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Assessment of mental workload: an ergonomics strategy in people management

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Summary

This study seeks to investigate aspects of mental workload from a theoretical and practical point of view. From there, it is intended to enhance reflection on the importance of studying mental workload as one of the stages of AET, to enable a complete analysis ergonomics, thus considering the psychophysiological aspects of the work. From this study, the mental load for work activities classified as generating high cognitive demand is evaluated and the results of the mental workload found from two measurement methods, currently the most used - NASA TLX and SWAT. Through this study, the mental load required for both the manual assembly activity and the automatic assembly activity of electronic boards was evaluated in an energy solutions company in Santa Catarina. The results of the mental load assessment showed that between the two ways of carrying out the activity, the mental demands are greater in the manual assembly activity. The mental load assessment methods applied in ergonomics studies make it possible to understand the worker's capabilities and limitations, characteristics of the work organization and facilitate the quantitative and qualitative presentation of results in relation to the mental load experienced by the worker. The comparison of performance between the two methods of assessing mental load is also a pertinent study for the field of ergonomics, as there are few comparative studies regarding the performance of the methods. When comparing the general performance between the two methods, the NASA TLX method makes it possible to evaluate mental load by analyzing different dimensions of the work situation and presents advantages when compared to SWAT, as it can be easily applied and has shown greater acceptance by those evaluated. .

Keywords: Ergonomics. Mental Load. Measurement Methods. People management.

1. INTRODUCTION

There is an increasing need to invest in mental health through and for work. Since Sigmund Freud, mental health has been the “capacity to love and work”, which in a way does not require a specialty to agree with this and, even if we had never heard this type of statement, from psychology, for example; We would agree that these are two major areas in the life of an adult human being: love and work... Where through love we reproduce and through work we produce.

In other words, if, by an inverse logic, mental illness can be seen as the inability to love and work, in theory we already know that love and work themselves enhance the problem and affect the subject's cognitive capabilities, influencing their skills and competencies.

In this study to better address the proposed issues: mental health, mental load ergonomics: a strategy for people management. Initially, we sought to conceptualize, we sought to address the main concepts related to ergonomics and mental workload, human behavior and implications of work on mental health, methods for measuring mental workload, methodological procedures for the study, analysis and discussion of results;

For Moraes and Mont'Alvão (1998 p. 48), the main objective of ergonomics is

recover the meaning of work, generate active and reforming knowledge that prevents worker alienation, value work as human action through which man transforms himself and transforms society, as a free expression of the creative society, as overcoming the limits of the species human.

For the authors, the reality of work, its physical and social environment exert certain constraints on the worker, requiring an expenditure of physical, mental, affective and emotional energy, which therefore evolves into wear and tear and human cost applied to the worker. . This human cost is the result of a process classified as workload and, in this study, the process of mental workload is investigated in particular.

For Wisner (1994), all work activities have at least three aspects, including: physical, cognitive and psychological. Each of these aspects can determine the overload process and one can influence the other. According to the author, in the psychic dimension, disorders can originate due to suffering and physical fatigue, changes in work rhythms, sleep quality impaired by the distribution of work and cognitive work overload. Velazques et al. (1995) add that the aspects mentioned above are interconnected and can influence the workload in the following way: the physical load is related to muscular effort, the cognitive load comes from mental effort and the psychic load is related to the component affective effect of the task.

Considering that ergonomics also seeks to study the relationship between man and his work and that it contemplates all the variables involved in this process, including the study of mental load at work, it becomes important to investigate mental load, since This has a direct influence on man's ability to use his skills and competencies to carry out his activities.

Generally, the mental requirement is observed wherever the processes of human experience and behavior occur. The term also refers to the cognitive, informational and emotional processes of human existence, so it ranges from cognitive aspects (attention, concentration, memory, perception, decision-making) to emotional aspects, which encompass affections, feelings and motivation towards work. . The term mental is used because these aspects occur in an interrelated way and, in practice, may or may not be treated separately.

It is observed, through literature, that the most suitable methods for measuring mental workload are subjective and the most suitable of these are: NASA TLX and SWAT. However, most studies using such methods were developed only through simulations of certain work situations, not in real situations. The work situation to which this study refers is the interrelationship between the worker and the variables involved in their work activity.

In view of the above, this study seeks to verify: What is the performance of the SWAT and NASA TLX methods applied to the real work situation in an energy solutions company? Which of the methods addresses, with greater scope and effectiveness, the mental workload?

