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THE PROCESS OF ADJUSTING THE POSITION OF DRIVER SEAT, ITS MENTAL WORKLOAD AND ITS POSSIBLE HUMAN ERRORS.

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Resumen: A lo largo de los años, el asiento del automóvil del conductor ha evolucionado en su forma, materiales e incluso en sus funciones secundarias. Hoy en día, la ergonomía ha influido significativamente en el diseño del asiento del automóvil para el conductor, al cuidar la salud del conductor. La presente investigación realiza un análisis sobre cómo los conductores ajustan su asiento a través de dos perspectivas ergonómicas cognitivas diferentes. Primero, se aplicó un perfil de carga de trabajo mental al proceso para evaluar los recursos cognitivos necesarios durante el proceso. Más tarde, un proceso de error humano identificó las tareas que posiblemente fueron confundidas o se realizaron mal. Los resultados muestran que el ajuste de la distancia entre el volante y el asiento del conductor son los recursos cognitivos más exigentes en el proceso. Además, el estudio SHERPA demuestra que la mayoría de las personas no ajustan correctamente el asiento debido a la falta de conocimiento y conciencia de la importancia de estos ajustes.

Palabras clave: Asiento de Conductor, Proceso de Manejo, Análisis Jerárquico de Tareas, SHERPA, Workload Profile.

Relevancia para la ergonomía: El estudio contribuye a la ergonomía, analizando el proceso en el que los conductores ajustan el asiento del conductor y evalúa la cantidad de recursos mentales que son utilizados en cada uno de los pasos del proceso. Así también, el estudio puede predecir los posibles errores humanos que pueden llevar a un mal ajuste en el asiento del conductor y por consecuente, una mala postura.

Abstract: Over the years, the driver car seat has evolved its shape, materials and even on its secondary functions. Nowadays, ergonomics has significantly influenced on the driver´s car seat design on taking care about driver´s health. The current

investigation performs an analysis on how drivers adjust their seat through two different cognitive ergonomic perspectives. First, a mental workload profile was applied to the process to evaluate the cognitive resources needed during the process. Later, a human error process identified the tasks possibly were mistaken or poorly performed. Results show that adjusting the distance between steering wheel and driver seat is the cognitive resources most demanding on the process. Also, the SHERPA study proves that most people do not properly adjust the seat because lack of knowledge and awareness of how important these adjustments are.

Keywords: Driver Seat; Driving Process; Hierarchical Task Analysis; SHERPA; Workload Profile.

Relevance to Ergonomics: The study contributes to ergonomics analyzing the process of drivers adjust the driver seat and evaluates the quantity of mental resources used in each step of the process. Also, it can predict possible human errors which can lead to a bad adjustment on the seat and so on, with a wrong posture.

1. INTRODUCTION

Since the beginnings of the vehicle, the seats have been suffering modifications, especially the driver seat. This seat has changed along the time, going from the simple seat that just was a one whole piece without aesthetics and no other function than just seating, to a very complex, expensive and full of features car seats. According to Lara Rivero, Trujano, & García Garnica (2005) there are two main seat generations along the time. The 1st generation seat was improved with some features like; the seatbelt, a smooth foam and certain mechanisms that allow the driver to adjust the seat back inclination and the distance between the steering wheel and the driver. The 2nd generation seat, on the other hand, contains a variety of different seats equipped with electrical subsystems like the airbags, climate seat control, and memory to stock the different driver's positions, even they have a headrest that could inflate itself to prevent cervical damage in case of car accident.

All these seat improvements have contributed to prevent driver and passengers' injuries, even taking care of their lives. But, nowadays even with these improvements, people still are presenting injuries and dying because of wrong postures while they are driving. Pain in the neck, shoulders, column and joints are examples of incorrect position consequences of an incorrect position while driving (Camara, 2018).

A wrong position taken while driving can be caused by either a muscular imbalance generated by a genetic deformation or more frequently, by maintaining a static posture for a long-time period (Armas & Carlosama, 2012), which is exactly what happens while driving. That is the reason why the adjustments on driver seat and back became fundamental while the driver is seated on large distances. To assure the adjustments are the closest as possible to the optimal posture, the

process of adjusting them, would be analyzed with a mental workload technique and a possible human error procedure.

Mental workload is a well-known concept and it has been studied for so long and has been worked for several authors, each of them with his own definition. For purposes of the current analysis, mental workload would be defined according to Brad Cain (2007), who after a literature review conclude that “mental workload it is a mental condition that results from performing a task under specific environmental and operational conditions, coupled with the capability of the operator to respond to those demands”.

