different Clients/ professionals interactions. This kind of business is characterized by large open spaces where different sections with food and non-food services/goods are identified. The hypothesis that clients and professionals may be exposed to the same ergonomics risk factors should be taken into consideration. Take as example the possibility of Clients' or professionals' injuries development related to manual material handling activities or during the operation of shopping trolleys (Clients can mobilize a total weight of approximately 600 kg/ 1322 lbs). 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.

Two main steps were considered: (1) the ETdA implementation and (2) the decision-making process. The ETdA implementation was conducted using the general ETdA guidelines, as presented in Figure 1 (Loureiro, 2012).

After a brief presentation of the general guidelines for the ETdA implementation to the manager of the commercial area, it was decided the application of the ETdA observation tools. Later, the data collected was processed in order to obtain the ETdA variables: Ce, Pe and Ae. It is important to remark that these variables were obtained from the ETdA questionnaire, the ETdA evaluation form and the ETdA ergonomic checklist. These variables are related to the set of the Ergonomic factors that were evaluated. For each of these variables, the average was calculated. 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%. The decision-making is based upon the obtained weighted value. The decision-making process considers a 3-point colored scale: 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 and 1.5 were considered as score 1, values between 1.6 to 2 were scored as 2, and values higher than 2.6 were scored as 3. Regarding the development of the weighting tables, it is important to underline that, when there is legislation or governmental recommendations, its fulfillment should always be ensured, and only after this situation is accomplished, is then considered the weight of the obtained results.

The process used to obtain the decision-making result is presented in Figure 2.

A part of the weighting table designed for the commercial area is provided on Table 1 with a 33% weight for each ETdA dimension. This weighting table was the base of the study of the Clients influence on the decision-making process.

The criteria used to perform this study are defined in Table 2. A quantification of the number of changes on the results obtained from the weighting table, under different weights was done. The weighting tables' number 1, 2 and 3 are related to an occupational ergonomic analysis where the

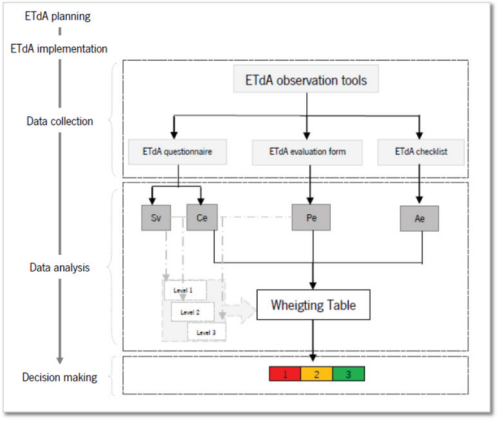

Figure 1. Main steps for the ETdA implementation (Loureiro, 2012).

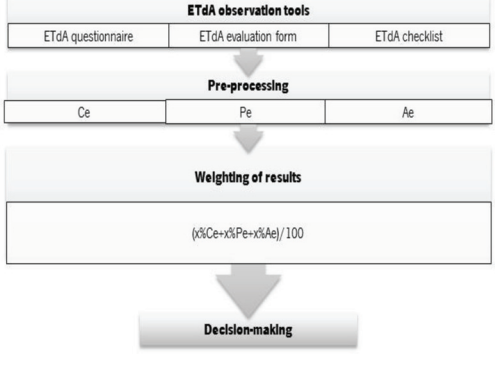

Figure 2. Decision-making process.

Table 1. Weighting table.

Sections	Noise	Lighting	Accident risk	Thermal env.	Workspace
1	2,59	2,63	1,90	2,22	2,55
2	2,46	2,63	1,90	2,28	2,55
3	2,50	2,57	1,91	1,48	2,65
4	2,54	2,61	1,82	1,67	2,60
5	2,59	2,65	1,88	2,23	2,55
6	2,51	2,48	1,63	2,15	2,38
7	2,55	2,57	1,50	2,40	2,51
8	2,52	2,63	2,30	1,82	2,08
9	2,52	2,63	2,30	1,82	2,08
10	2,41	2,51	1,46	2,15	2,42
11	2,46	2,63	1,90	1,62	2,55

Table 2. Weightings' criteria percentages.

	Dimension		
WT*	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

*WT—weighting table.

Table 3. Results of the decision-making.

	Weight percentage (%)			Decision-making (n)		
WT	C	A	P	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

*WT—weighting table; C, A, P—ETdA dimensions; R, Y, G—colors scale.