1.1 Main concepts and definitions of mental workload in the context of ergonomics

The concept of mental workload is a conceptual product originating from the notion of workload, understood generically as a field of interaction between task demands and human achievement capacity. The term also comes from Work Psychology, as proposed by Leplat and Cuny (1983). This concept is taken up by French ergonomics and North American Human Factors and disseminated in the field of Work Psychopathology and Occupational Health.

According to Guéland et al. (1975), the mental workload is derived from the workload and does not only depend on factors characteristic of the task or activity, but also on external factors, such as: cultural, sociocultural, intellectual capacity or level of knowledge, psychomotor capacity, professional training, previous experience and environmental factors (noise, heat, light, others). Therefore, the mental load will depend both on the demands of the job and on the worker's ability to perform their work. For the authors, this is the main reason why ergonomists should investigate work considering any and all aspects involved in the workload.

Furthermore, it is important to understand the main concepts associated with mental load, therefore, a summary of some concepts and their definitions is presented in Table 1, which allows for greater understanding of the loads that involve mental exhaustion at work.

Table 1 - Summary of concepts and definitions of mental load.

Concepts	Definitions
Psychic Charge	Loads that relate to the affective aspects present in the work or the meaning of the work for those who perform it. It also relates to how the worker is affected by the work they perform.
Cognitive Load	It refers to the loads arising from the cognitive demands of tasks. The use of memory, perception, attention, concentration, reasoning and decision-making related to the task.
Mental Load	It contemplates psychic and cognitive aspects, covering the concepts of psychic load and cognitive at the same time.

Source: Author.

In this way, it can be said that psychic burdens relate to the experience of tensions or psychological decompensations related to the organization. From a conceptual point of view, the notion of psychic load finds operational specificities among the main authors of work psychology, ergonomics and worker health, due to the degree of theoretical complexity attributed to it.

According to Facchini (1994), psychic loads are mainly derived from elements of the work process that are a source of stress, they are related to all elements of the work process and, therefore, to other workloads. However, in more specific terms, the main source of stress in modern work processes can be located at the level of organization and division of labor.

For Velázquez et al., mental work implies mental decision-making and information processing mechanisms, in which higher structures are used, such as attention, thinking and memorization. The authors propose two types of mental work: skilled and low-skilled. In the first, overload appears due to the excessive use of cognitive and intellectual functions. In the second, underload arises due to the exaggerated use of sensorimotor mechanisms with little use of higher structures, resulting in a decrease in intellectual functions, since the type of work performed involves little or no mental commitment, becoming repetitive and monotonous. In overload, however, mental work becomes absorbing, exceeding the limits tolerable by the worker.

It is observed through the various concepts that the use of the notion of Mental Load in the

ergonomic context does not appear to be unanimous. However, this view is opposed by Moray's view, which raises the possibility of building a unified theory of Workload, which provides greater clarity in the definition of mental load, as well as making it possible not only to analyze the components of the load, but also predict your behavior. The same author does not hide how far away this possibility is, but makes reservations about the enormous advantages in building this path.

1.2 Human behavior and implications of work on mental health

According to Zanelli (2004), since the 1970s, studies of human behavior in organizations have had their main interest in cognition, considering from this the balance between cognition, emotions and affections, as a reflection of mental health at work. Therefore, it is admitted that the interaction processes between man and work can be better understood if we also take emotions and affections into account. The emotions we refer to in this study can be defined as processes with multiple cognitive components and which also encompass motivational, behavioral and physiological processes, all directly related to the results of man's interaction with his work and consequently influence the level of mental workload and/or mental health of each worker.

For the same author - Zanelli (2004), emotions can influence not only people's lives, but also business and work management, as the worker faces difficulties in maintaining balance, thus affecting mental health. by and for work and generating behaviors that can compromise their overall performance.

In this way, it is understood why factors in the work context are seen as capable of producing or altering human behavior, in a way that is detrimental to the worker's balance and/or even mental health. Among the factors present in the reality of work, which influence or may influence the general well-being and health of the worker, there are some categories previously classified:, such as: stressful events (aversive stimuli, in which direct and indirect tasks), leadership management, characteristics of the work group, conditions of the physical environment and the system of organizational rewards and punishments (Brief and Weiss, 2002).