Hancock & Verwey (1997) on their article “Fatigue, Workload and Adaptative Driver Systems” as its title mentions, evaluates fatigue and workload on the process. On the other hand, Fatima Pereira (2014) on “Mental Workload, Task Demand and Driving Performance: What Relation?” analyses the existing relationship between the driver and the cognitive resources he may need while driving. As the previous couple of studies, there are more of them evaluating workload focused on the driving process but none of them is just emphasized on workload on adjusting the driver car seat, and that is what this investigation is about, to demonstrate how this task influences the entire process of driving and how it contributes to the total mental workload.

In addition, to have a more complete understanding about adjusting the driver seat a human error process is added to the investigation, to know what may negatively affects the process when the driver does not is capable to get the optimate position to drive. To evaluate the possible human error a SHERPA (Systematic Human Error Reduction and Prediction Approach) method would be used to analyses the human reliability qualitatively and quantitatively (D. Embrey, 2009).

2. OBJECTIVE

2.1. Main Objective

Study the way drivers adjust their seat before driving, the way they manipulate the basic adjustments and how it affects in the driving process and wrong posture.

2.2. Specific Objectives

-Evaluate mental workload on the process of adjusting the driver seat.

-Analyze the possible errors may occur on the process of adjusting the driver seat.

3. METHODOLOGY

3.1. Method A, Workload Profile

The Work Load Profile is a technique that allows the investigator to identify a mental workload a person presents while performing a specific task. It is used to measure the workload in eight principle aspects; Perceptual process, response, spatial, verbal, visual, and auditory processing, manual output and speech output (Agency for Healthcare Research and Quality, 2005).

For this article the workload profile would measure the mental workload presented on a driver when he/she adjust her/his seat before driving.

The sample of the population was of 10 volunteers, 5 males and 5 females between the ages of 22 to 60 who drive frequently at least twice a day and a minimum of 45 minutes. Following the technique, the task would be evaluated for each volunteer, grading the difficulty of the mental workload in a scale from 0 to 1 where zero means that there are no resources needed from the task, otherwise if the task is ranked as 1, it would mean the task need the maximum amount of attention to be performed.

3.2. Method B, SHERPA

To evaluate the aspects that may go wrong during the process of adjusting the driver seat to the most comfortable position, a SHERPA analysis would be needed. According to Embrey (1986), SHERPA method would evaluate in a quantitative and qualitative way, the possible errors a person could make along a specific task or process and how to minimize them.

The SHERPA method has eight main steps that need to be followed to achieve a good human error analysis. First, a Hierarchical Task Analysis will be the base of the analysis (3.2.1), then all tasks need to be classified in a taxonomy already established (Action, Retrieval, Checking, Selection, Information communication and Selection). After this, the investigator needs to make a human error identification in every task of the analyzed process and define the error type with the “Error Mode Checklist” (Table 1), and describe the consequences and recovery plan of each (Harris et al., 2005).

Table 1. SHARPA Error Mode Checklist

Error Category	Error Mode	Code	Error Category	Error Mode	Code
Action	Operation too long/short	A1	Checking	Check omitted	C1
	Operation mistimed	A2		Check incomplete	C2
	Operation in wrong direction	A3		Right check on wrong object	C3

	Too little/much operation	A4		Wrong check on right object	C4
	Misalignment	A5		Check mistimed	C5
	Right operation on wrong object	A6		Wrong check on wrong object	C6
	Wrong operation on right object	A7	Communi cation	Information not communicated	I1
	Operation omitted	A8		Wrong information communicated	I2
	Operation incomplete	A9		Information communication incomplete	I3
	Wrong operation on wrong object	A10		Selection omitted	S1
Retrieval	Information not obtained	R1		Wrong selection made	S2
	Wrong information obtained	R2			
	Information retrieval incomplete	R3			

3.2.1. Hierarchical Task Analysis (HTA)

The hierarchical task analysis is a method emphasized on members and organization on the process. It constructs plans that shows how the order of the tasks would be done and who will do each task (Sarker, Chang, Albrani, & Vincent, 2008). Along time, the HTA has been applied to different pourposes and on different disciplines such as job aid design, error prediction, workload assesement, interface design, between others (Stanton, 2006).

On HTA, the main task are divided into subtasks which are the tasks needed to reach an objective and after it is necessary to define a plan for each subtask. The plans are the order and the conditions in which the tasks need to be done (Salavert, Caballero, & Pérez, 2017).