Clients are not considered. The weighting Tables 4 to 11 represent different weights given to the Clients dimension. To ensure that the study was focused on Clients' influence, equal weights were assigned to Professionals and Analyst dimensions.

3 RESULTS

Based on the weighting table presented on Table 1 and according to the criteria previously defined (see Table 2), a summarization of the results regarding the identification of the number of decisions (n) for each color is presented and according to the weight percentage (see Table 3). The decision-making values were obtained by summing the Ce, Pe and Ae variables related to the ETdA questionnaires, ETdA evaluation forms and ETdA checklist.

Results show that the increase of the weights given to clients dimension is related to the 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. It is possible to observe the influence of Clients on the decision-making, R/Y and Y/G, from a minimum weight of 25%. G/Y changes occur from a weight of 5%. Regarding the changes obtained from a 33% of weight, some considerations should be made. In one hand, the weighted values can be very close to the boundary of the decision limit and, on the other hand, the Ce value is very different from Ae and Pe values. Take as example the weights of 33% corresponding to the Accident risk (Ar) and Thermal evaluation (Te) ergonomic factors (equations 1 and 2). In both situations, small weighting values assigned to clients' dimension produces a change in decision-making.

$$W(Ar) = \frac{1}{3}(Ce + Pe + Ae) = \frac{1}{3}(1.89 + 1.5 + 1) = 1.46 \quad (1)$$

$$W(Te) = \frac{1}{3}(Ce + Pe + Ae) = \frac{1}{3}(2.45 + 1 + 1) = 1.48 \quad (2)$$

The type of change that occurs with different weights was observed and each type of change was studied separately. Results presented in Table 4 show red to yellow changes (R/Y). These changes were identified in the following ergonomic factors: Accident risk, Thermal environment and Postures and movements.

Results also allow the identification of the weighted values close to the boundaries of the decision limit, corresponding to 1.50 (values in the interval [1.46, 1.48]). The value corresponding to 1.32 (marked with an asterisk in Table 4) is considered an outlier. Regarding the weighting equation for this weight value (equation 3) 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.

$$W(Ar) = \frac{1}{4}Ce + \frac{3}{8}Pe + \frac{3}{8}Ae\Big) = \frac{1}{4}2.45 + \frac{3}{8}1.40 + \frac{3}{8}1 = 1.32 \quad (3)$$

Results presented in Table 5 shows 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.

Both Communication and Decision-making EFs 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). Most of the changes occur with a 25% weight, regarding clients' dimension.

Table 4. Study of the red to yellow changes, by weight.

WT	EF	Additional information
0% → 25%	Thermal environment	1.46 → 1.58
		1.32* → 1.51
25% → 33%	Accident risk	1.46 → 1.50
	Postures and movements	1.47 → 1.52
33% → 40%	Accident risk	1.46 → 1.50
	Thermal environment	1.48 → 1.58
	Postures and movements	1.46 → 1.53

Table 5. Study of the changes green to yellow.

WT	EF	Additional information
0% → 5%	Accident risk	2.50 → 2.47
	Decision-making	2.54 → 2.46
		2.53 → 2.42
10% → 25%	Physical activity	2.55 → 2.44
		2.53 → 2.42
		2.51 → 2.34
	Communication	2.58 → 2.40
		2.58 → 2.40

Table 6. Study of the changes yellow to green.

WT	EF	Additional information
25% → 33%	Noise	2.49 → 2.52
	Lighting	2.49 → 2.51
	Workspace	2.41 → 2.51
50% → 70%	Noise	2.49 → 2.51
		2.49 → 2.54
70% → 80%	Noise	2.50 → 2.66
80% → 90%	Workspace	2.48 → 2.57

Results presented in Table 6 shows Yellow changes to Green (Y/G).

Results show that Y/G changes were observed on Noise, workspace and lighting EFs. Once more, the values that determine the changes are positioned in the boundary limit, corresponding to 2.50.

4 FINAL CONSIDERATIONS

This study highlighted the Clients' importance on the ergonomic analysis, by the comparison of the results obtained through the definition of Weighting Tables, with and without considering Clients dimension. The use of the ETdA methodology allows studying the influence of each of the ETdA dimensions on the decision-making process. This study can be conducted to analyze 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.

It is important to remark that the profile of the Clients obtained from the ETdA questionnaire can also have influence on the decision-making process.

As different profiles and weighting tables can be obtained according to the commercial area under study, these considerations suggest that results should not be extensible to other companies of the same franchising.

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