In this way and according to Zanelli (2004), environmental conditions can also be classified as the set of environmental variables that surround a person while carrying out their activities and can be represented by: physical conditions (temperature, lighting and noise), temporal conditions (working hours, rest breaks, duration of the work shift) and social conditions (relationships with colleagues, leadership style and organizational climate). From this, it is believed that all these aspects must be considered when intending to evaluate the mental workload, or factors influencing general mental health. To this end, some methods of measuring mental load directly or indirectly contemplate the dimensions of work that affect mental load levels and consequently mental health at work. Such methods are also addressed in this study with the aim of enabling a better understanding of the possible methods to be used to analyze characteristics of mental workload.

1.3 Measures for measuring mental workload

For Moray (1986), the mental load construct is divided into four classes: subjective, physiological, behavioral and analytical. Among these classes, the first three are classified as empirical, while the analytical class is seen as predictive and normally used in the early stages of projects to avoid future over or underload. However, to date, there is no unified theory of mental load that clarifies the different effects on the different classes of load proposed by the author.

The author adds that the mental load experienced by a worker is a complex function specific to individual conditions and the task:

there are characteristics of the task, the effort invested, the motivation, as well as other idiosyncratic factors, which end up characterizing it as multidimensional. Therefore, there is currently no definitive model for representing the mental load construct, what exists are several methods to access it (MORAY, 1988, p. 127).

O'Donnell and Eggemeier (1986) and Rubio and Diaz (1999) agree with Moray regarding the multidimensionality of mental load. However, they classify methods into only three types: behavioral, physiological and subjective. Corroborating Moray, the authors Jorgensen (1999) and Sander and McCormick (1993) describe the four classes that encompass the main methods of measuring access to mental load. The authors propose a division of behavioral measures into two aspects, primary task and secondary task. To better illustrate the authors' point of view in relation to the four classes, Table 2 is presented.

Table 2 - Categories and definitions of mental workload assessment methods for Jorgensen (1999) and Sander and McCormick (1993).

Category of methods	Definition
Measurement of primary tasks	It is directly related to the performance of the task itself.
Multiple task measures	It measures the load level through the use of two tasks, a primary, more sophisticated task and a second, less sophisticated task with a known load level.
Physiological measurements	They measure physiological responses related to responses to changes in mental load levels.
Subjective measures	They seek subjective answers to experiences related to mental workload, often administered through questionnaires administered at the end of the task.

Source: Definition of category of methods for measuring mental load. Jorgensen, (1999) and Sander and McCormick (1993).

It is believed that subjective measures have high diagnostic potential, as they enable the observation of load levels through psychomotor manifestations. However, it is worth noting that in predominantly cognitive tasks, it is not as effective. The interesting thing about this type of assessment is that it becomes an indicator of the person being evaluated without them having to express themselves verbally. Such measures will also serve as a complement or support to those classified as subjective or behavioral. Therefore, physiological variables should not serve as sole indicators of mental load, but rather be associated with other ways of measuring mental load. It is worth highlighting the existence of some physiological parameters, used more frequently to investigate levels of mental load. Such parameters are proposed by Rehmann (1995).

1.4 Most used measures to measure mental load

1.4.1 NASA TLX

Through this study it was observed that, given the subjectivity that encompasses the involvement of each worker with their work, as well as the demands of the task and the uniqueness with which each worker performs them and considering aspects proposed by specialized literature, it was observed- It is clear that subjective measures are the most suitable for evaluating mental workload levels (CARDOSO, M.S. 2010).

According to Moray (1986), subjective measures are the most reliable and have the best performance for measuring mental load. The best known are NASA TLX and SWAT, which is why both methods will be adopted in the methodological procedures of this research. In research using such methods, load results are addressed by correlating them with: length of the working day, pain symptoms, gender, age, level of education, time in the role performed. In this study, these aspects will be addressed, with the difference that the work activity will be related to the work of a Santa Catarina energy generation company and that, by analyzing the mental load of those evaluated, the aim is not only to quantify the results, but also qualify them, identifying the variables involved in the mental workload.

The NASA TLX Task Load Index was developed by Hart and Staveland (1988) and is a multidimensional rating procedure that provides an overall Work Load score based on a weighted average of ratings on six subscales: Mental Demand, Demand (Physical Demand, Temporal Demand, Own Performance – these are understood as Levels of Achievement, Effort and Frustration.

1.4.2 The SWAT method

This method was developed by the research group Reid et al. (1981; 1982) and uses data analysis procedures based on joint measurement techniques, indicating that the mental load of a task or activity is determined by three factors or dimensions, which are: time, mental effort and stress.