4. RESULTS

4.1. Method A Results, Workload Profile

Each result was averaged and presented a single workload (Table 2), this was done to know in general how many resources were needed during the process of adjusting the driver seat just before driving. As the total workload does not have a specific unit, it can be compared to another task to estimate how demanding the process would

be or this could be used as a first part of a post analysis about the Theory of Multiple Resources of Wickens.

Table 2. Workload Profile Results of the driver seat adjustments.

		Average Work Load Dimensions								
		Stage of Processing		Code of Processing		Input		Output		
TASK		Per-ceptual	Res-ponse	Spatial	Verbal	Visual	Audi-tory	Manual	Speech	Total WL
1	Seating on driver seat	0.66	0.7	0.7	0	0.68	0	0.92	0	3.660
2	Adjust distance between the seat and the steering wheel	0.7	0.74	0.76	0	0.64	0	0.96	0	3.800
3	Adjust Seat Height	0	0	0	0	0	0	0	0	0.000
4	Adjust cushion angle	0	0	0	0	0	0	0	0	0.000
5	Adjust seatback angle	0.32	0.38	0.48	0	0.24	0	0.58	0	2.000
6	Adjust Headrest Height	0	0	0	0	0	0	0	0	0.000
PROCESS TOTAL AVERAGE WORK LOAD										**1.892**

4.2. Method B Results, SHERPA

Once the HTA was made (4.2.1), the same 10 users of the work load profile were asked to realize the needed adjustments in a driver seat just before driving and recorded to analyze the possible errors they would take. As a result, each possible error, its consequences and remedial measures were registered on table 3.

Table 3. SHARPA Human Error Analysis of adjusting the driver seat process

Task Step	Task Type	Error Mode	Description	Consequence	Recovery	Remedial Measure
2	Adjust distance between the seat and the steering wheel	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
2.1	Identify mechanical or electrical system that moves the seat forward and backward	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**2**	Search again the handle or button that does the right movement
2.2	Move the Seat Forward	**A3**	The movement was done in wrong direction	Get a wrong a position	**2.1**	correct direction
2.3	Move the seat backward	**A3**	The movement was done in wrong direction	Get a wrong a position	**2.1**	correct direction
3	Adjust seat height	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
3.1	Identify mechanical or electrical system that moves the seat up and down	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**3**	Search again the handle or button that does the right movement
3.2	Move the Seat up	**A3**	The movement was done in wrong direction	Get a wrong a position	**3.1**	correct direction
3.3	Move the seat down	**A3**	The movement	Get a wrong a position	**3.1**	correct direction

			was done in wrong direction			
4	Adjust cushion angle	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
4.1	Identify mechanical or electrical system that inclines and flex the cushion	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**4**	Search again the handle or button that does the right movement
4.2	Incline cushion	**A3**	The movement was done in wrong direction	Get a wrong a position	**4.1**	correct direction
4.3	Flex cushion	**A3**	The movement was done in wrong direction	Get a wrong a position	**4.1**	correct direction
5	Adjust cushion angle	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
5.1	Identify mechanical or electrical system that inclines and flex the seatback	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**5**	Search again the handle or button that does the right movement
5.2	Incline seatback	**A3**	The movement was done in wrong direction	Get a wrong a position	**5.1**	correct direction
5.3	Flex seatback	**A3**	The movement was done in wrong direction	Get a wrong a position	**5.1**	correct direction

6	Adjust seat height	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
6.1	Identify mechanical or electrical system that moves the headrest up and down	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**6**	Search again the handle or button that does the right movement
6.2	Move the headrest up	**A3**	The movement was done in wrong direction	Get a wrong a position	**6.1**	correct direction
6.3	Move the headrest down	**A3**	The movement was done in wrong direction	Get a wrong a position	**6.1**	correct direction

4.2.1. Hierarchical Task Analysis Results

The purpose of the HTA in this investigation is to identify those tasks which demand a bigger amount of energy and effort when the driver seat is adjusted in the desired position before driving the vehicle. This activity follows a non-lineal analysis what means that the sub-tasks must not follow a specific order during the task.

5. DISCUSSIONS

5.1. Method A Discussions, Workload Profile

In this article, the workload profile can provide the amount of resources are needed for each tasks of the entire process. As shown on Table 2, the action that need more mental resources of the process, is the manual output when adjusting the distance between the seat and the steering wheel. On the other hand, the visual input of adjusting the seatback angle was the task with less visual input, this is because the user rarely can see the seatback and in consequence, the perception of the adjust is more perceptual and spatial.