2. METHODOLOGICAL PROCEDURES

2.1 Characterization of the research

The research is characterized as exploratory and descriptive developed by a field study. Exploratory because it aims to investigate ergonomic aspects of work activity, an action that can be seen as a tool for better management of people and work. Furthermore, emphasis was placed on assessing mental workload, as well as aiming to study the performance between two recognized methods that enable the measurement of mental workload – SWAT (Subjective Workload Assessment Technique) and NASA TLX.

2.2 Characterization of the field research location

The study was developed in a company that operates in the technological solutions market, developing and providing solutions (products and services) for the management, control and protection of electrical energy systems, applicable both in the generation and in the areas of transmission and distribution of electrical energy. . The company is known in the market technology as the pioneer in Latin America in the development of voltage regulators with Digital Signal Processing (DSP) technology.

2.3 Characterization of the population

Eleven (11) operators from the assembly sector participated in the assessment of mental workload, 40% of whom know and operate both manual assembly and automatic assembly of electronic boards, of those evaluated, 30% are female and 70 % male.

2.4 Research procedures

2.4.1 Consultations with bibliographic sources

The entire bibliographic review process was carried out using electronic databases, as well as instruments, texts and books that provided the opportunity to build knowledge for the development of this research. From the bibliographical research, approximately 2000 titles related to Mental Workload and approximately 400 titles referring to the assessment of Mental Workload were obtained, all published in the period between 2000 and 2009. Of the titles, approximately 350 texts, of which the summaries were analyzed. Subsequently, the 40 main studies used to support this research were selected.

The following databases were used:

- a) CAPES theses and dissertations bank – CAPES allows consultation of summaries and information on theses presented by postgraduate programs in the country. We sought to consult information to complement this study covering the period from 2000 to 2008.
- b) Scielo – Scientific Electronic Library Online.
- c) Medline – Online medicine, specializing in physiological and epidemiological medical articles.

2.4.2 Field data collection instruments

To identify the sector with the greatest mental demand and/or with the greatest number of complaints associated with the mental workload, we chose to use the respective methods: general working conditions assessment method, NASA TLX method and SWAT method, both associated with results from individual interviews and job visits.

3. ANALYSIS AND DISCUSSION OF RESULTS

3.1 Comparison of results and performance between methods for measuring mental workload – NASA TLX and SWAT

From a comparative point of view and emphasizing the results obtained from the application of methods for evaluating the mental workload of operators in the manual and automatic electronic board assembly sector, it is observed that both methods indicate some important differences and some results in fact that can be better illustrated by Table 7:

Table 7: Comparison of mental load results obtained using the NASA TLX and SWAT methods.

MÉTHOD	APPEARANCE EVALUATED	ATIVIDADE	RESULTS	
	Featured dimensions	Manual Assembly	Mental and Temporal	
SWAT		Automatic Assembly	Mental and Temporal	Greater mental demands for manual assembly
NASA TLX	Featured dimensions	Manual Assembly	Mental and Temporal	
		Automatic Assembly	Effort and Mental	

Source: CARDOSO M.S. 2010

Both methods assess mental load based on the dimensions that compose it, despite this, it is known that the particular characteristics of each one can imply differences in results. However, it was observed through this study that, for both methods, results that show greater levels of mental load in the manual assembly activity predominate. In this sense, the applicability of the methods to the activities under study proved to be effective and enabled clear and complementary results.

The most prominent dimensions in the results obtained through the two methods were: mental, effort and time, the dimension associated with mental exhaustion appears in both forms of plate assembly operation (manual and automatic) and is highlighted in the results of both methods. The dimension related to the time taken to carry out the activities is highlighted in the results of the two methods, but not in the two ways of carrying out the activity.

Even though each mental load assessment method used in this research, in a certain way, presents unique characteristics, we sought to use them with the main interest of identifying which one contributes most, in terms of results, to the measurement of associated aspects. to the mental workload in the activity of assembling electronic boards. Between the two methods applied in this study, from a general comparison perspective, it is clear that the SWAT method has greater sensitivity, showing higher levels of mental load. This statement can be seen in Table 8, which illustrates results (in percentage) obtained through NASA and SWAT.

Table 8: Comparison of results of general mental load obtained through the NASA and SWAT methods – Manual Assembly.

Comparison of General Mental Load Results (NASA and SWAT) – Manual Assembly										
Identification assessed	Suj. 1	Suj. 2	Suj.3	Suj.4	Suj. 5	Suj. 6	Suj. 7	Suj.8	Suj. 9	Suj. 10
NASA Overload	56,50 %	85%	79%	71,60	54%	65%	63%	82%	86%	59%
SWAT Overload	100%	88%	92,30%	38,40 %	88,40 %	84,60 %	100%	46%	88,46 %	53,80 %

Source: CARDOSO M.S. 2010

It can be seen in Table 8 that, only for subjects 2, 9 and 10, the loads are similar for both NASA and SWAT. In general, it is not possible to make a comparison or standardization in terms of general mental load results, due to the low correlation between the data found. It is also evident that the results indicated by SWAT are at higher levels, which may be associated with the difference in the number of dimensions that the method covers, concentrating the load with greater intensity on the few demands that are measured through the method .

3.2 Main variables influencing the mental load of the studied population

It is recalled that, from a qualitative point of view, to provide information that can, perhaps, understand the personal and professional demands associated with the mental workload. It was observed that the results of mental load are related both to events linked to work and the general characteristics of the worker (age, sex, time in the role, level of education, etc.), and to the ability of each worker to deal with his work, the latter covers each person's limitations in the face of the demands of the environment and the task. Therefore, we sought to draw a comparison between the profile of the population studied and the intensity of the general mental load. However, there was no emphasis in this regard, as variables such as age, gender, time at the company or position and education did not represent a significant interference in the variation in the mental load presented by those evaluated. In general, through the results, it can be said that the most impactful aspects to the general mental load are: mental demand, demand for effort and time.

4. CONCLUSION

Considering that ergonomics seeks to provide improvements and control of the psychophysiological conditions present in the work reality, it is understandable why measuring mental workload is a complementary factor in ergonomic assessment. Therefore, it is up to the ergonomist to understand the complexity involved in ergonomic studies and recognize that mental health, from a social and organizational point of view, is fundamental so that man can be seen as a being capable of using his skills and achieving his goals. . This highlights the importance of investing more in research that values aspects of mental workload, including it as a tool for better management of people and, consequently, work.

It should be noted that most research measuring mental load is applied to situations that simulate the reality of work. However, such forms of research add little to the ergonomist, since for ergonomics, the advantages arise through research applied in practice, as they allow the ergonomist to observe all aspects that are present in the work reality, such as: characteristics environmental issues, notions of biomechanics to understand physiological phenomena, interpersonal relationships at work, general organization of work. In short, all the complexity of the work that can interfere with the worker's performance and the mental demands imposed by the work. Therefore, the theoretical-methodological study of the mental workload of operators who work in the assembly of electronic boards proved to be relevant, since in Brazil there are still few studies investigating characteristics of mental workload in real work situations and the based on studies in ergonomics, in particular, few that correlate studies like these with investment in people management.

Considering the subjectivity with which each worker develops and accepts the demands imposed by work, as well as considering aspects proposed by specialized literature, it was observed that subjective measures are the most suitable for evaluating mental workload levels. . Furthermore, they are recommended because they represent low cost, ease of application and acceptance. However, in view of the complexity associated with the mental load phenomenon, we return to the need to construct and validate new measures or methods that encompass greater reliability, as, despite the advancement of research in cognitive sciences, aimed at improving methods of analysis of mental aspects at work, this research also made it possible to understand that currently, none of the existing methods in specialized literature meet all the criteria proposed by the theory.

From a comparative point of view, those evaluated who know the two ways of carrying out the plate assembly activity, report that manual assembly requires greater capacity mental health of the worker associated with the time pressure to carry out the work, which for those evaluated generates greater wear and tear than that required by automatic assembly. Therefore, the time pressure to achieve results added to the requirement of mental capacity, indicate the importance of investing in studies to adapt the working conditions of manual assembly in order to control the impact of these variables on the mental workload.

However, in relation to the performance of the NASA and SWAT methods, both present

similarities in the graded correction scale, as well as accessing the mental load with the scope it deserves, assuming that it is a multidimensional phenomenon. However, differences were observed and refer especially to the following aspects:

- Through the results obtained, it was identified that the NASA method, through its results presentation model, appears to be slightly more sensitive in terms of dimensions associated with mental load. While SWAT is slightly more sensitive in terms of the general result of mental workload and in cases of comparing the worker's performance in different activities.
- Some aspects observed through the results obtained indicate that each of the methods can be better applied according to the objective of the study. Therefore, the SWAT method proved to be more suitable for comparing load results in different tasks and the NASA method for comparing the results of different subjects for the same task.
- In relation to the time invested in applying the methods, the application of the SWAT method was quite tiring for those evaluated, as it included a greater number of possible combinations that represent the weight of each dimension. As a result, acceptance of the NASA TLX method was more evident, in the opinion of those assessed.

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