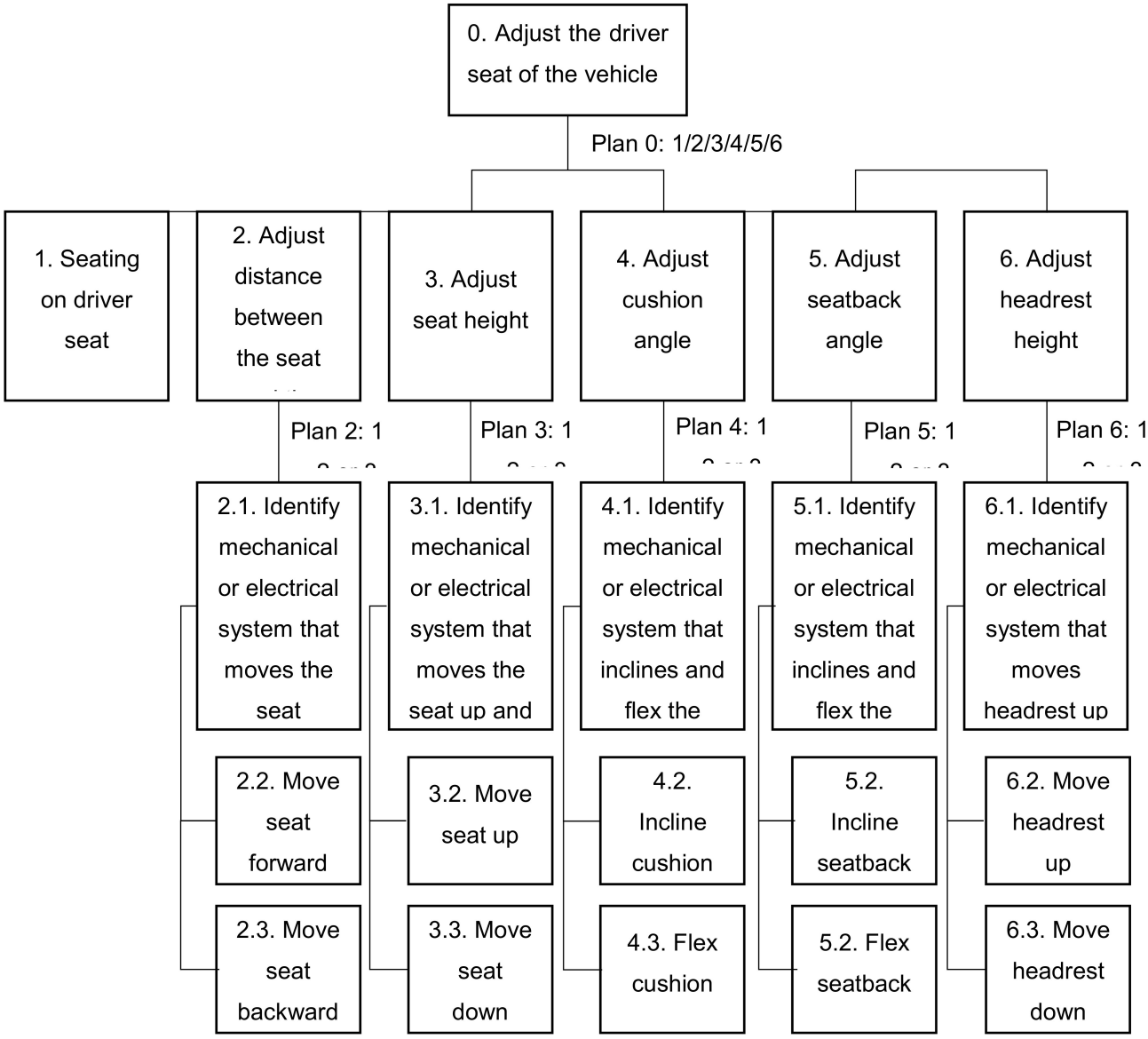

Figure 1. Hierarchical Task Analysis of the process of adjusting the driver seat.

5.2. Method B Discussions, SHERPA

As the process of adjusting the driver seat is a process in which the activities tend to be repetitive or with the same basic principles, the possible human errors are also repetitive and almost the same. On table 3 is shown all the errors but it can be detected 3 main errors; A8 (operation omitted) when the driver totally forgets to do a specific adjustment, I1 (information not communicate) this happened when the user did not find the mechanism that does the adjustment they need, and the A3 (operation in wrong direction) when a user does the adjustment but he or she got the wrong direction than the one they need.